AUSTAR COAL MINE
PART OF THE YANCOAL AUSTRALIA GROUP

AUSTAR COAL MINE
LWB4-B7 MODIFICATION
ENVIRONMENTAL ASSESSMENT

umwelt

MAY 2017

YANCOAL
兖煤澳大利亚有限公司

LWB4-B7 MODIFICATION ENVIRONMENTAL ASSESSMENT

Austar Coal Mine

FINAL

Prepared by

Umwelt (Australia) Pty Limited

on behalf of

Austar Coal Mine Pty Ltd

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Executive Summary

Austar Coal Mine Pty Ltd (Austar) is seeking to modify DA 29/95 (the Bellbird South consent) to permit the transfer and processing of coal from four additional longwall panels within the Austar Coal Mine. This modification is referred to as the LWB4-B7 Modification and is sought under 75W of the *Environmental Planning and Assessment Act 1979*.

Mining operations at the Austar Coal Mine are currently progressing within the LWB1-B3 area. The LWB4-B7 Modification will provide mining and business continuity following the completion of LWB3.

The LWB4-B7 Modification seeks to extend the Bellbird South consent area to cover the four proposed longwall panels. No other changes to the approved mining operations associated surface facilities or production rates are proposed as part of the modification.

The modification will facilitate the recovery of approximately 3.65 million tonnes of additional ROM coal using conventional longwall mining methods and maximises the use of existing infrastructure and facilities.

The LWB4-B7 Modification is located within an area surrounded by previous underground mine workings. The proposed longwalls are located beneath a mix of Austar owned land, privately owned rural land, and Crown and Council landholdings. The primary land use within the modification area is rural and agricultural, with a focus on grazing. The modification area has no major constraints to the proposed deep underground operations, with specific assessment conducted in relation to all relevant natural, cultural and built surface features. This has included detailed assessment in relation to residential and rural structures on private properties, portions of local roads and other public infrastructure, and the biodiversity, water resource and cultural heritage features of the area.

The detailed impact assessments undertaken for the LWB4-B7 Modification conclude that the proposed modification is likely to result in only minor environmental impacts. This is primarily due to the substantial depth of mining, which is a minimum of 400 metres below ground, the design of the longwall panels, the overlying and surrounding site characteristics and Austar's commitment to continued implementation of appropriate monitoring, management and mitigation measures.

Predicted subsidence parameters are less than those previously approved in Stage 2 and Stage 3 mining areas. Extensive monitoring within these previously extracted areas has shown no significant impacts associated with underground mining, including no visible surface cracking, negligible impact to creeks or near surface aquifers, no observable impact on flora or fauna and no significant impacts to built features. The LWB4-B7 Modification is predicted to have similarly low impact on natural and built features and on existing land uses within the modification area.

Existing management measures implemented at the Austar Coal Mine will be extended to the LWB4-B7 Modification Area and additional monitoring is proposed to confirm potential subsidence impacts within the modification area. Management plans will be updated or prepared as part of the Extraction Plan process for the LWB4-B7 Modification Area.

This Environmental Assessment demonstrates that with the continued implementation of existing monitoring, management and mitigation measures, the proposed modification can proceed within acceptable environmental standards.

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1.0 Introduction

Austar Coal Mine Pty Ltd (Austar), a subsidiary of Yancoal Australia Limited (Yancoal) operates the Austar Coal Mine, an underground coal mine located approximately 10 kilometres south of Cessnock in the Lower Hunter Valley in NSW (refer to **Figure 1.1**). The Austar Coal Mine incorporates the former Pelton, Ellalong, Cessnock No. 1 (Kalingo) and Bellbird South Collieries and includes coal extraction, handling, processing and rail and road transport facilities (**refer to Figure 1.2**).

Extensive mining has been undertaken within the Austar Coal Mine since 1916. Historical mining was predominantly via bord and pillar mining and more recently via conventional longwall mining and Longwall Top Coal Caving (LTCC) methods. Mining within the Bellbird South areas (Southland, Stage 1 and Stage 2, refer to **Figure 1.2**) was approved by the Minister for Urban Affairs and Planning in 1996 under DA 29/95 (the Bellbird South Consent), while mining of Stage 3 was approved by the Minister for Planning in 2009 under Project Approval 08_0111. Longwall mining commenced in the Ellalong Colliery area in 1983 and has subsequently progressed into the Bellbird South and the Stage 3 areas.

Mining is currently proceeding in the LWB1-B3 mining area in accordance with DA 29/95 (as modified).

A review of accessible coal resources within the Bellbird South / Ellalong Colliery areas has identified the potential for four additional longwall panels (LWB4-B7) adjacent to LWB3 that can be accessed from the Bellbird mains (refer to **Figure 1.3**). This additional longwall resource would provide continuity of mining following the completion of LWB3, and with minimal additional mine development would provide approximately 3.65 million tonnes (Mt) of additional run-of-mine (ROM) coal which can be processed using the existing site facilities to provide export quality metallurgical product coal.

1.1 Overview of Proposed LWB4-B7 Modification

Austar proposes to modify the Bellbird South Consent to permit the transfer and processing of coal from four proposed longwall panels (LWB4-B7) via the existing Bellbird mains and to extend the development consent area to cover the four proposed longwall panels (refer to **Figure 1.3**).

No other changes to the approved mining operations associated surface facilities or production rates are proposed as part of the modification.

1.2 Proposed Modification Area

The environmental impacts of the proposed LWB4-B7 Modification have been assessed within the predicted 20 millimetre subsidence contour for LWB4-B7. This area is referred to as the 'LWB4-B7 Modification Area' throughout this EA and is shown on **Figure 1.3**.

The 20 millimetre subsidence contour is considered the vertical limit of subsidence. While some far field horizontal movements may occur beyond the limit of the 20 millimetre subsidence contour, any natural or built surface features that could be sensitive to such movements have also been considered in this assessment.

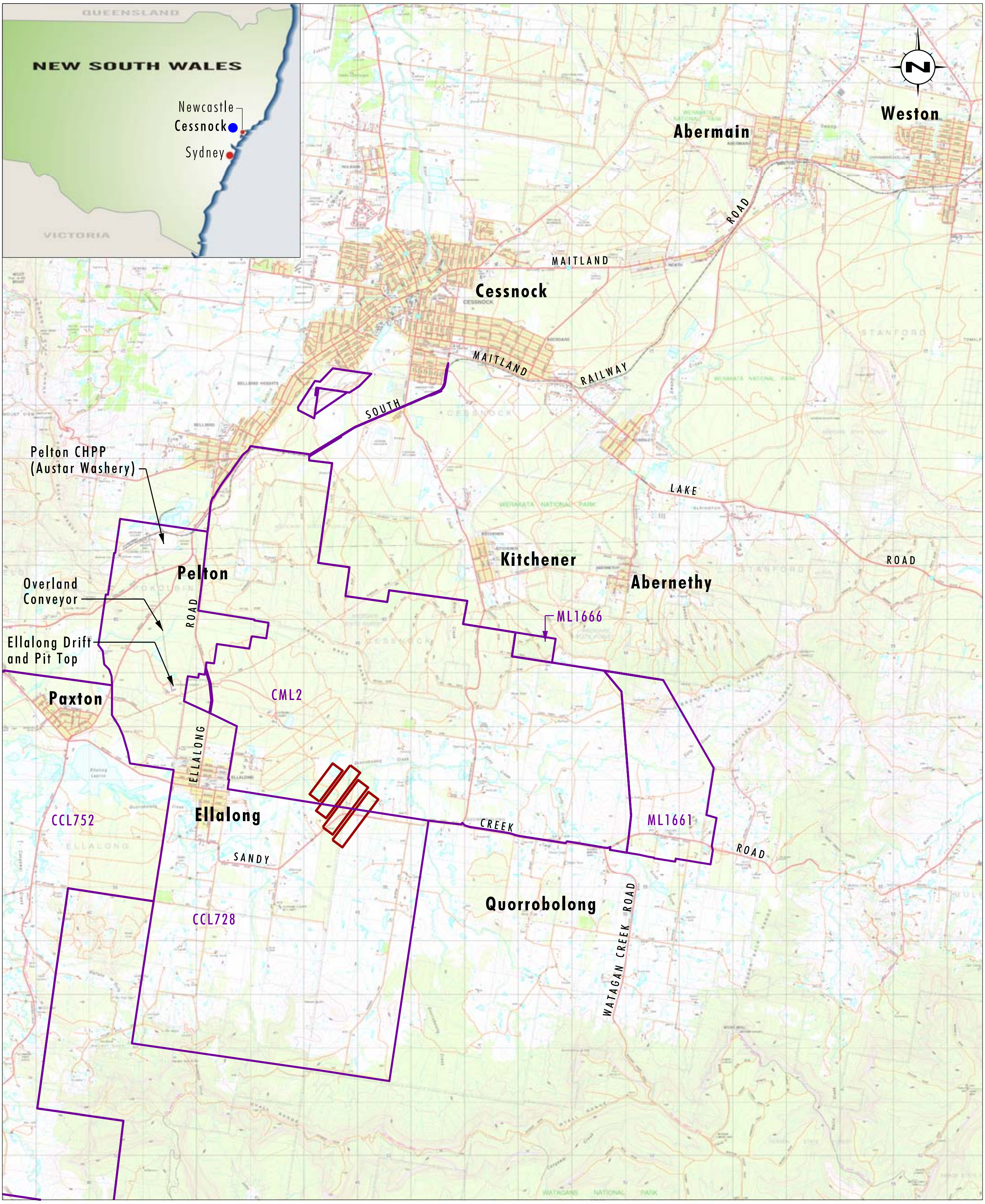

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

0 1.0 2.5 5.0km
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Legend

- Proposed LWB4-B7 Longwall Panels
- Mining Lease Boundary

FIGURE 1.1

Locality Plan

umwelt

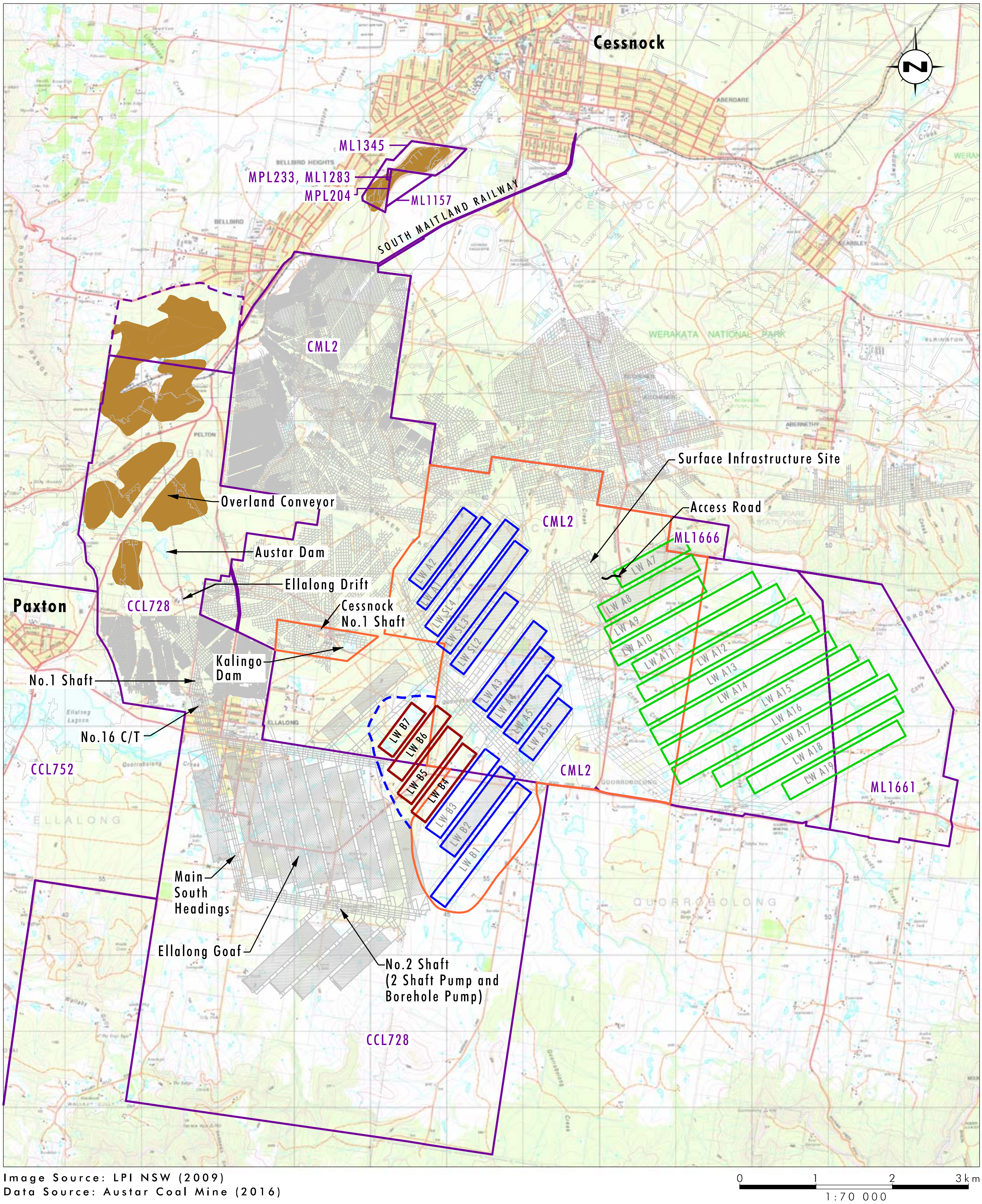

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

Legend

- Bellbird South Stage 1, Stage 2, Southland and LWB1-B3 Longwall Panels (DA 29/95)
- Proposed LWB4-B7 Longwall Panels (DA 29/95)
- Stage 3 Longwall Panels (PA08_0111)
- DA 29/95 Bellbird South Consent Area (Subsurface) - As Approved
- DA 29/95 Bellbird South Consent Area (Subsurface) - Proposed Extension
- Approved Reject Emplacement Areas
- Completed Underground Workings
- Mining Lease Boundary
- Austar owned CHPP Land

FIGURE 1.2

Austar Coal Mine and Proposed LWB4-B7

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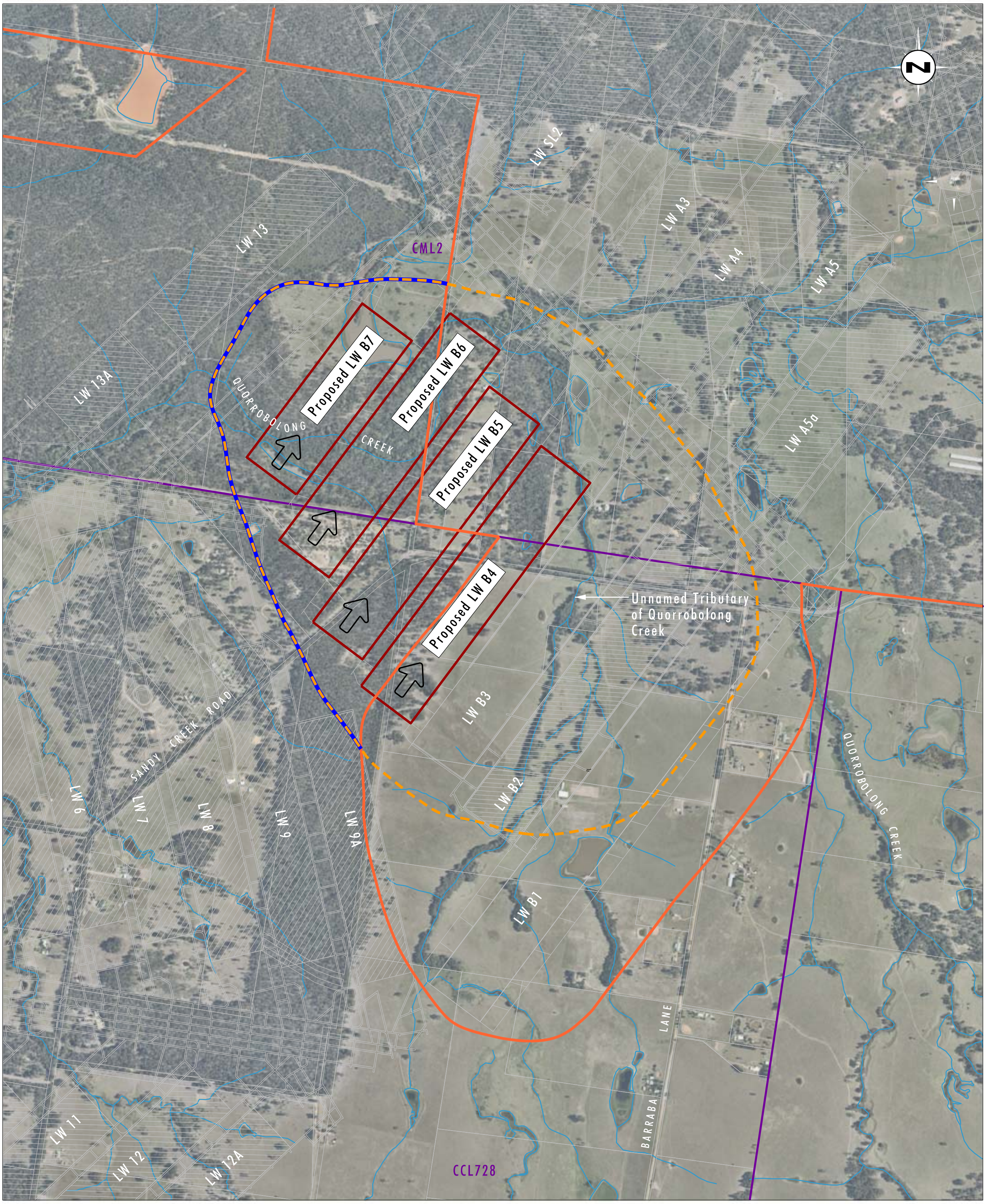

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

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Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- DA 29/95 Bellbird South Consent Area (Subsurface) - As Approved
- DA 29/95 Bellbird South Consent Area (Subsurface) - Proposed Extension
- Mining Lease Boundary
- Completed Underground Workings
- Direction of Mining
- Drainage Line

FIGURE 1.3

Proposed LWB4-B7 Modification

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20170515 13.05

1.3 Environmental Context and Land Use

The LWB4-B7 Modification Area is located in Quorrobolong, approximately two kilometres east of the township of Ellalong in the lower Hunter Valley of NSW (refer to **Figure 1.1**).

The Austar Coal Mine is located in the Newcastle Coalfield and targets coal extraction from the Greta Coal Seam within the Permian Age Greta Coal Measures. The depth of the cover directly above the proposed longwalls ranges from approximately 400 metres in the north-west above LWB7 to approximately 505 metres in the south-east above LWB4. The Greta Seam is the main economic coal seam in the Greta Coal Measures. The Greta Coal Measures are overlain by the Branxton Formation, which is comprised of a substantial thickness of sedimentary rocks and is up to 1300 metres thick in some locations (Geoscience Australia 1988).

The topography of the LWB4-B7 Modification Area is generally characterised by low undulating hills and creek flats associated with Quorrobolong Creek and its unnamed tributaries (refer to **Figure 1.4**). Elevations within the LWB4-B7 Modification Area range from approximately 115 metres to 160 metres Australian Height Datum (AHD). Steeper slopes associated with the Broken Back Range are located approximately 1.5 kilometres to the north of the LWB4-B7 Modification Area within the Werakata State Conservation Area.

The LWB4-B7 Modification Area is situated within the Quorrobolong Creek Catchment, a sub-catchment to the larger Wollombi Brook and ultimately the Hunter River catchment. Quorrobolong Creek forms part of the Congewai Creek Management Zone of the Upper Wollombi Water Source within the Hunter Unregulated and Alluvial Water Sources Water Sharing Plan area. Quorrobolong Creek crosses the northern portion of the LWB4-B7 Modification Area above proposed LWB6 and LWB7 (refer to **Figure 1.4**) and flows west into Ellalong Lagoon approximately 3.5 kilometres to the west. Quorrobolong Creek is ephemeral; however localised areas of ponding occur along its alignment. An unnamed tributary (4th order) of Quorrobolong Creek drains in a northerly direction through the LWB4-B7 Modification Area above LWB1 to LWB4, converging with Quorrobolong Creek upstream of LWB5 (refer to **Figure 1.4**).

A 1st order drainage line also traverses above LWB6 and LWB7 and includes an ephemeral ponded area adjacent to Quorrobolong Creek above LWB7. This drainage line acts as an overland flow path for Quorrobolong Creek during high out of bank flows (refer to **Figure 1.4**). A number of farm dams are located across the modification area, including a large farm dam waterbody located on Austar owned land in the north of the modification area that drains into Quorrobolong Creek (refer to **Figure 1.4**).

One soil landscape type is found within the LWB4-B7 Modification Area, being the Quorrobolong soil landscape (Kovac and Lawrie 1991) (refer to **Figure 1.5**). The main soils within this landscape are prairie soils which form in alluvium and occur in drainage depressions and on lower slopes. They are generally poorly drained, have moderate permeability and the upper horizon has moderate erodibility (Kovac and Lawrie 1991). The soils are moderately fertile and the main land use is generally grazing on unimproved pasture.

Land ownership within and surrounding the LWB4-B7 Modification Area is shown on **Figure 1.6**. The LWB4-B7 Modification Area is located beneath a mix of Austar owned land, privately owned rural land, and Crown landholdings. Austar owns approximately 21 per cent of the land within the modification area.

The primary land use within the LWB4-B7 Modification Area is rural and agricultural grazing including cattle and goat grazing on private landholdings in the south and east of the modification area. Six rural dwellings are located on the private landholdings within the modification area (refer to **Figure 1.4**). Land within the north and west of the modification area which is owned by the Crown and Austar and is currently vacant, supporting remnant and regrowth vegetation.

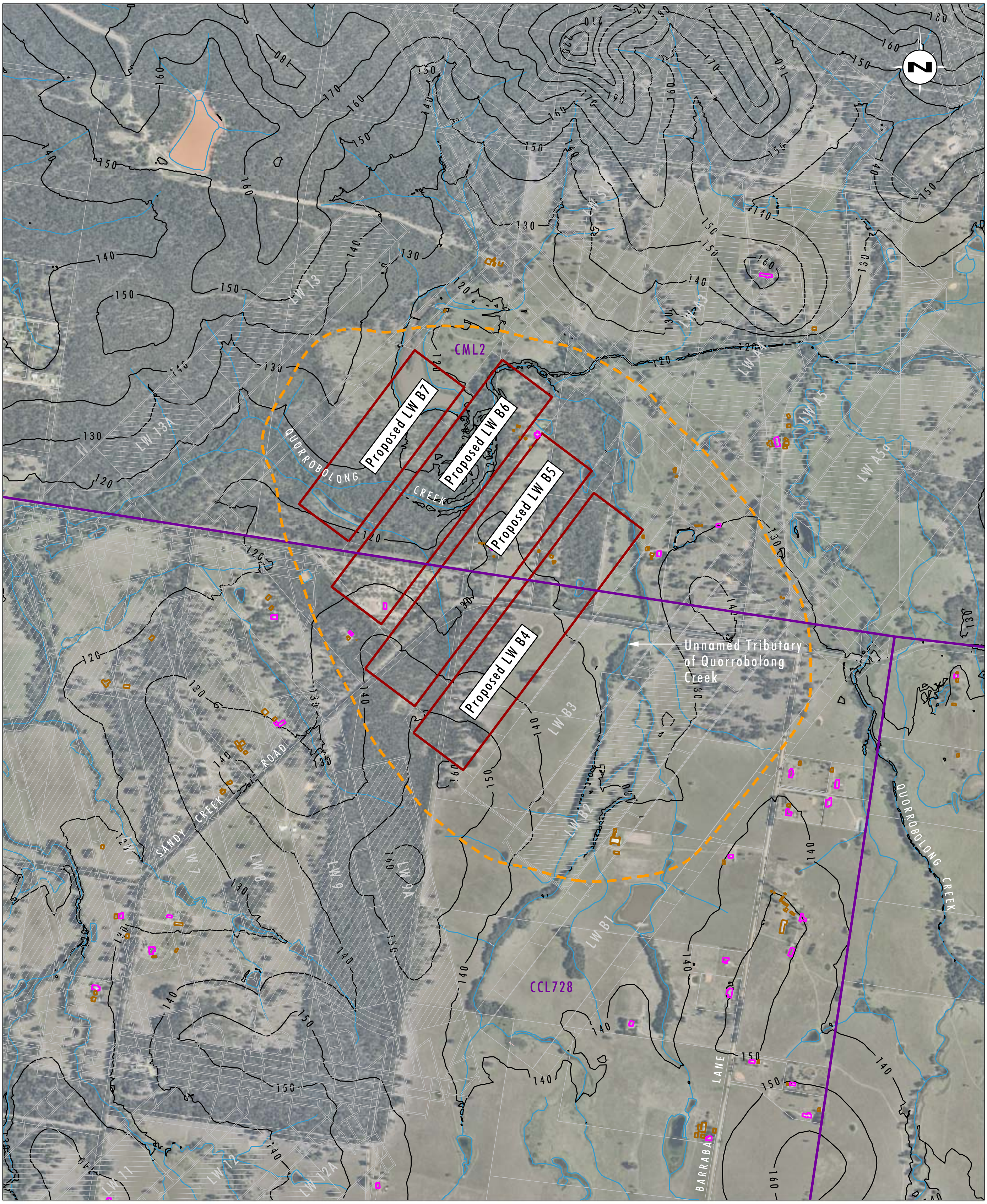

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2015)
Note: Contour Interval 10m

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Drainage Line
- Contour
- Dwelling
- Other Structure

FIGURE 1.4

Topography and Land Use Context

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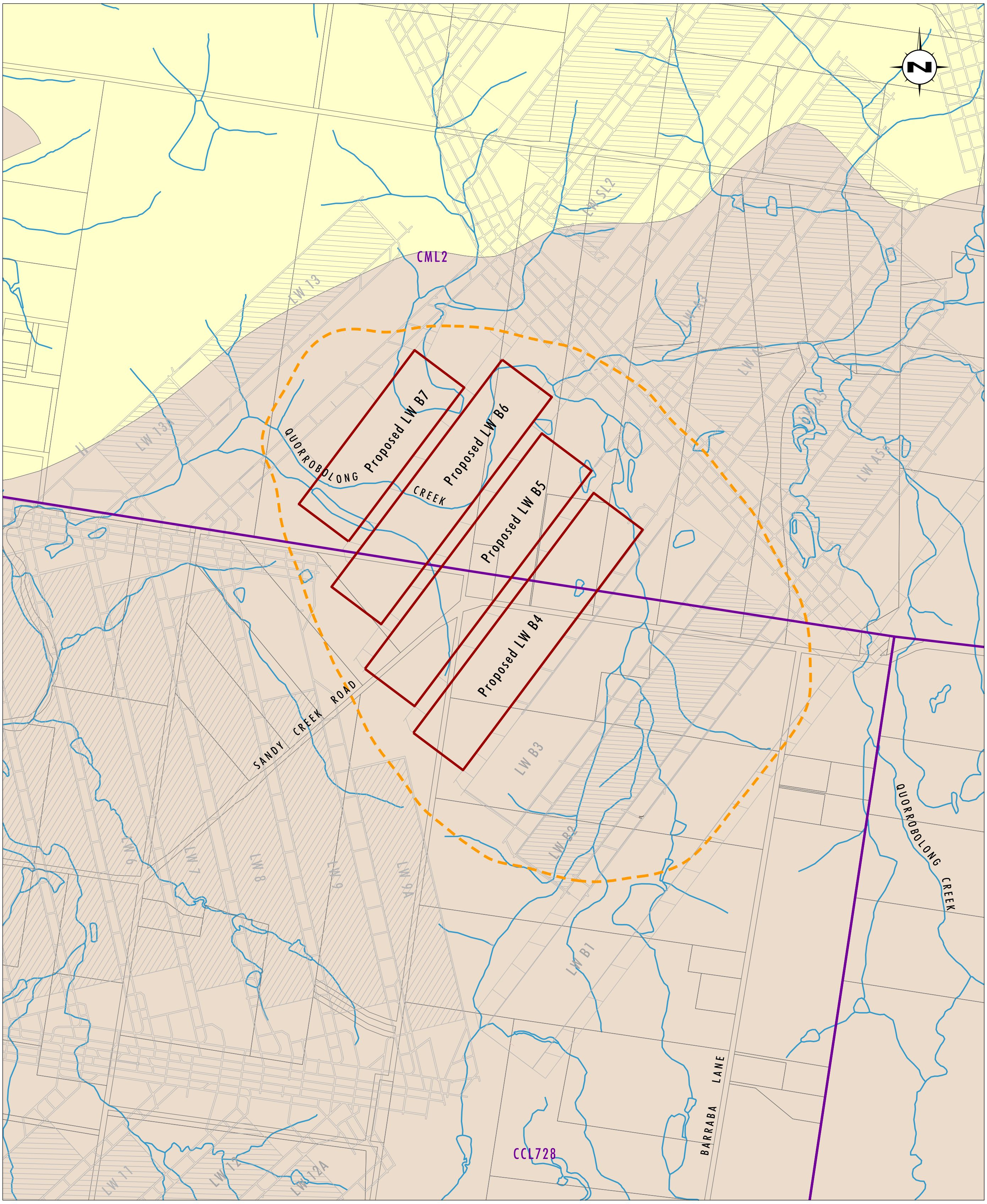
20170515 13.17



Data Source: Austar Coal Mine (2015), Department of Natural Resources (2005)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Drainage Line
- Quorrobolong Soil Landscape
- Aberdare Soil Landscape

FIGURE 1.5

Soil Landscapes

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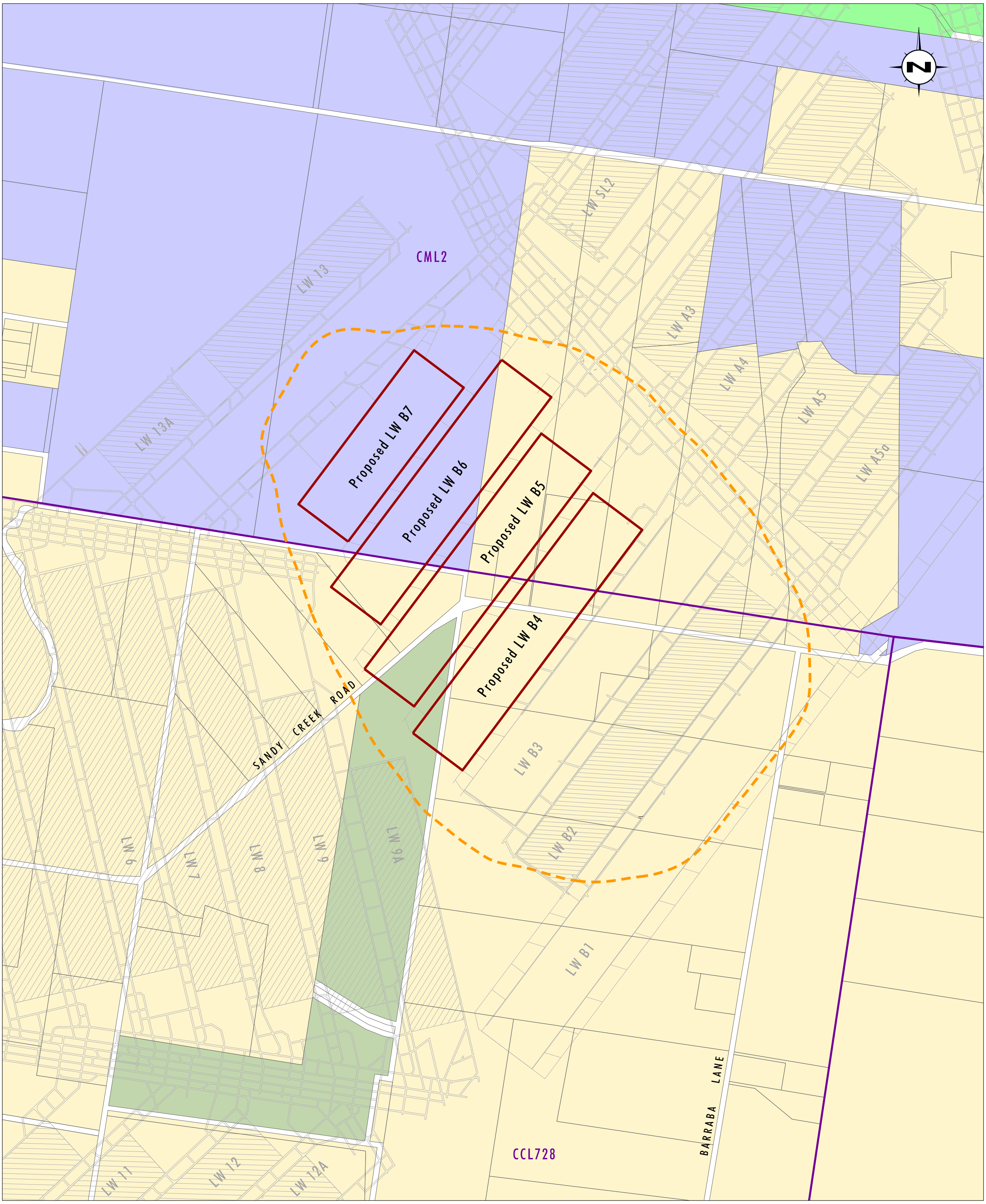

Data Source: Austar Coal Mine (2016)

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1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Austar Owned Land
- Privately Owned Land
- Crown Land

FIGURE 1.6

Land Ownership

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Land use surrounding the LWB4-B7 Modification Area is primarily rural and is dominated by cleared grazing land. Vegetated land to the northwest is owned by Austar and utilised for a variety of surface infrastructure associated with the mine. This Austar owned land connects to the north with the Werakata State Conservation Area which is dominated by vegetation. Other land uses in the surrounding area include rural residential, roads, underground mining and surface mining infrastructure associated with the Austar Coal Mine. The small township of Ellalong is located approximately 2 kilometres west of the LWB4-B7 Modification Area and the villages of Kitchener and Pelton are located approximately 4 kilometres to the northeast and northwest respectively (refer to **Figure 1.1**). The Watagans National Park is located approximately four kilometres south of the LWB4-B7 Modification Area, the Werakata State Conservation Area is located approximately one kilometre to the north and Werakata National Park is located approximately five kilometres to the north-east.

The LWB4-B7 Modification Area is located beneath Sandy Creek Road, with LWB4 and LWB5 passing beneath the road. Barraba Lane and its intersection with Sandy Creek Road is also located just inside the south eastern corner of the modification area, however will not be directly undermined by the proposed modification. Both Sandy Creek Road and Barraba Lane are local Council roads. Two unformed road reserves also occur within the LWB4-B7 Modification Area, north and south of Sandy Creek Road.

1.4 The Proponent

The proponent for the LWB4-B7 Modification is Austar Coal Mine Pty Ltd (Austar). Austar is a wholly owned subsidiary of Yancoal Australia Ltd (Yancoal).

1.5 Environmental Assessment Team

This EA was prepared by Umwelt (Australia) Pty Limited on behalf of Austar with specialist input provided by the following organisations/specialists. The specialist assessments prepared for this EA and their authors are presented in .

Table 1.1 Specialist Reports included within this EA

Report	Author
Mine Subsidence Impact Assessment	Mine Subsidence Engineering Consultants Pty Ltd
Groundwater Impact Assessment	Dundon Consulting Pty Ltd
Flooding and Drainage Assessment	Umwelt
Ecological Assessment	Umwelt
Aboriginal Cultural Heritage and Archaeological Assessment	Umwelt

A full listing of the project team members and their respective roles are provided in **Appendix 1**

1.6 Environmental Assessment Structure

This EA has been prepared in accordance with the EP&A Act and Regulation (refer to EA Statement of Authorship in **Appendix 1**). The EA comprises a main text component and supporting studies, which are included as appendices. An overview of the layout of the main text is presented in **Table 1.2** below.

Table 1.2 Environmental Assessment Structure

EA Section	Environmental Assessment Details
Executive Summary	Provides a brief overview of the proposed modification, the major outcomes of the environmental assessment and key project commitments to mitigate potential impacts.
Section 1.0	Provides the background and context for the proposed modification, key modification details, the proponent and environmental assessment team.
Section 2.0	Describes the existing Austar operations and approvals including environmental management and monitoring at the Austar Coal Mine.
Section 3.0	Describes the proposed modification.
Section 4.0	Provides a description of the current planning context for the proposed modification.
Section 5.0	Describes the stakeholder consultation process undertaken as part of the environmental assessment process.
Section 6.0	Provides a comprehensive analysis and assessment of the potential environmental and community impacts of the proposed modification, including the project specific and cumulative impacts.
Section 7.0	Provides a summary of proposed management and mitigation measures for the proposed modification
Section 8.0	Provides a conclusion and justification for the proposed modification, including how the proposed modification meets the principles of ecologically sustainable development.
Sections 9.0 and **10.0**	References and Abbreviations.

2.0 Overview of Existing Operations

2.1 Mine History

The Austar Coal Mine is an amalgamation of several older mines and operates within a number of mining leases under 14 separate development consents issued by Cessnock City Council between 1975 and 2012. Additionally, Austar operates under the Bellbird South consent granted by the NSW Minister for Urban Affairs and Planning in 1996 and Project Approval 08_0111 granted by the Minister for Planning in 2009. The Bellbird South consent permits underground longwall mining in the Bellbird South area and includes the Stage 1, Stage 2, Southland and LWB1-B3 mining areas (refer to **Figure 2.1**). Project Approval 08_0111 permits underground longwall mining in the Stage 3 mining area (refer to **Figure 1.2**).

The Austar Coal Mine and its associated infrastructure have a long and productive history. A chronology of mining within the Greta Coal Seam at the site and related activities is presented in **Table 2.1**. The locations of previous underground workings in the area are shown on **Figure 1.2.** The location of infrastructure currently used in the handling and processing of coal from the Austar Coal Mine is also shown on **Figure 1.2**.

Table 2.1 Summary of Mining Activities and Approvals at Austar Coal Mine

Year	Historical Details
1916	Underground mining commenced at Pelton Colliery.
1921	Underground mining commenced at Cessnock No. 1 (Kalingo) Colliery.
1960/1961	Pelton Coal Handling Preparation Plant (CHPP) constructed.
1961	Underground mining ceased at Cessnock No. 1 Colliery.
Late 1960s	Cessnock No. 1 Colliery amalgamated into Pelton Colliery.
1975	1975 development consent for Ellalong Colliery granted under Part X11 of the *Local Government Act 1919* as DA 74/75/79 (Ellalong Consent).
1978	Underground mining commenced at Ellalong Colliery with coal being delivered by overland conveyor to the coal preparation plant, raw and washed coal handling systems and train loading facilities at Pelton Colliery.
1983	Longwall production commenced at Ellalong Colliery.
1992	Underground mining ceased at Pelton Colliery.
1994	High levels of gas (primarily carbon dioxide) encountered in the underground workings at Ellalong Colliery, preventing further mining of additional seams to the south-east.
1994	Development consent for the extraction of two longwall panels as a minor extension to the Ellalong Colliery granted by Cessnock City Council.
1995	Pelton Open Cut Coal Mine established.

Year	Historical Details
1996	DA 29/95 approved by the Minister for Urban Affairs and Planning and underground operations from the Ellalong Colliery extended into the Bellbird South Colliery area (Bellbird South consent).
1998	Ellalong and Pelton Collieries amalgamated with Bellbird South Colliery and re-named Southland Colliery.
2003	Spontaneous combustion event resulting in a fire in the underground workings in Bellbird South. Mine placed in 'care-and-maintenance' for approximately 18 months.
2004	Yancoal purchased Southland Colliery and changed the name to Austar Coal Mine.
2005	Austar recommenced underground mining in the Bellbird South Colliery area.
2006	DA 29/95 modified to allow underground mining using LTCC technology in the Stage 1 area.
2008	DA 29/95 modified to allow underground mining using LTCC technology in the Stage 2 area.
2009	DA 29/95 modified to increase the size and dimensions of Longwalls A4 and A5 in the Stage 2 area.
2009	PA 08_0111 for underground mining using LTCC in the Stage 3 area approved by the Minister for Planning.
2010	DA 29/95 modified to allow extraction of one additional longwall panel (Longwall A5a) using LTCC technology in the Stage 2 area.
2010	PA 08_0111 wording of Condition 1 of Schedule 3 modified.
2012	PA 08_0111 modified to reorient Stage 3 longwalls and increase chain pillar width.
2012	DA 29/95 modified to increase the length of Longwall A5a.
2013	Mining completed in Stage 2 longwall A5a.
2013	Kitchener Surface Infrastructure Site ventilation shafts, services borehole, and services completed, and underground longwall mining commenced in Stage 3 area in Longwall A7.
2013	PA 08_0111 modified to extend the length of Longwalls A7 to A10.
2014	Stage 3 development works temporarily suspended.
2015	Development operations relocated to the Bellbird South and Ellalong Colliery areas to maintain business continuity in the medium term.

Year	Historical Details
2016	DA 29/95 modified to permit the transfer and processing of coal from LWB1-B3 in the Bellbird South/Ellalong Colliery areas and to extend the life of the consent to 14 February 2022. Underground longwall mining commenced in the LWB1-B3 mining area in LWB2.

As set out in **Table 2.1**, underground mining commenced at Pelton Colliery in 1916. The Pelton CHPP was constructed in about 1960/1961 for the washing of Pelton Colliery coal. Pelton Colliery was amalgamated with the neighbouring Cessnock No. 1 Colliery in the late 1960s.

In 1975 development consent for Ellalong Colliery was granted under Part X11 of the Local Government Act 1919 and the mine was officially opened in July 1979. The 1975 development consent envisaged that coal from Ellalong Colliery would be transported by conveyor from the Ellalong Drift and Pit Top to the Pelton CHPP. Longwall production commenced at Ellalong Colliery in 1983. Mining within the Ellalong Colliery is still permissible under the 1975 consent.

In early 1994 high gas levels were encountered in the southern part of Ellalong Colliery. Development consent was granted by Cessnock City Council in June 1994 to allow extraction of two longwall panels within existing mining leases to the north of the Ellalong Colliery and allow continuity of operations whilst investigations into alternate mining options were undertaken for the Ellalong Colliery.

In 1996 the Bellbird South consent was granted by the Minister for Urban Affairs and Planning to extend Ellalong Colliery to the north-east into the Bellbird South area to allow development in an area not affected by high levels of coal seam gas. The Bellbird South consent allowed for mining within CML2 by conventional retreat longwall mining producing up to 3 million tonnes per annum (Mtpa) of product coal. The approved mining area that formed part of the Bellbird South consent is shown in **Figure 2.1**.

In 1998 Southland Coal Pty Limited acquired Ellalong and Pelton Collieries and amalgamated them with Bellbird South Colliery. Ellalong, Pelton and Bellbird South Collieries became known as the Southland Colliery. Southland Colliery was operated until 2003 when spontaneous combustion resulted in the mine ceasing operations and being placed on care and maintenance for a period of 18 months.

Southland Colliery and its associated infrastructure was acquired by Yancoal in December 2004 and was renamed Austar Coal Mine.

Austar recommenced development mining in the Bellbird South area in April 2005. A modification to the Bellbird South consent was approved by the Minister for Planning in 2006 to allow for the extraction of coal to a height of 6.5 metres using LTCC technology in the Stage 1 area (consisting of LWA1 and A2 as shown on **Figure 2.1**). A further section 96 Modification (Stage 2) was approved by the Minister for Planning in 2008 to allow LTCC extraction of LWA3 to A5 in Stage 2 (see **Figure 2.1**). A third minor section 96 (1a) modification to vary the length and widths of LWA4 and A5 was approved in 2009, and a fourth modification under Section 75W of the EP&A Act adding LWA5a to the Stage 2 area was approved in November 2010. Modification 5 was approved on 27 April 2012 to lengthen LWA5a. Mining of LWA5a was completed in February 2013. Modification 6 was approved on 29 January 2016, permitting the transfer and processing of coal from three additional longwall panels, LWB1-B3 (refer to **Figure 2.1**).

A new Project Approval (PA 08_0111) was granted by the Minister for Planning in September 2009, enabling longwall mining using LTCC technology in the Stage 3 area and construction and operation of a new Surface Infrastructure Site and access road south of Kitchener (refer to **Figure 1.2**).

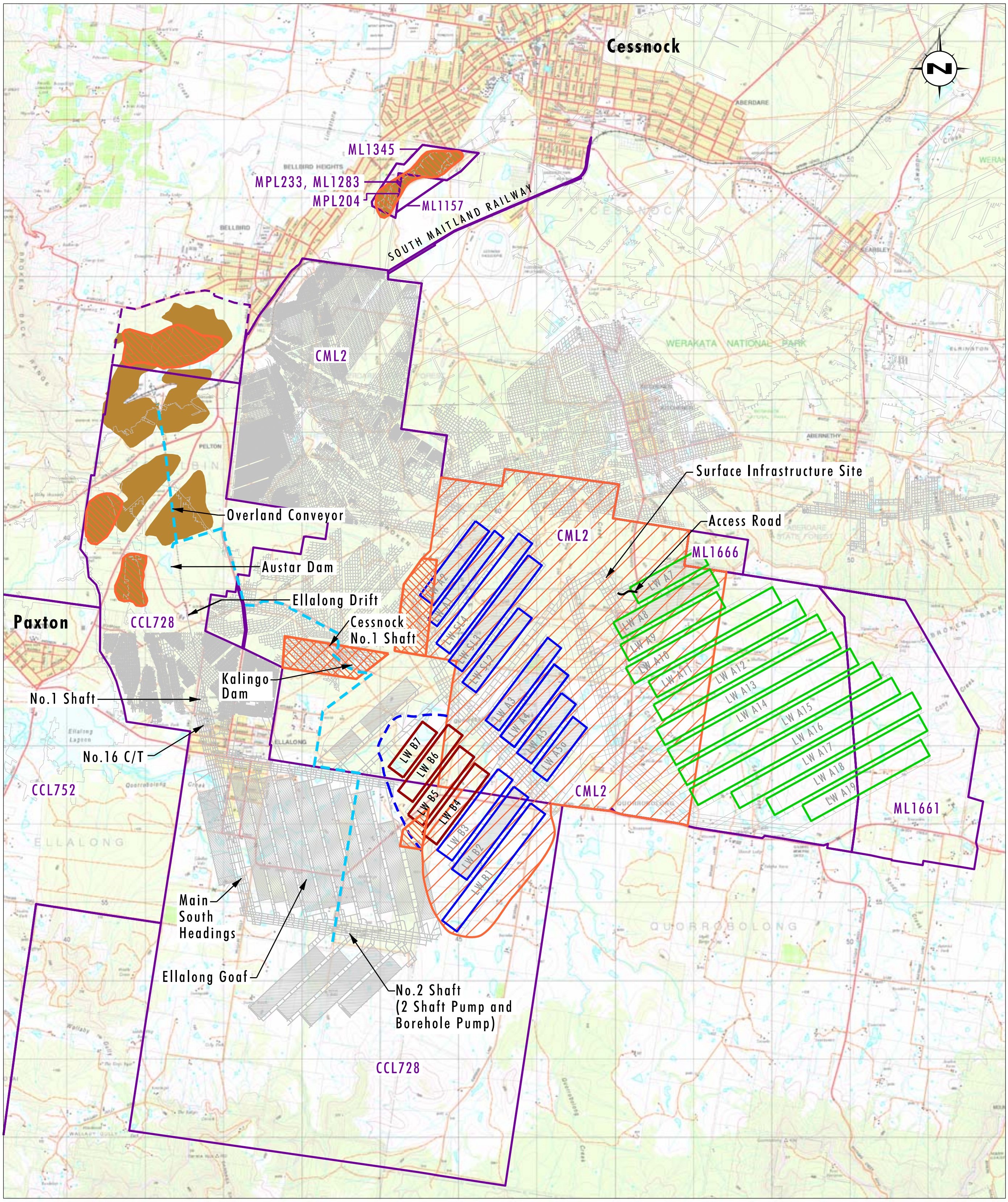

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

0 1 2 3km
1:70 000

Legend

- Bellbird South Stage 1, Stage 2, Southland and LWB1-B3 Longwall Panels (DA 29/95)
- Water Pipeline
- Proposed LWB4-B7 Longwall Panels (DA 29/95)
- Stage 3 Longwall Panels (PA08_0111)
- DA 29/95 Bellbird South Consent Area (Subsurface) - As Approved
- DA 29/95 Bellbird South Consent Area (Subsurface) - Proposed Extension
- Surface Application Area (DA 29/95)
- Approved Reject Emplacement Areas
- Completed Underground Workings
- Mining Lease Boundary
- Austar owned CHPP Land

FIGURE 2.1

DA29/95 Approved Mining Area and Proposed LWB4-B7 Modification

File Name (A4): R01/3900_013.dgn
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The new Surface Infrastructure Site includes new pit top facilities including an access road, upcast and downcast ventilation shafts, main ventilation fans, winder house, bathhouse, workshop, electricity substation and distribution line, service boreholes, potable and reticulated sewerage services, telecommunication services, offices and store. Ventilation shaft/fans and ancillary services construction at the Kitchener Surface Infrastructure Site was substantially completed in June 2013, with underground longwall mining also commencing in the Stage 3 area in June 2013.

2.2 Current Mining Operations

Since 2013, underground mining within the Austar Coal Mine has progressed within the Stage 3 area under Project Approval 08_0111, and more recently in the LWB1-B3 mining area under the Bellbird South consent (as modified). Austar Coal Mine has approval to extract up to 3.6 Mt of run of mine (ROM) coal a year until 31 December 2030.

Coal mined from within the Stage 3 area (PA 08_0111) and from the Bellbird South consent area (DA 29/95) is bought to the surface at the Ellalong Drift and Pit Top via an underground conveyor through the Ellalong East and South Headings (refer to **Figure 1.2**). Coal is then conveyed to the Pelton CHPP via an overland conveyor system, processed and handled at the Pelton CHPP and railed to the Port of Newcastle via the Austar Rail Line, South Maitland Railway and Main Northern Rail Line. Up to 60,000 tonnes of specialty coal product is also transported by road from the Pelton CHPP.

Reject from the Pelton CHPP is emplaced at approved emplacement areas at the Pelton CHPP and Aberdare Extended Open Cut Voids and may be emplaced at other approved sites as shown on **Figure 1.2**.

Longwall mining within the Stage 3 area has progressed to the end of LWA8. Mining of LWA8 was completed in June 2015. Austar has approval to mine longwalls A9 to A19 in Stage 3, however development operations were temporarily suspended in the Stage 3 area in 2014, causing discontinuity to Stage 3 longwall operations.

Austar returned mining operations to the Bellbird South/Ellalong Colliery areas in June 2015. Following approval of a modification to the Bellbird South consent (DA 29/95 Modification 6) in January 2016, Austar commenced longwall mining in the LWB1-B3 area. Mining has been completed in LWB2 and has commenced in LWB3.

2.3 Environmental Management of Existing Operations

The environmental management of existing operations at the Austar Coal Mine is undertaken within the framework of the Austar Environmental Management Strategy (Austar 2013a) and supporting management plans, the Austar Mining Operations Plan (MOP) (Austar 2016) and the Environment Protection Licence for the mine (EPL 416). This section provides an overview of the environmental management framework at the Austar Coal Mine and its current environmental performance.

2.3.1 Environmental Management and Monitoring

The Austar Environmental Management Strategy (2013a) and supporting environmental management and monitoring plans provide a methodical and integrated approach to fulfilling Austar’s environmental obligations and ensuring the effective ongoing environmental management of the site.

An independent environmental audit of the Austar Coal Mine undertaken in 2014 found that Austar’s Environmental Management Strategy provides a sound basis for the management of environmental aspects of the activities and operations within the Austar Coal Mine (AEMC 2015).

It also found that Austar has generally demonstrated a high degree of compliance with conditions of consent and approval under the Bellbird South consent and Project Approval 08_0111 (AEMC 2015).

Current environmental management and monitoring plans include:

- Environmental Management Strategy
- Environmental Monitoring Program
- Subsidence Management Plans for the Stage 1 and Stage 2 areas including:
  - Property Subsidence Management Plans
  - Public Safety Subsidence Management Plan
  - Infrastructure Subsidence Management Plans
  - Subsidence Monitoring Strategy
- Extraction Plan/Subsidence Management Plan for Stage 3 LWA7 to LWA10 including:
  - Subsidence Monitoring Program
  - Land Management Plan
  - Biodiversity Management Plan
  - Built Features Management Plan
  - Heritage Management Plan
  - Public Safety Management Plan
- Extraction Plan for LWB1-B3 including:
  - Water Management Plan
  - Land Management Plan
  - Biodiversity Management Plan
  - Built Features Management Plan
  - Public Safety Management Plan
  - Subsidence Monitoring Program
- Noise and Vibration Management Plan
- Air Quality and Greenhouse Gas Management Plan
- Site Water Management Plan
- Bushfire Management Plan
- Aboriginal Cultural Heritage Management Plan
- Historic Heritage Management Plan

- Stage 2 Ecological Monitoring Program
- Stage 3 Surface Infrastructure Site – Traffic Management Plan
- Stage 3 Surface Infrastructure Site – Shaft Construction Environmental Management Plan
- Stage 3 Surface Infrastructure Site – Landscape Management Plan Kitchener Surface Infrastructure Site.

Austar's environmental management plans have been prepared and implemented in accordance with the conditions of the Bellbird South consent or Project Approval 08_0111, where appropriate.

Annual review and reporting of environmental performance is provided in the Annual Environmental Management Report (AEMR).

2.3.2 Subsidence Management and Monitoring

The monitoring, management and mitigation of subsidence is an integral component of current mining operations and requirements of the existing Austar Extraction and Subsidence Management Plans.

Austar has implemented a range of subsidence monitoring procedures that have been developed in consultation with overlying landholders and other relevant stakeholders to monitor the impact of the Austar Coal Mine. This includes:

- subsidence monitoring lines to be located as determined as part of the Extraction Plan process
- visual assessment of natural features and items of surface infrastructure before, during and following longwall mining to detect subsidence impacts such as surface cracking, irregularities in the subsidence profile, erosion, changes in drainage patterns or loss of water from drainage structures
- assessment of buildings and other relevant structures by a structural engineer before and after longwall mining
- verification and revision of subsidence predictions as mining progresses.

Verification and ongoing refinement and calibration of the subsidence predictive model are critical components of subsidence management. As the coal resource is extracted, verification of the model is undertaken by assessing measured subsidence against predictions. This monitoring information may then be incorporated into future iterations of subsidence predictions. This allows a continual refinement process for the assessment and management of subsidence impacts as operations progress.

Monitoring of subsidence parameters and subsidence induced impacts for the mining of two LTCC panels in Stage 1 confirmed that observed subsidence levels were within Maximum Predicted Subsidence for those panels. The same observation has been recorded for extraction of LWA3, A4, A5 and A5a in the Stage 2 area; LWA7 and LWA8 in the Stage 3 area; and for LWB2 in the LWB1-B3 area. Surface impacts associated with subsidence within the Stage 1, Stage 2 and LWB1-B3 areas have been minimal and have very rarely required surface remediation works.

The results of the Subsidence Monitoring Program are communicated on a regular basis to a range of stakeholders, including landholders over the mining area, the Austar Community Consultative Committee, infrastructure owners, and relevant Government authorities. In addition, results are regularly provided on the Austar website, and formally reported on an annual basis through the AEMR.

Austar will continue to communicate with relevant stakeholders regarding the subsidence impact assessment, potential subsidence impacts, and the monitoring and management of these impacts (as described in **Section 6.2**).

2.3.3 Austar Mining Operations Plan

Operational aspects of the Austar Coal Mine, including environmental management and rehabilitation, are managed in accordance with the current Austar MOP as amended (Austar 2016), which was approved by the Department of Industry, Division of Resources and Energy (now Department of Planning and Environment - Resources and Energy), in 2016. The current MOP covers all mining operations at the Austar Coal Mine over a seven year period from 2016 to 2023. A new MOP will be prepared and submitted for approval prior to the expiry of the existing MOP. The MOP encompasses all mining activities within the Austar Coal Mine mining leases including:

- underground mining
- activities at Ellalong Drift and Pit Top
- overland transport of ROM coal from Ellalong Drift to Pelton CHPP
- processing and handling of coal at Pelton CHPP
- disposal of tailings to former underground workings
- reject management and emplacement activities
- water management
- use and management of remote infrastructure sites (No. 1, 2, 3, 4, 5 and 6 shafts, the Kalingo site, and the Kitchener Surface Infrastructure Site
- rehabilitation activities.

Review and reporting of Austar's performance against the MOP is provided through AEMRs and inspections by Resources and Energy.

3.0 Description of Proposed LWB4-B7 Modification

Austar proposes to modify the Bellbird South consent to:

- permit the transfer and processing of coal from LWB4-B7 via the existing Bellbird mains, and
- extend the development consent area to encompass the four proposed longwall panels (refer to **Figure 1.3**).

The existing Austar Coal Mine infrastructure is sufficient to support the mining of the four proposed longwalls and there will be no change to surface facilities, approved rates of mining, coal processing and handling or product transport rates as a result of the modification. This additional longwall resource will provide continuity of mining following the completion of LWB3, and with minimal additional mine development will provide access to approximately 3.65 Mt of additional ROM coal.

Austar holds mining authorities CCL728 and CML2 over the LWB4-B7 Modification Area. The LWB4-B7 Modification Area is located entirely within CCL728 and CML2 and no change to Austar's existing mining authorities is required to accommodate the LWB4-B7 Modification (**Section 4.1.2**).

Further detail of the proposed modification is provided in the following sections.

3.1 Proposed Longwalls

LWB4-B7 are located to the southeast of the Bellbird mains in the former Bellbird South / Ellalong Colliery areas (refer to **Figure 1.2**). The depth of cover above LWB4-B7 ranges from approximately 400 to 505 metres, consistent with surrounding underground workings. The approximate dimensions of the proposed longwalls are provided in **Table 3.1**.

Table 3.1 LWB4-B7 Approximate Dimensions

Longwall Panel	Approximate Void Length (m)	Approximate Void Width (m)	Approximate Extraction Height (m)
LWB4	1,125	237	3.4
LWB5	1,105		
LWB6	1,065		
LWB7	725		

3.2 Mining Method

Coal will be extracted from LWB4-B7 using conventional longwall mining techniques.

3.3 Surface Facilities and Infrastructure

Access to LWB4-B7 will be achieved via the existing Bellbird mains and no additional surface facilities or changes to existing surface infrastructure will be required to accommodate the LWB4-B7 Modification.

The proposed modification will utilise the existing and approved Austar Coal Mine infrastructure and facilities to handle, process and transport ROM coal from LWB4-B7.

Rejects (comprising coarse and fine rejects) generated from the processing of LWB4-B7 ROM coal will be managed in a manner consistent with approved rejects management practices. This includes the disposal of rejects in surface emplacement areas and in former underground workings (via pipelines and boreholes), as described in the approved Austar MOP. The LWB4-B7 Modification will generate approximately 0.36 Mt of additional reject material. The total remaining reject disposal capacity (within approved reject emplacement and underground disposal areas) at the Austar Coal Mine is greater than 10Mt, which is more than adequate for the management of rejects to be generated from approved (Stage3 and LWB1-B3) and proposed (LWB4-B7) mining areas.

3.4 Employment

Austar Coal Mine currently employs a workforce of approximately 240 people. The proposed modification will allow for the continued employment of the current workforce and avoid the loss of staff that would otherwise be associated with a significant break in mining continuity at the site.

3.5 Hours of Operation

The underground mining of LWB4-B7 will be undertaken on a 24 hour, seven day a week basis, consistent with the current consent.

3.6 Project Timing

Approval for the LWB4-B7 Modification is sought by the end of August 2017 to provide for certainty of the continuation of mining within Bellbird South mining area of the Austar Coal Mine.

3.7 Project Justification and Alternatives

3.7.1 Business Continuity

The LWB4-B7 Modification provides the opportunity to access and extract additional high quality metallurgical coal resources within an area of historical underground workings which, with relatively minimal development time and cost, will provide mining and business continuity following the completion of LWB3. The LWB4-B7 Modification will therefore maximise resource utilisation at the Austar Coal Mine and enable the efficient and continued use of existing mining services employees, facilities and infrastructure.

3.7.2 Coal Tonnage and Surface Impact

The LWB4-B7 Modification will provide access to approximately 3.65 Mt of additional ROM coal.

As shown in **Figure 1.2,** there has been significant longwall mining undertaken surrounding the LWB4-B7 Modification Area over a long period of time, including most recently the extraction of LWB2 in the southern portion of the LWB4-B7 Modification Area. As a result, the potential subsidence impacts associated with mining in the local area are well understood, and as the proposed longwalls will be extracted from the same coal seam at similar depths as surrounding historical workings, it is expected that subsidence and associated surface impacts from the proposed longwalls will be similar to that previously experienced in adjacent areas and less than that previously experienced in the LTCC extracted areas. Surface impacts associated with subsidence within the surrounding area have been minimal and have very rarely required surface remediation works.

A detailed assessment of the extent and nature of surface impacts associated with the LWB4-B7 Modification has been completed and confirms the subsidence related impacts on the environment and built features will be minimal and are able to be readily managed in accordance with existing management practices for recent operations at Austar Coal Mine (refer to **Section 6.0**).

3.7.3 Efficient Resource Recovery

The LWB4-B7 Modification optimises the efficient use and management of resources through maximising resource utilisation within an area of historical underground workings. The proposed modification can be achieved with minimal additional mine development, will utilise well established surface facilities and will require no changes to existing surface infrastructure.

3.7.4 Ecologically Sustainable Development (ESD)

Austar has identified additional high quality coal within its existing mining leases that can be recovered without having a significant impact on built features or the environment.

The proposed modification has been assessed with consideration of the principles of ESD (refer to **Section 8.3**), including the precautionary principle, intergenerational equity, conservation of biological diversity and valuation and pricing of resources. These principles have been incorporated into the planning and assessment of the LWB4-B7 Modification so as to minimise the potential for serious irreversible environmental damage. This has been achieved through careful project design, identification and assessment of potential impacts, the development of appropriate management and mitigation measures to address identified risks and the implementation of monitoring and reporting mechanisms.

3.7.5 Project Alternatives

Austar has considered the alternative of not proceeding with the proposed LWB4-B7 Modification. Not proceeding with the proposed LWB4-B7 Modification would result in the loss of an additional 3.65 Mt of ROM coal that could be readily accessed with relatively minimal additional development time and cost. It would also result in a significant discontinuity of longwall mining as at least twelve months of development would be required in other approved areas of the mine prior to longwall recommencement. This would represent a significant business interruption for Austar and would lead to loss of employment for a number of mine workers. A significant business interruption would risk business viability in an already marginal economic environment. The alternative of not proceeding with the proposed LWB4-B7 Modification is therefore not considered viable.

4.0 Planning Context

This section provides details of the relevant State and Commonwealth legislation and planning provisions and a discussion of their application to the proposed modification.

4.1 NSW State Legislation

4.1.1 Environmental Planning and Assessment Act 1979

As outlined in **Section 1.0**, a modification to the Bellbird South consent is sought under Section 75W of the EP&A Act.

The Bellbird South consent was granted by the Minister for Urban Affairs and Planning on 14 February 1996 pursuant to section 91 of the EP&A Act and clause 8 of the State Environmental Planning Policy No. 34 – Major Employment prior to the commencement of the (now repealed) Part 3A provisions.

Clause 8J(8) of the *Environmental Planning and Assessment Regulation 2000* provides that:

> *For the purposes only of modification, the following development consents are taken to be approvals under Part 3A of the Act and section 75W of the Act applies to any modification of such a consent …*
>
> *(b) a development consent granted by the Minister under State Environmental Planning Policy No 34—Major Employment-Generating Industrial Development,*

Further, Clause 12 of Schedule 6A of the EP&A Act provides that:

> *Section 75W of Part 3A continues to apply to modifications of the development consents referred to in clause 8J (8) of the Environmental Planning and Assessment Regulation 2000, and so applies whether an application for modification is made before or after the commencement of this clause.*

Accordingly, the Bellbird South Consent is a transitional Part 3A project and may continue to be modified pursuant to Section 75W of the EP&A Act.

Section 75W is therefore the appropriate approval pathway for the LWB4-B7 Modification.

Permissibility

Environmental planning instruments, other than State Environmental Planning Policies (SEPPs), do not apply to projects assessed under Section 75W of the EP&A Act, except as regards to permissibility.

The LWB4-B7 Modification Area is located within the Cessnock local government area (LGA). Hence, the Cessnock Local Environment Plan (LEP) 2011 is relevant to the permissibility of this modification. Under the LEP the LWB4-B7 Modification Area is zoned RU2 Rural Landscape (refer to **Figure 4.1**). Under the LEP, mining is permissible with consent on land zoned RU2.

The permissibility provisions of SEPP (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP) also provide that 'underground mining carried out on any land' is permissible with development consent. Consequently, the proposed modification is permissible with development consent under the Mining SEPP.

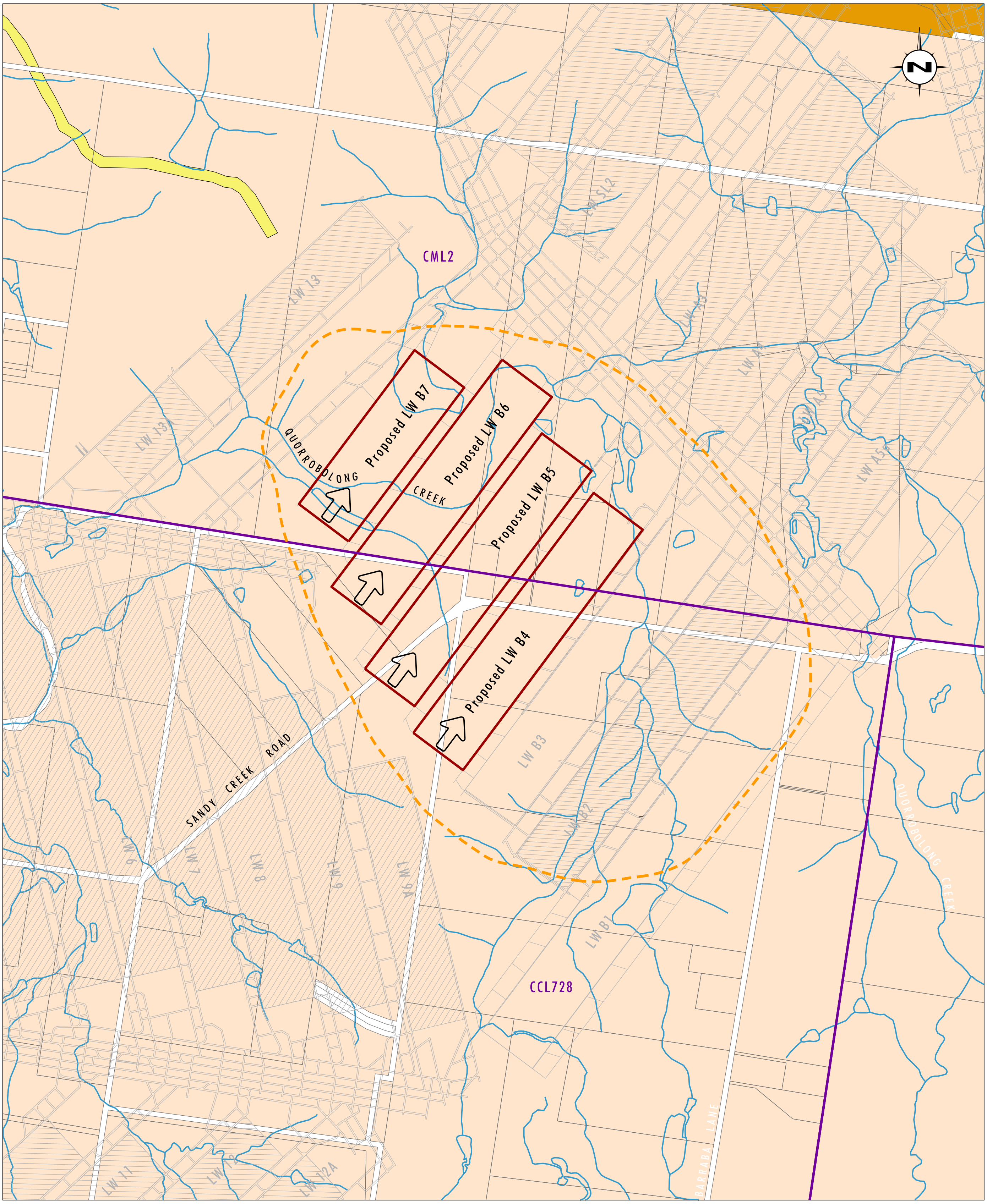

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2015), Cessnock LEP (2011)

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Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Direction of Mining
- Drainage Line
- Cadastral Boundary
- RU2 Rural Landscape Zone (LEP)
- E1 National Parks and Nature Reserves (LEP)
- SP2 Infrastructure (LEP)

FIGURE 4.1

Cessnock LEP 2011 Land Zoning

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4.1.2 Other State Legislation and Environmental Planning Instruments

A summary of the other State environmental and planning legislation potentially relevant to the proposed modification is provided in **Table 4.1**.

Table 4.1 Summary of State Legislation and Relevance to the LWB4-B7 Modification

Act	Comment	Further Approval Required for Proposed Modification
Mining Act 1992	Under this Act a ML is required before any mining or specified mining purpose can be carried out on the land. Austar currently holds mining leases CML2 and CL728 over the LWB4-B7 Modification Area, which provides Austar with the mining rights to the target seam for the proposed LWB4-B7 Modification. All mining operations must be subject to a Mining Operations Plan (MOP) and approved Extraction Plan.	No, however Austar will be required to update the existing approved MOP and Extraction Plan in accordance with the conditions of the existing mining leases
Work Health and Safety (Mines) Act 2013 and Regulation	The *Work Health and Safety (Mines) Act 2013* commenced on 1 February 2015, replacing the Coal Mine Health and Safety Act 2002. The new laws align specific mine safety laws with general work health and safety laws. Under the Act, mine operators are required to notify the regulator of certain high risk activities, including secondary extraction by longwall methods. The approval of the regulator is however not required for these activities.	No, however Austar will be required to notify the regulator of all proposed high risk activities, including secondary extraction.
Protection of the Environment Operations Act 1997 (PoEO Act)	The PoEO Act is administered by the EPA and requires licences for environmental protection including waste, air, water and noise pollution control. Austar currently holds Environment Protection Licence (EPL) 416. No changes to surface operations, noise emissions, dust emissions or surface water management are proposed as a result of the proposed LWB4-B7 Modification.	No.
National Parks & Wildlife Act 1974 (NP&W Act)	An Aboriginal Heritage Impact Permit is required under section 90 of the NP&W Act to harm an Aboriginal object. An assessment of the proposed modifications potential to harm Aboriginal objects is provided in **Section 6.6.**	No, except in the very unlikely event subsidence remediation works are required at the location of the identified Aboriginal sites.

Act	Comment	Further Approval Required for Proposed Modification
Heritage Act 1977 (Heritage Act)	Approval is required under Section 60 of the Heritage Act to disturb an item listed on the State Heritage Register or the subject of an Interim Heritage Order. An excavation permit is required under section 140 to disturb or excavate other heritage items. A very small portion of one locally listed heritage site is partially located within the LWB4-B7 Modification Area, however will not be adversely impacted by the proposed modification.	No
Roads Act 1993	The Roads Act 1993 is administered by Roads and Maritime Services (RMS), local council or the Department of Industry - Lands depending on the classification of the road; the RMS has jurisdiction over major roads, the local council over minor roads, and the Department of Industry - Lands over Crown roads and Crown road reserves. The Act requires that applications for the closure of Crown roads be made to the Minister. Consent under Section 138 of the Roads Act 1993 is required in order to undertake works within a road reserve. Subsidence remediation works may be necessary along sections of Sandy Creek Road and approval for any such works will be required from Cessnock City Council under s138 of the Roads Act 1993. If any works are required, approvals would be obtained prior to such works being undertaken.	Yes, if subsidence remediation works are required within any road reserve
Crown Lands Act 1989	The Act provides for the administration and management of Crown land in the eastern and central divisions of the State. Crown land may not be occupied, used, sold, leased, dedicated, reserved or otherwise dealt with unless authorised by this Act or the *Crown Lands (Continued Tenures) Act 1989*. It is noted that the *Crown Lands Act 1989* will be replaced by the *Crown Land Management Act 2016* on its commencement (anticipated for 2018). The LWB4-B7 Modification Area extends across a parcel of Crown Land along its western boundary. The approval of the Department of Industry - Lands will be sought for any subsidence remediation works required within this area.	Yes, if subsidence remediation works required on Crown Land.

Act	Comment	Further Approval Required for Proposed Modification
Water Management Act 2000	This Act regulates the taking, interception, storage and use of surface water and groundwater within areas subject to water sharing plans. The *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* (Hunter Unregulated and Alluvial WSP) applies to the surface water and alluvial water sources within the Modification Area. The *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016* (North Coast Fractured and Porous Rock WSP) applies to the non-alluvial groundwater sources within the Modification Area. Any water extracted from water sources regulated by a WSP will require licensing under the WM Act. Based on the findings of the subsidence assessment (refer to **Section 6.2**), surface water impact assessment (refer to **Section 6.3**) and groundwater impact assessment (refer to **Section 6.4**), no loss of surface water or water from alluvial or non-alluvial groundwater sources regulated by the WM Act is predicted as a result of the proposed modification. Austar holds sufficient non-alluvial groundwater licences to account for the inception and take of groundwater from the mine workings (refer to **Section 6.4**). Therefore no further water access licences are expected to be required under the WM Act. The following approvals are not required under the WM Act for the proposed modification: water use approval; water management work approval; or activity approval.	No
Water Act 1912	This Act applies to the licensing and regulation of water that is not covered by a water sharing plan under the WM Act. There are no areas of the Austar Coal Mine or Modification Area that are not covered by a WSP.	No
Environmentally Hazardous Chemicals Act 1985	The EPA is granted power under *the Environmentally Hazardous Chemicals Act 1985* to assess and control chemicals and declare substances to be chemical wastes. A licence is required for any storage, transport or use of prescribed chemicals. The modification will not result in any changes to the storage, transport or use of prescribed chemicals.	No

Act	Comment	Further Approval Required for Proposed Modification
Mine Subsidence Compensation Act 1961	Under this Act, the approval of Subsidence Advisory NSW (formerly the Mine Subsidence Board) is required for the erection or alteration of improvements within a mine subsidence district. The erection or alteration of improvements is not proposed as part of the modification. Therefore approval under Section 15 of the *Mine Subsidence Compensation Act 1961* does not apply. It is noted that changes are currently proposed to the mine subsidence compensation process whereby Subsidence Advisory NSW would no longer be responsible for processing claims for subsidence damage from active mines, rather, mining operators would directly compensate property owners for any subsidence damage that they cause. These proposed changes to the *Mine Subsidence Compensation Act 1961* are yet to be enacted. It is further noted that the Austar Coal Mine including the Modification Area is proposed to be included in a new mine subsidence district, however this is yet to be formalised.	No
Dams Safety Act 1978	The *Dams Safety Act 1978* requires that large dams that may constitute a hazard to human life and property must be periodically reviewed by the NSW Dams Safety Committee (to be known as Dams Safety NSW under the *Dam Safety Act 2015*). These dams are known as prescribed dams and are listed in Schedule 1 of the Act. There are no prescribed dams within the LWB4-B7 Modification Area, with the closest being the Austar Coal Mine owned Kalingo Dam approximately 750 metres to the north (refer to **Figure 4.2**). The proposed modification is outside the Kalingo Dam notification area and will not adversely impact the Kalingo Dam. The LWB4-B7 Modification will also not require the construction of any new dams. No approvals will be required under this Act. It is noted that this Act will be replaced by the provisions of the *Dam Safety Act 2015* on its commencement.	No

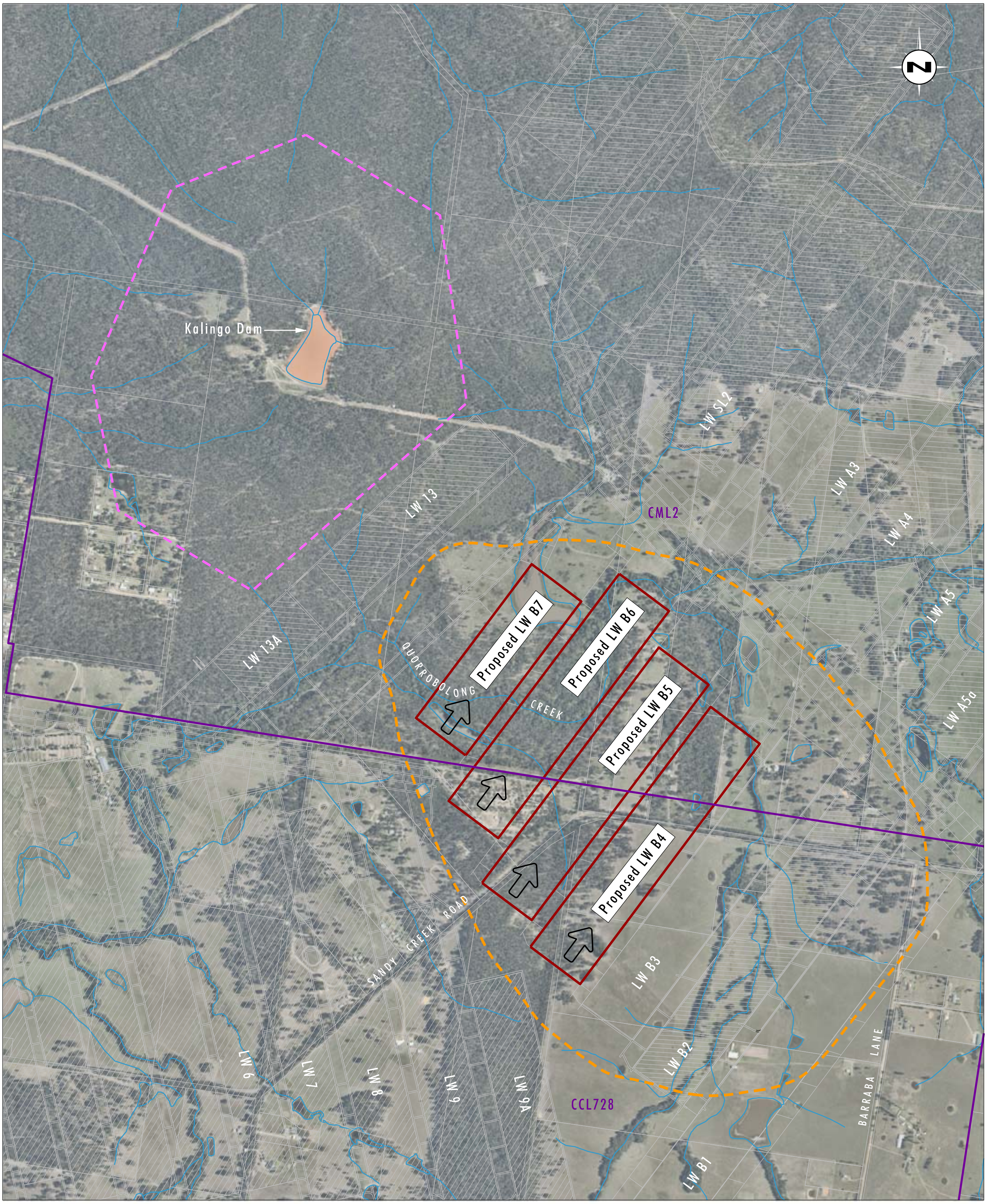

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016), NSW Dam Safety Committee (2008)

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Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Kalingo Dam Notification Area
- Mining Lease Boundary
- Completed Underground Workings
- Direction of Mining
- Drainage Line

FIGURE 4.2

Kalingo Dam Notification Area

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Table 4.2 outlines the relevant SEPPs required to be considered in relation to the LWB4-B7 Modification.

Table 4.2 Relevant SEPPs for Consideration in Relation to the LWB4-B7 Modification

NSW Legislation – Environmental Planning Instruments		
Planning Provision	**Comment**	**Relevance**
State Environmental Planning Policy (State & Regional Development) 2011	The LWB4-B7 Modification is of a class of development listed in the SEPP and would have been categorised as State significant development if s75W did not apply to the proposed modification.	The proposed modification is categorised as State Significant Development but for the application of section 75W of the EP&A Act via schedule 6A of the EP&A Act.
State Environmental Planning Policy (Mining, Petroleum Production & Extractive Industries) 2007	Regulates the permissibility of mining and related development and specifies matters that must be considered in assessing mining developments requiring consent under Part 3A (repealed) and Part 4 of the EP&A Act.	The proposed modification is permissible with consent.
State Environmental Planning Policy 33 (Hazardous & Offensive Development) 1992	SEPP No. 33 requires the consent authority to consider whether an industrial proposal is a potentially hazardous industry or a potentially offensive industry. A preliminary hazard analysis is completed for potentially hazardous development to assist the consent authority to determine acceptability.	The existing Austar Coal Mine operations are not considered as hazardous or offensive. The proposed modification will not result in any changes to the existing operations which would alter this classification. No further consideration of SEPP No. 33 is required.
State Environmental Planning Policy 44 (Koala Habitat Protection)	SEPP No. 44 restricts a Council from granting development consent for proposals on land identified as core koala habitat without preparation of a plan of management.	No core koala habitat has been identified within the LWB4-B7 Modification Area. The provisions of SEPP 44 do not apply and a koala plan of management is not required for the modification.
State Environmental Planning Policy 55 (Remediation of Land)	SEPP No. 55 restricts a consent authority from granting consent for the carrying out of development on land unless the consent authority has considered any potential contamination issues.	No potential contamination issues have been identified within the LWB4-B7 Modification Area.

Table 4.3 outlines the relevance of other NSW strategic policies in relation to the LWB4-B7 Modification.

Table 4.3 Potentially Relevant NSW Strategic Policies

NSW Strategic Policies		
Policy	**Comment**	**Relevance**
Upper Hunter Strategic Regional Land Use Plan	The Upper Hunter Strategic Regional Land Use Plan (Upper Hunter SRLUP) contains the detailed policy direction for assessing and managing strategic land use decisions in the Upper Hunter Valley. The objective of the Upper Hunter SRLUP is to balance the strong economic growth in Regional NSW with the protection of valuable agricultural land and the sustainable management of natural resources. In particular, the Upper Hunter SRLUP seeks to minimise land use conflicts arising from the growth of coal mining activities and the coal seam gas industry. Key to the implementation of the Upper Hunter SRLUP is the assessment of impacts from mining and coal seam gas development on land identified as being strategic agricultural land.	The LWB4-B7 Modification Area is not located within the boundary of the Upper Hunter SRLUP, accordingly this plan does not apply to the LWB4-B7 Modification.
Aquifer Interference Policy	The Aquifer Interference Policy requires mining activities to consider 'Minimal Impact Considerations' with respect to groundwater sources.	Predicted groundwater impacts associated with the LWB4-B7 Modification have been assessed against the Aquifer Interference Policy as part of this EA. This assessment concludes that the proposed modification adequately satisfies the minimal impact considerations for less productive groundwater sources defined by the NSW Aquifer Interference Policy (refer to **Section 6.4**).

4.2 Commonwealth Legislation

4.2.1 Environment Protection and Biodiversity Conservation Act 1999

Under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), approval from the Commonwealth Minister for the Environment and Energy is required for any action that may have a significant impact on matters of national environmental significance.

If an 'activity' is likely to have a significant impact on a matter of national environmental significance then it may be a 'controlled action' and should be referred to the Commonwealth Minister for consideration.

Matters of national environmental significance potentially relevant to the LWB4-B7 Modification are:

- Threatened Species and Ecological Communities
- Migratory Species
- Water Resources.

The water resources trigger relates to the protection of water resources from impacts of coal seam gas and large coal mining projects. According to Significant Impact Guidelines 1.3 prepared by the Department of Environment (2013), an action is likely to have a significant impact on a water resource if there is a real chance or possibility that it will directly or indirectly result in:

- a substantial change to the hydrology of a water resource
- a substantial change in water quality of a water resource.

that is of sufficient scale or intensity as to reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes, or to create a material risk of such reduction in utility occurring.

Detailed assessment of surface water and groundwater resources has been prepared for the LWB4-B7 Modification and is discussed in **Sections 6.3** and **6.4**. These water resources impact assessments were undertaken with consideration of the key aspects of hydrological change listed by the Significant Impact Guidelines 1.3 (Department of Environment 2013).

Detailed ecological assessment has also been conducted and is discussed in **Section 6.5**.

On the basis of the detailed subsidence assessment, water resources assessments and ecological assessment undertaken for the LWB4–B7 Modification, it is considered that the proposed modification will not have a significant impact on any of the matters of national environmental significance listed above. Details of the subsidence, water resources and ecological assessments undertaken for the LWB4-B7 Modification are provided in **Sections 6.2** to **6.5**.

Approval of the LWB4-B7 Modification under the EPBC Act is therefore not required.

4.2.2 Native Title Act 1993

The (NSW) *Mining Act* 1992 must be administered in accordance with the Commonwealth *Native Title Act 1993* (NT Act). The primary effect of the NT Act on mining authorities is to provide native title parties with a 'right to negotiate' prior to the Minister (administering the NSW Mining Act) considering the grant or renewal of the mining authority. The LWB4-B7 Modification Area is completely within existing Austar Coal Mine mining leases (CL728 and CML2) and therefore no new mining authorities are required for the LWB4-B7 Modification.

Further details of registered Native Title Claims relevant to the LWB4-B7 Modification Area are provided in **Appendix 6**.

5.0 Stakeholder Consultation

5.1 Agency Consultation

During the preparation of this EA, the following government agencies were consulted to assist in identifying the matters to be addressed in the EA:

- NSW Department of Planning and Environment (DPE)
- Cessnock City Council
- Department of Planning and Environment - Resources and Energy (DPE - Resources & Energy)
- Department of Primary Industries - Water (DPI Water)
- Office of Environment and Heritage (OEH)
- NSW Environment Protection Authority (EPA).

The proposed approach to the environmental assessment, preliminary findings of relevant studies, and the approach to completing the assessment was confirmed. The approach to preparation of the proposed Extraction Plan and associated management plans was also discussed with DPE-Resources and Energy.

The DPE, Cessnock City Council and DPE - Resources and Energy identified a range of issues for consideration in the assessment of the LWB4-B7 Modification, these are outlined in **Table 5.1**

Table 5.1 Key Environmental and Community Issues

Issue	EA Reference
Surface water ponding impacts	**Section 6.3**
Impacts on private land & infrastructure	**Section 6.2** and **6.8**
Impacts on agricultural use of the land	**Section 6.8**
Impacts on riparian vegetation	**Section 6.5**
Impacts on aquatic biodiversity	**Section 6.5**
Description of landform, objectives of post mining land use and future land use sustainability	**Section 6.8**

5.2 Stakeholder and Community Consultation

Austar maintains close relationships with neighbouring private landholders and nearby communities as part of normal business. As well as operating the Austar Community Consultative Committee, Austar regularly conducts formal and informal consultation with individual residents who live in areas potentially affected by the mine.

Regular correspondence is provided to landholders within the Bellbird South and Stage 3 areas, more recently in the existing LWB1-B3 area, giving updates of underground mining operations and the results of subsidence and environmental monitoring.

The LWB4-B7 Modification Area extends beyond the Stage 2, Stage 3 and LWB1-B3 areas, consequently there are a small number of landowners within the modification area that Austar has not previously had direct contact with. A specific community consultation program has therefore been implemented for the LWB4-B7 Modification in order to introduce these landholders to the operations of the Austar Coal Mine and the details of the proposed modification. This involved correspondence and meetings with individual landholders within the LWB4-B7 Modification Area. Ongoing consultation with affected landholders will be undertaken as part of the Extraction Plan process.

Austar has also provided regular briefings to the Community Consultative Committee and has undertaken consultation with the registered Aboriginal parties as part of preparation of the Aboriginal Cultural Heritage and Archaeological Assessment for the LWB4-B7 Modification (refer to **Appendix 6)**

6.0 Environmental Assessment

6.1 Environmental Risk Analysis

A preliminary environmental risk analysis was undertaken for the proposed modification to identify the key issues that required detailed assessment as part of the EA process.

The LWB4-B7 Modification is for the transfer and processing of coal from four proposed longwall panels and does not include any changes to surface infrastructure or production. The proposed modification will provide access to approximately 3.65 Mt of additional ROM coal. Sufficient capacity exists within existing approved reject emplacement and underground mine workings for the management of rejects generated from approved and proposed (LWB4-B7) mining areas (refer **Section 3.3**). The key issues requiring assessment therefore relate to the potential impacts of subsidence associated with the extraction of LWB4-B7.

The identification of the key environmental issues that require assessment was based on consideration of:

- the scale and potential impact of the modification
- outcomes of the previous and current stakeholder consultation
- the planning and environmental context of the modification
- the findings of the previous environmental impact assessments (Umwelt 2008, 2011, 2013, 2015) and ongoing environmental monitoring of the existing Austar Coal Mine operations.

The outcomes of the preliminary environmental risk analysis are provided in **Table 6.1**. The following sections provide a detailed assessment of the key issues associated with the LWB4-B7 Modification.

Table 6.1 Review of Potential Environmental Impacts of LWB4-B7 Modification

Aspect	Environmental Assessment
Subsidence	The secondary extraction of LWB4-B7 will result in subsidence of the land surface. Based on previous experience of mining at similar depths of cover elsewhere within the Austar Coal Mine, subsidence impacts at the surface are likely to be minimal. A detailed subsidence impact assessment has been undertaken to confirm predicted impacts to built and natural features and inform proposed subsidence management. The subsidence assessment is included as **Appendix 3** and a summary of the findings of the subsidence assessment is provided in **Section 6.2**.
Surface Water Resources	Based on previous experience of mining at similar depths of cover elsewhere within the Austar Coal Mine, the LWB4-B7 Modification is unlikely to cause significant changes to flow regimes, flooding or ponding. However, given the presence of Quorrobolong Creek, its unnamed tributary and farm dams within the LWB4-B7 Modification Area, a review of the potential impacts of the LWB4-B7 Modification on the flooding and drainage regime was undertaken. The existing Austar flood model was amended to incorporate the cumulative effects of the modification. The assessment is included as **Appendix 3** and a summary of the results are provided in **Section 6.3**.

Aspect	Environmental Assessment
Groundwater Resources	Due to the extent of previous mining surrounding the LWB4-B7 Modification Area, the coal seam aquifer is largely depressurised in this locality. No material changes are expected in relation to groundwater impacts as a result of the LWB4-B7 Modification. An assessment of potential impacts of the proposed modification has been undertaken based on a review of the previous groundwater assessment and existing monitoring and impact verification data. The assessment is included as **Appendix 4** and a summary of the findings is provided in **Section 6.4**.
Ecology	The LWB4-B7 Modification will not result in any direct clearing of vegetation, however subsidence, potential subsidence remediation works and associated changes to landform or hydrological regimes have the potential to impact on ecological features within the LWB4-B7 Modification Area. An ecological survey and assessment has been undertaken within the modification area. The ecological assessment is provided as **Appendix 5**, with the results summarised in **Section 6.5**.
Aboriginal Archaeology and Cultural Heritage	Subsidence has the potential to result in surface cracking and changes to landform or hydrological regimes which may require surface remediation works that could potentially impact on archaeological features within the LWB4-B7 Modification Area. An Aboriginal Cultural Heritage and Archaeological Assessment has been undertaken in consultation with Registered Aboriginal Parties. The assessment is provided as **Appendix 6**, with the results summarised in **Section 6.6**.
Historic Heritage	A very small portion of the LWB4-B7 Modification Area is located within the boundary of the locally listed heritage item, being the Collieries of the South Maitland Coalfields/Greta Coal Measures. A Historic Heritage Assessment has therefore been undertaken to identify potential impacts of the modification on this item and any potential items of historic heritage. The assessment is provided in **Section 6.7**.
Land Resources and Agriculture	The LWB4-B7 Modification will result in minor changes to the landform within the LWB4-B7 Modification Area as a result of subsidence. Subsidence impacts on land resources and agricultural use of the land were identified as having a low risk of significant impacts given predicted subsidence is less than previously demonstrated to be compatible with existing land uses within the Austar Coal Mine. Further assessment of potential landform and land use impacts due to subsidence is provided in **Section 6.8**.
Greenhouse Gas	The LWB4-B7 Modification will result in the recovery of approximately 3.65 Mt of additional ROM coal. The extraction of this coal will change the greenhouse gas and energy profile of the existing approved operation, therefore a greenhouse gas and energy assessment has been undertaken to quantify the emissions associated with the modification. The assessment is presented in **Section 6.9**

Aspect	Environmental Assessment
Vibration	Underground mining has the potential to create vibration events as the land subsides. The potential impacts of vibration from mining in the LWB4–B7 Modification Area are considered to be consistent with those previously assessed and approved under DA 29/95 and PA 08_0111. Vibration monitoring will be undertaken to monitor the potential vibration impacts of the LWB4–B7 Modification, subject to landholder access. Additionally, management measures to be implemented for the LWB4–B7 Modification will be consistent with those outlined in the existing Austar Noise and Vibration Management Plan which will be updated where required to include LWB4-B7.
Noise	The LWB4-B7 Modification does not involve any change to existing approved surface facilities, operations or production rates. Subsidence impacts on the land surface from underground mining are not predicted to require significant surface remediation. The LWB4-B7 Modification is therefore not predicted to result in any additional noise impacts. Based on this preliminary assessment, no further assessment of noise impacts has been undertaken.
Air Quality	The LWB4-B7 Modification does not involve any change to existing approved surface facilities, operations or production rates. Subsidence impacts on the land surface from underground mining are not predicted to require significant surface remediation. The LWB4-B7 Modification is therefore not predicted to change air quality impacts associated with existing approved facilities (including coal handling and transportation, ventilation facilities). Based on this preliminary assessment, no further assessment of air quality impacts has been undertaken.
Traffic	No change to existing approved traffic volumes, employee numbers, production levels, coal transport or access arrangements are proposed as a result of the LWB4-B7 Modification. As such no further assessment of traffic impacts has been undertaken.
Visual Amenity	The nature of the modification (i.e. underground longwall mining) and the existing undulating landform means there is very limited potential for visual impacts to occur as a result of the modification. Potential visual impacts are limited to minor changes in terrain associated with subsidence within the LWB4-B7 Modification Area. Based on this preliminary assessment, no further assessment of potential visual impacts has been undertaken.

Aspect	Environmental Assessment
Socio-Economic	There are no proposed changes to employment and no changes to existing surface facilities or operations associated with the LWB4-B7 Modification. Based on previous experience of mining at similar depths of cover elsewhere within the Austar Coal Mine, the proposed modification is also likely to have minimal impact on built and natural features on the surface associated with subsidence and will not cause any serious disruption to existing land uses. The modification is therefore unlikely to result in significant social impacts. By providing for business continuity and extraction of an additional 3.65 Mt of ROM coal, while avoiding reductions in the workforce associated with an extended discontinuity of mining, the LWB4-B7 Modification will have a positive economic benefit. No further assessment has been undertaken.
Waste Management	The proposed modification will not generate any additional waste streams or increase existing waste volumes, therefore no further assessment has been undertaken. As discussed in **Section 3.3**, there is sufficient capacity within approved reject emplacement areas for all approved and proposed mining at the Austar Coal Mine.
Hazard/Risk	Existing operations within the Austar Coal Mine are not considered as hazardous or offensive as they are authorised by an Environment Protection Licence under the PoEO Act. The proposed modification will not result in any changes to the existing operations which would alter this classification, therefore no further assessment has been undertaken.
Rehabilitation	Rehabilitation within the Austar Coal Mine is managed in accordance with the current approved Austar MOP. The MOP provides a detailed description of emplacement areas, emplacement methods, final landform and final land use. The LWB4-B7 Modification will not impact the current rehabilitation targets and objectives described in the MOP. No change to the existing approved rehabilitation measures is considered necessary to accommodate the proposed modification, therefore no further assessment has been undertaken. The MOP will be updated where required to incorporate the LWB4-B7 Modification Area.

6.2 Subsidence

Mine Subsidence Engineering Consultants (MSEC) has undertaken an assessment of the potential incremental and cumulative subsidence impacts of the LWB4-B7 Modification, including predictions of subsidence related ground movements, impacts on natural and built features and management recommendations for preventative measures and monitoring. The assessment is provided in **Appendix 2** and a summary of findings presented below.

6.2.1 Prediction Methodology

MSEC has used the Incremental Profile Method to predict the incremental and total subsidence profiles resulting from the extraction of LWB4-B7. The Incremental Profile Method is based on a series of subsidence prediction curves derived from an extensive subsidence monitoring database from the Newcastle and Hunter Coalfields.

Subsidence predictions were refined using local geological information and the model calibrated using monitoring results from completed longwalls within the Austar Coal Mine. The calibration process found that the Incremental Profile Method provided reasonable, if not slightly conservative, predictions of subsidence when compared to observed subsidence.

6.2.2 Subsidence Predictions

The predicted total subsidence contours following extraction of LWB4-B7 alone are shown in **Figure 6.1.** The predicted total cumulative subsidence contours following the extraction of LWB1-B7 are shown in **Figure 6.2**.

The maximum predicted cumulative subsidence parameters following extraction of LWB1-B7 are provided in **Table 6.2**. Also provided in **Table 6.2** is a comparison of the predicted cumulative subsidence parameters for LWB1-B7 with that of the completed Stage 2 and approved Stage 3 mining areas.

Table 6.2 Maximum Predicted Cumulative Subsidence Parameters for LWB1-B7 and Comparison to Stage 2 and Stage 3 Maximum Predicted Subsidence Parameters

Layout	Maximum Predicted Total vertical Subsidence (mm)	Maximum Predicted Total Tilt (mm)	Maximum Predicted Total Hogging Curvature (km^{-1})	Maximum Predicted Total Sagging Curvature (km^{-1})
LWB1-B7 [1]	1,350	5.5	0.05	0.06
Completed Stage 2 (LWA3-A5a) [2]	1,500	6.0	0.05	0.12
Approved Stage 3 (LWA8 –A19) [2]	1,800	6.5	0.05	0.09

Notes: [1] LWB1-B7 extraction using conventional longwall mining techniques
[2] Stage 2 and 3 extraction using Longwall Top Coal Caving techniques

As shown in **Table 6.2**, the maximum predicted cumulative subsidence from the extraction of LWB4-B7 is less than that predicted to occur within the completed Stage 2 and approved Stage 3 areas.

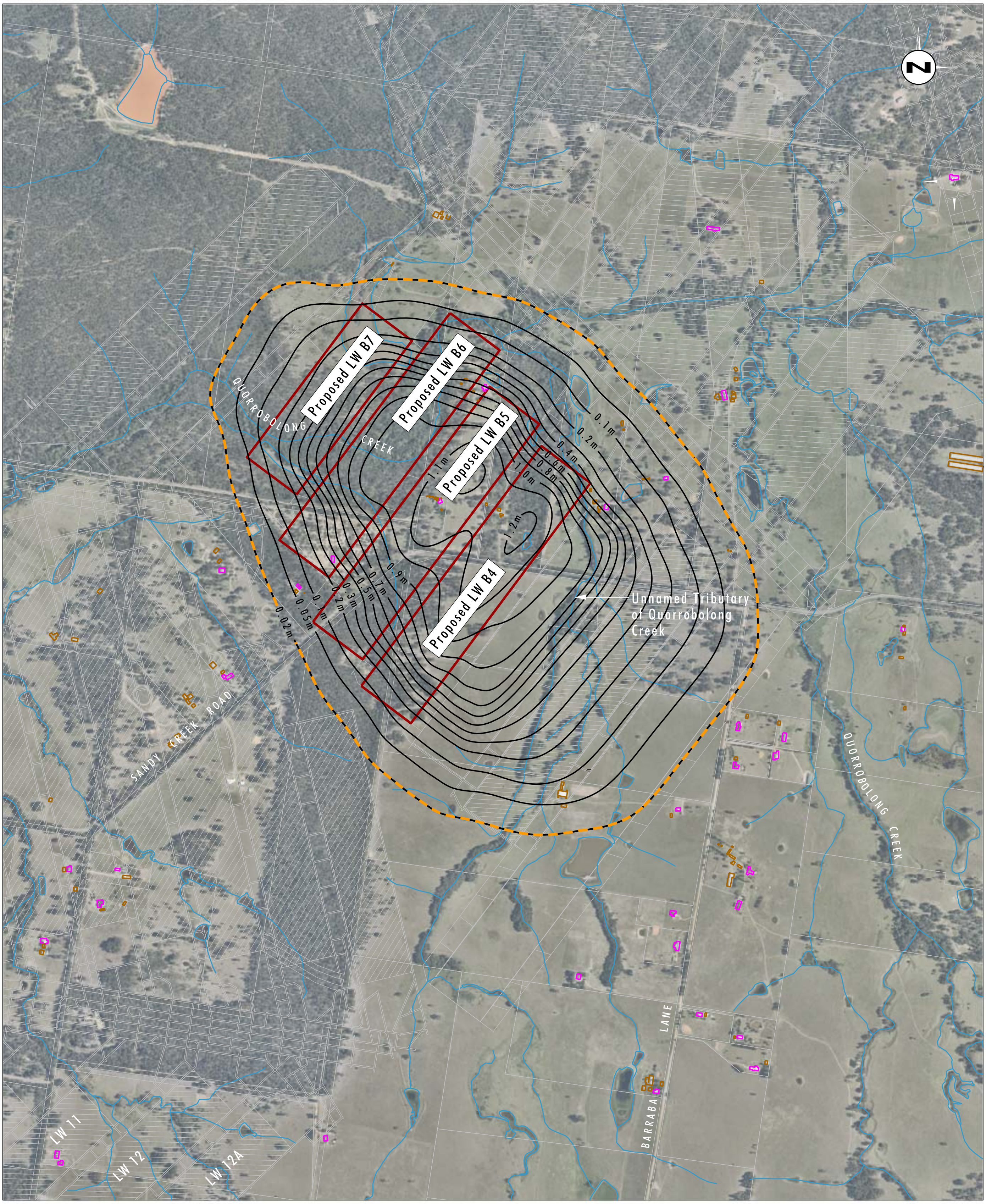


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016), MSEC (2017)
Note: Contour Interval 0.1m unless otherwise marked

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- Subsidence Contour
- Drainage Line
- Dwelling
- Other Structure

FIGURE 6.1

Predicted Total Vertical Subsidence LWB4-B7

File Name (A4): R01/3900_084.dgn
20170515 13.49

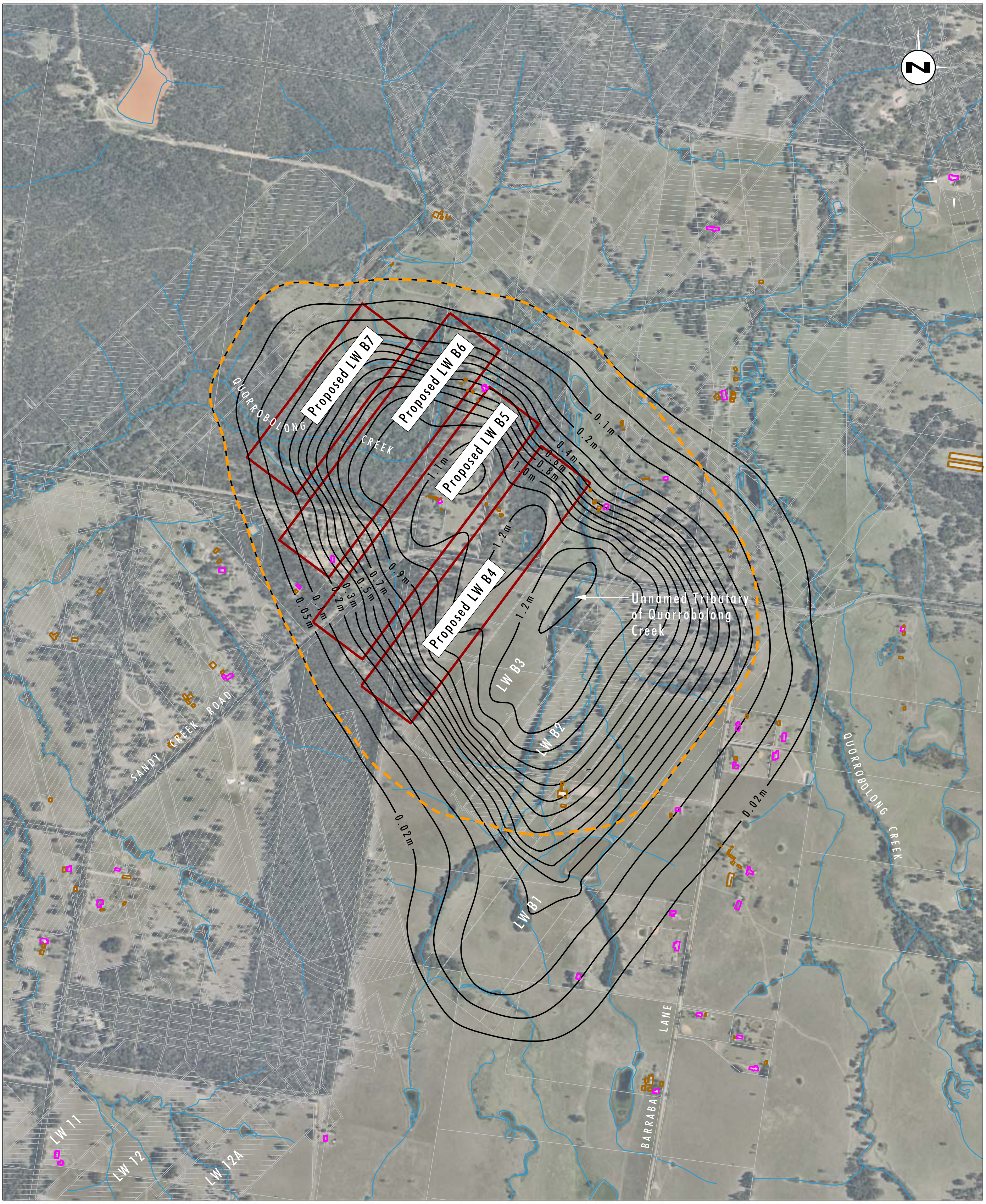


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016), MSEC (2017)
Note: Contour Interval 0.1m unless otherwise marked

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- Subsidence Contour
- Drainage Line
- Dwelling
- Other Structure

FIGURE 6.2

Predicted Cumulative Vertical Subsidence LWB1-B7

File Name (A4): R01/3900_085.dgn
20170515 13.55

6.2.3 Subsidence Impacts

Subsidence induced impacts to the ground surface are dependent on a number of factors, including mine geometry, depth of cover, overburden geology and surface topography. Potential impacts include surface cracking, slope and bank instability and changes to the hydrological regime including changes in ponding, channel alignment, channel gradients and redirection of surface or groundwater flow due to subsidence induced cracking.

Potential changes in the ground surface resulting from subsidence have been assessed by MSEC. The subsidence assessment findings conclude that due to the depth of mining (greater than 400 metres), the small magnitude of predicted ground curvatures and strains and the absence of any steep slopes or cliffs within the modification area, the potential for surface cracking is low.

This is supported by monitoring evidence within the Stage 2, Stage 3 and LWB1-B3 areas, where there has been no significant or visible surface cracking observed above previously extracted LWA3 to LWA8 or LWB2. Subsidence predictions for the LWB4-B7 Modification Area are less than that previously experienced in the LTCC extracted Stage 2 and Stage 3 areas, therefore subsidence impacts are also predicted to be less than those observed within the Stage 2 and Stage 3 areas.

Based on previous experience within the broader Austar Coal Mine, remediation of surface cracking is unlikely to be required within the LWB4-B7 Modification Area. If in the unlikely event that surface cracking does occur, it is expected to be minor and readily remediated by infilling with soil or other suitable material, or, if necessary, by locally regrading and compacting the surface.

The height of discontinuous fracturing above the longwall panels is predicted to be in the order of 235 to 355 metres above the seam. The depth of cover above LWB4-B7 varies between 400 and 505 metres, consequently, it is expected that a constrained zone would develop in the upper section of the overburden, due to the high depths of cover, where vertical fracturing is generally discontinuous and unlikely to result in significantly increased vertical hydraulic conductivity.

A summary of the potential subsidence impacts on key natural and built features within the LWB4-B7 Modification Area is provided in the following sections.

6.2.3.1 Watercourses

Quorrobolong Creek is the main watercourse within the LWB4-B7 Modification Area (refer to **Figure 6.1**). Quorrobolong Creek flows in a westerly direction where it drains to Ellalong Lagoon approximately 3.5 kilometres west of the modification area. Quorrobolong Creek is an ephemeral drainage line, however localised areas of natural ponding occur along its alignment. Approximately 1.3 kilometres of the Creek crosses directly above proposed LWB6 and LWB7. Quorrobolong Creek has an average natural grade of approximately 2 mm/m within the modification area. The LWB4-B7 Modification is predicted to result in a reduction in the creek grade along a 600 metres section of the creek between proposed LWB6 and LWB7. This reduction in creek grade could result in increased potential for ponding within this section of the existing channel (refer to **Section 6.3.3**).

There are also a number of ephemeral drainage lines within the LWB4-B7 Modification Area, the largest being an unnamed tributary of Quorrobolong Creek (refer to **Figure 6.1**). The unnamed tributary of Quorrobolong Creek is located above LWB2, LWB3 and the northern end of LWB4, drains in a northerly direction and has an average natural grade of 6mm/m within the modification area. The post-mining grades along this tributary are similar to the natural grades, therefore is unlikely to experience changes to surface flows such as increased potential for ponding.

Loss of water from these watercourses is not expected as the height of connected or discontinuous fracturing above the longwalls is not predicted to extend to the surface and surface cracking is not predicted to occur. No significant surface cracking or loss of surface water flows has been observed as a result of mining within the existing Stage 2, Stage 3 or LWB1-B3 mining areas. Any surface cracking that does occur within the ephemeral watercourses would tend to be filled naturally by sediment during subsequent flow events.

Further assessment of the potential impacts of predicted subsidence on water resources (surface water and groundwater) is provided in **Sections 6.3** and **6.4**.

6.2.3.2 Groundwater Bores

There are three registered groundwater monitoring bores located within the modification area, one owned by Austar Coal Mine and two owned by DPI Water. It is possible that these bores could experience some impacts as a result of mining, including temporary lowering of the piezometric surface, blockage of the bore due to differential horizontal displacements and changes to groundwater quality. Such impacts, should they occur, can be readily managed by repairing or replacing the bores at the completion of mining.

6.2.3.3 Steep Slopes

No broad areas of steep slopes occur within the LWB4-B7 Modification Area. That is, the natural grades are typically less than 1 in 3, apart from some isolated locations, such as along the banks of drainage lines.

6.2.3.4 Houses

Six privately owned houses are located within the LWB4-B7 Modification Area, of which three are located directly above the proposed longwalls, and one is located directly above approved LWB3.

The potential impacts on houses are dependent on differential subsidence parameters such as tilt, curvature and strain, as opposed to vertical subsidence. Vertical subsidence can affect the heights of houses above the flood level, as discussed further in **Section 6.3**.

The maximum predicted tilt experienced by houses within the LWB4-B7 Modification Area is 5 mm/m, representing a change in grade of 1 in 200. Previous experience from underground longwall mining has found that tilts of less than 7 mm/m generally do not result in significant impacts on houses (MSEC 2017). Therefore houses within the LWB4-B7 Modification Area are not expected to be significantly adversely impacted. Houses may however experience some minor serviceability impacts such as door swings and issues with roof gutter and wet area drainage, which can be readily repaired.

All houses are predicted to remain in a safe and serviceable condition throughout mining.

The maximum predicted curvatures and strains for the houses within the modification area are similar to those predicted for houses above the previously extracted Stage 2 area, where seven houses were mined directly beneath with no substantial impacts reported.

Consistent with the established processes undertaken for the existing LWB1-B3 Extraction Plan and Built Features Management Plan, the management of impacts on private houses will be the subject of an individual Built Features Management Plan to be developed in consultation with each landholder prior to subsidence impacts occurring.

6.2.3.5 Local Roads

Sandy Creek Road and Barraba Lane are located within the LWB4-B7 Modification Area, with sections of Sandy Creek Road passing directly above the proposed longwalls (refer to **Figure 6.1**). Barraba Lane is located approximately 0.7 kilometres east of proposed LWB4. Sandy Creek Road is a sealed local road which links Ellalong to Freemans Drive and Lake Road. Barraba Lane is an unsealed local road which provides access to a small number of private properties.

Based on subsidence predictions, it is unlikely that there would be any adverse impacts (additional to that already approved) on the serviceability, safety or surface water drainage of Sandy Creek Road or Barraba Lane. Predicted subsidence parameters for Sandy Creek Road are similar to or less than those predicted for this road within the Stage 2 and Stage 3 mining area where only isolated and minor impacts to the road surface have been observed, which were remediated using normal road maintenance techniques. Subsidence predictions for Barraba Lane are very low and the road is unlikely to experience adverse impacts as a result of the proposed longwalls.

It is possible that the LWB4-B7 Modification could result in cracking in the culverts beneath Sandy Creek Road for sections located directly above the proposed longwalls, however it is unlikely that this would adversely impact on the stability or the structural integrity of the culverts. This can be managed through visual inspection and if required repair/replacement of the culvert/s.

6.2.3.6 Electrical and Telecommunications Infrastructure

Electrical and telecommunications infrastructure within the proposed modification area include: above ground 11kV powerlines supported by timber poles located adjacent to Sandy Creek Road and Barraba Lane; low voltage powerlines supplying power to rural properties; direct buried copper telecommunications cables following the general alignment of Sandy Creek Road and Barraba Lane; and some aerial connections to houses.

Based on predicted subsidence parameters, infrastructure tolerances and extensive experience successfully mining directly beneath powerlines and telecommunications cables elsewhere within the Austar Coal Mine, it is considered unlikely that electrical or telecommunications infrastructure would experience adverse impacts as a result of the proposed modification.

6.2.3.7 Rural Structures and Land Uses

MSEC has identified 48 rural structures within the LWB4-B7 Modification Area, of which 20 are located above the proposed longwall panels and 14 are located directly above approved LWB1-B3. These structures include farm sheds, garages and tanks. Based on previous longwall mining experience and the magnitude of predicted tilts, MSEC has assessed that significant impacts on rural structures are unlikely. Some minor serviceability impacts could occur at those structures located directly above the longwalls, including door swings and minor roof and pavement drainage, all of which are readily repairable.

It is expected that all rural structures will remain in a safe and serviceable condition, provided they are in sound existing condition. The risk of impact is greater if they are in poor existing condition, however the risk to safety remains low. As outlined in **Section 6.2.4**, rural structures located above the longwalls will be inspected prior to undermining to determine the need for any preventative measures.

With the continued implementation of the existing approved management strategies, it is unlikely that there would be any long term impacts on rural structures and associated rural land uses as a result of the proposed modification.

6.2.3.8 Farm Dams

There have been 24 farm dams identified within the LWB4-B7 Modification Area, of which six are located directly above the proposed longwall panels and 11 are located above approved LWB1-B3. Subsidence can affect farm dams by changing freeboard and storage capacity or by causing cracking and leaking of water. Based on subsidence predictions and extensive experience of mining directly beneath dams both within the Austar Coal Mine and elsewhere in NSW, the potential for impacts on farm dams within the LWB4-B7 Modification Area is expected to be very low.

6.2.4 Subsidence Management and Monitoring

Subsidence within the Austar Coal Mine is currently managed in accordance with a comprehensive range of management measures outlined in approved Subsidence and/or Extraction Management Plans implemented across the Stage 2, Stage 3 and LWB1-B3 mining areas. A key feature of the subsidence management process (as required by recent consent conditions for an Extraction Plan) is a series of Built Features Management Plans for each private landholding and relevant public infrastructure feature potentially impacted by subsidence. Built Features Management Plans outline the potential impacts of mining on the property and the management and remediation measures to be implemented should impacts occur. The key performance objective of the Austar Built Features Management Plan process is to repair, restore or replace built features to pre-mining condition. Individual Built Features Management Plans will be prepared in consultation with relevant stakeholders prior to subsidence impacts occurring on the relevant features.

With the continued implementation of existing monitoring and management measures, it is unlikely that there would be any significant adverse impacts as a result of the LWB4-B7 Modification.

Monitoring and management measures proposed for the LWB4-B7 Modification include:

- Preparation an Extraction Plan for LWB4-B7 for approval by the Secretary of DPE prior to the commencement of secondary extraction of LWB4-B7. The Extraction Plan will incorporate the following management plans:
  - Water Management Plan
  - Land Management Plan
  - Biodiversity Management Plan
  - Built Features Management Plan
  - Heritage Management Plan
  - Subsidence Monitoring Program
  - Public Safety Management Plan.
- Where a potential subsidence impact is identified on private property, Austar will prepare a Built Features Management Plan in consultation with the property owner. This plan will clearly outline potential impacts of mining on the property and the management and remediation measures to be implemented.

- Subsidence management measures to be implemented as part of the proposed modification (where access to private landholdings allow) will include:
  - subsidence monitoring lines to be located as determined as part of the Extraction Plan process
  - visual assessment of natural features before, during and following mining to detect any subsidence impacts such as surface cracking, irregularities in the subsidence profile, erosion, changes in drainage patterns or loss of water from drainage structures
  - detailed subsidence monitoring in accordance with DPE - Resources and Energy requirements
  - remediation and rehabilitation of subsidence impacts will be carried out, where required, as soon as practicable following subsidence using methods specified in the Extraction Plan
  - building structures located within the LWB4-B7 Modification Area will be inspected by a structural engineer prior to and after undermining and appropriate management measures implemented
  - farm dams or water bores within the LWB4-B7 Modification Area will be monitored during and following undermining to ensure they remain in a safe and serviceable condition
  - in the event of any significant loss of water from a privately-owned farm dam, Austar will provide an alternate source of water, as required, until the dam is repaired.
- Austar will, prior to undermining of Sandy Creek Road, prepare and implement a Built Features Management Plan to manage any subsidence impacts on the roads and associated culverts in consultation with Cessnock City Council.
- Austar will prepare and implement a Built Features Management Plan with DPI Water to manage any subsidence impacts on DPI Water monitoring bores in consultation with DPI Water.
- Austar will prepare management plans in consultation with relevant service providers (Ausgrid, Telstra), for the protection of infrastructure and services within the LWB4-B7 Modification Area to ensure these remain in a safe and serviceable condition throughout the mining period. These plans will be prepared as part of the Extraction Plan prior to undermining of the services.

6.3 Surface Water and Drainage

An assessment of the impacts of the LWB4-B7 Modification on the local flood and drainage regime has been undertaken by Umwelt. The assessment is provided in **Appendix 3** and a summary of findings presented below.

6.3.1 Surface Water Context

The LWB4-B7 Modification Area is located within the catchment of Quorrobolong Creek. Quorrobolong Creek drains in a westerly direction through the northern portion of the LWB4-B7 Modification Area (refer to **Figure 6.3**). Quorrobolong Creek is ephemeral with localised areas of natural ponding occurring along its alignment. Quorrobolong Creek has been previously undermined within the Ellalong Colliery and Stage 2 mining areas at the Austar Coal Mine, with a total length of approximately 4 kilometres located directly above these previously extracted longwalls.

Monitoring of these previously extracted longwalls has shown no significant surface cracking or loss of surface water flows within Quorrobolong Creek or its tributaries as a result of mining.

An unnamed tributary (4th order) of Quorrobolong Creek, which includes a number of secondary drainage channels, drains in a northerly direction through the LWB4-B7 Modification Area above LWB2, LWB3 and LWB4, converging with Quorrobolong Creek upstream of LWB5 (refer to **Figure 6.3**). A large ponded farm dam water body is located to the north of the main channel of Quorrobolong Creek above LWB7 (refer to **Figure 6.3**). This feature is located within the floodplain of Quorrobolong Creek and overflows to the main channel. A 1st order drainage line also traverses above LWB6 and LWB7 and includes an ephemeral ponded area adjacent to Quorrobolong Creek above LWB7 (refer to **Figure 6.3**). This drainage line acts as an overland flow path for Quorrobolong Creek during high out of bank flows. Like Quorrobolong Creek, the unnamed tributary and the 1st order drainage line are ephemeral watercourses, with flows only occurring as a result of prolonged or high rainfall periods.

6.3.2 Flood Modelling Methodology

The primary aim of the flood and drainage assessment was to determine the potential impacts of the proposed extraction of LWB4 to LWB7 on the flood and drainage behaviour of the surrounding area, including cumulative impacts to the estimated flood behaviour in relation to the previously approved LWB1-B3, Stage 2 and Stage 3 mine plans.

A two dimensional (2D) hydrodynamic model previously developed for Austar Coal Mine was used to assess the potential impacts of the LWB4-B7 Modification. The model was modified to incorporate the predicted subsidence expected as a consequence of the mining operations proposed in the LWB4-B7 Modification. This included the cumulative impacts of subsidence from the earlier approved mining stages.

Consistent with previous studies (Umwelt 2007, 2008a, 2010, 2011a, 2012, 2013 and 2015a), the 100% and 1% Annual Exceedance Probability (AEP) design storm events were assessed. In addition, the scope of modelling for this assessment was expanded to include the 5% AEP storm event and the Probable Maximum Flood (PMF) event.

Modelling was undertaken to assess the cumulative impact of the proposed modification on flooding and drainage, for the following scenarios:

1. Approved mining scenario (incorporating all approved underground mining within the Stage 2 and 3 areas, being LWA3 to A19 and LWB1-B3); and

2. Proposed mining scenario (incorporating all approved underground mining in addition to the proposed LWB4-B7 Modification).

Based on the modelling outcomes, the following potential impacts of the proposed modification were assessed against approved impacts:

- Changes to flood regimes, including impacts on flood prone land, creek channels, flow paths and remnant ponding
- Changes to flood depths (in channel and out of channel)
- Impacts on scouring and erosion due to changes in flow velocities
- Changes to freeboard at dwellings, and
- Flood hazard categories for dwellings and private property access routes.

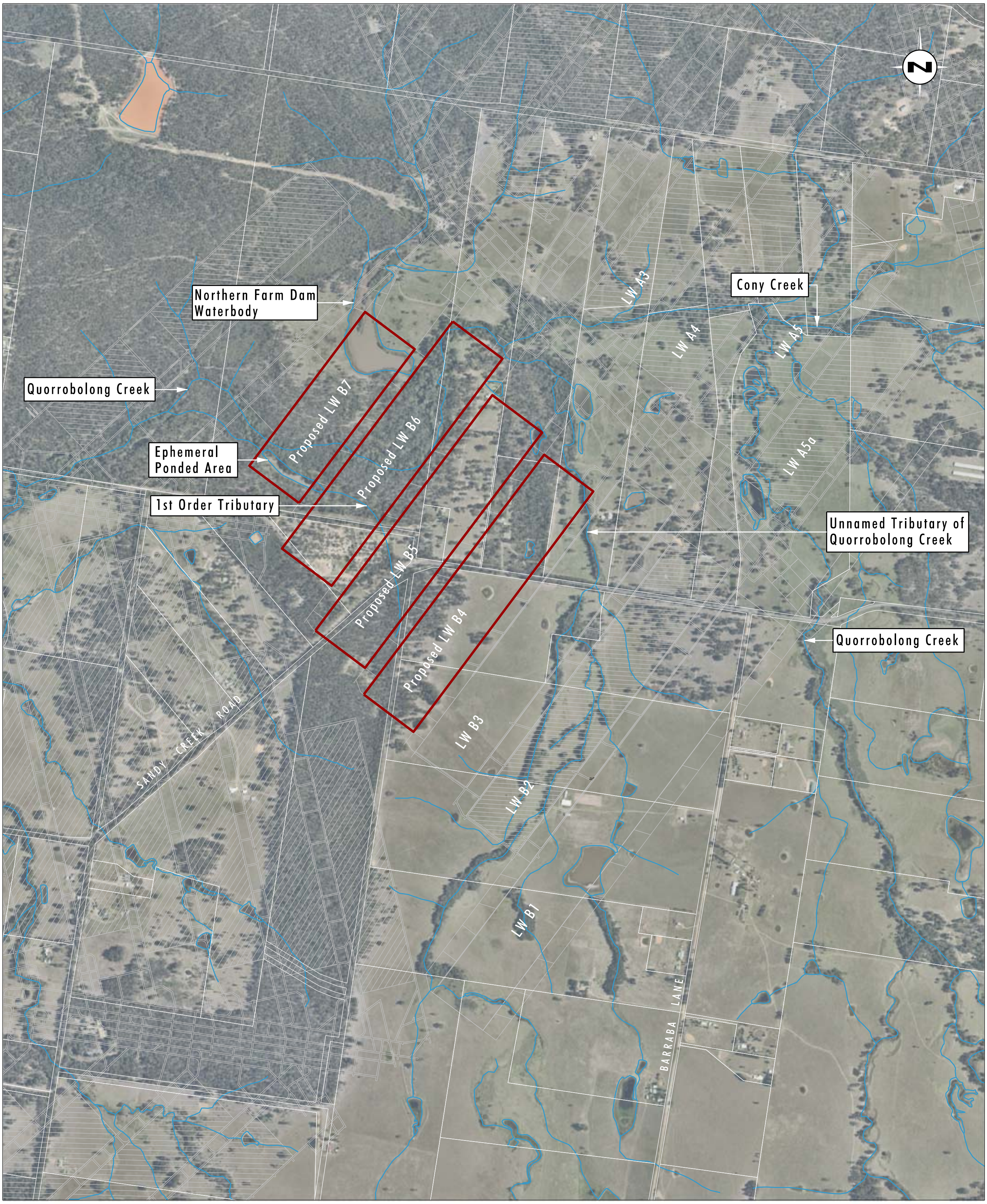


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend
- Proposed LWB4-B7 Longwall Panels
- Completed Underground Workings
- Drainage Line

FIGURE 6.3

Surface Water Context

6.3.3 Impact Assessment

Modelling indicates that the potential impacts on flooding and drainage associated with LWB4-B7 are generally limited in extent to the LWB4-B7 Modification Area. A description of the outcomes of the model in relation to changes in flood regimes, flow velocities, flood depths at dwellings and flood hazard categories are provided in the following sections.

6.3.3.1 Changes to Flooding Regimes

Flood model hydrographs on Quorrobolong Creek immediately downstream of the unnamed tributary and downstream of LWB4-B7 (refer to **Appendix 3** – Figures B13 and B14) are comparable to the flood hydrographs derived previously for the approved mining scenario, indicating that the proposed modification will have negligible effect on the flood response downstream of the mining area during the 100%, 5% and 1% AEP and PMF storm events.

The flood modelling analysis indicates that the proposed modification is unlikely to have a significant impact on the flow regimes of Quorrobolong Creek or its unnamed tributary, with only minor changes predicted in runoff regimes and peak discharges.

Based on the maximum predicted cumulative subsidence associated with the extraction of LWB1 to LWB7, the maximum predicted changes in longitudinal channel grade compared to the approved mining scenario channel conditions are minor and lie within the natural variations in longitudinal grades of the drainage channels within the Quorrobolong Valley. It is therefore considered that the proposed modification will not significantly alter the flow capacity, stream velocities or channel alignment relative to the existing ranges within the channels.

There are predicted to be minor changes to the extent of remnant surface ponding in the LWB4-B7 Modification Area (refer to **Figure 6.4**). The predicted impacts on remnant ponding are primarily confined to existing flow paths, paddocks and farm dams, with no predicted impact on access routes to, or within, the properties along Quorrobolong Creek or its unnamed tributary. As shown on **Figure 6.4,** an increase in the extent of remnant ponding is predicted to occur along an overflow channel south of Quorrobolong Creek at the southern end of LWB6 and LWB7 on Austar owned land. Analysis indicates ponding up to 0.5 metres deeper may occur on the overflow channel, extending 100 metres to 125 metres further upstream. An assessment of the potential ecological impacts of this change in remnant ponding is provided in **Section 6.5.2**.

6.3.3.2 Changes to Flood Depths

Modelling indicates that the extraction of LWB4-B7 will result in increased flood depths where the longwalls intersect the central drainage channels of the unnamed tributary of Quorrobolong Creek and the main channel of Quorrobolong Creek for all modelled storm events (100%, 5%, 1% AEP and PMF). Modelling predicts increases to flood depths within the channel of Quorrobolong Creek downstream of the Cony Creek junction (refer to **Figure 6.5**). Minimal changes in peak flood depths are predicted within the channel of Quorrobolong Creek upstream of the Cony Creek junction. Along the unnamed tributary, the modelling predicts increases in channel flood depths within the LWB4-B7 Modification Area in areas both upstream and downstream of Sandy Creek Road in all modelled storm events (100%, 5%, 1% AEP and PMF).

In addition, there are predicted increases and decreases in out of channel flood depths above the southern end of LWB6 and LWB7 in the catchment of Quorrobolong Creek and above the northern end of LWB4 in the catchment of the unnamed tributary (refer to **Figure 6.5**).

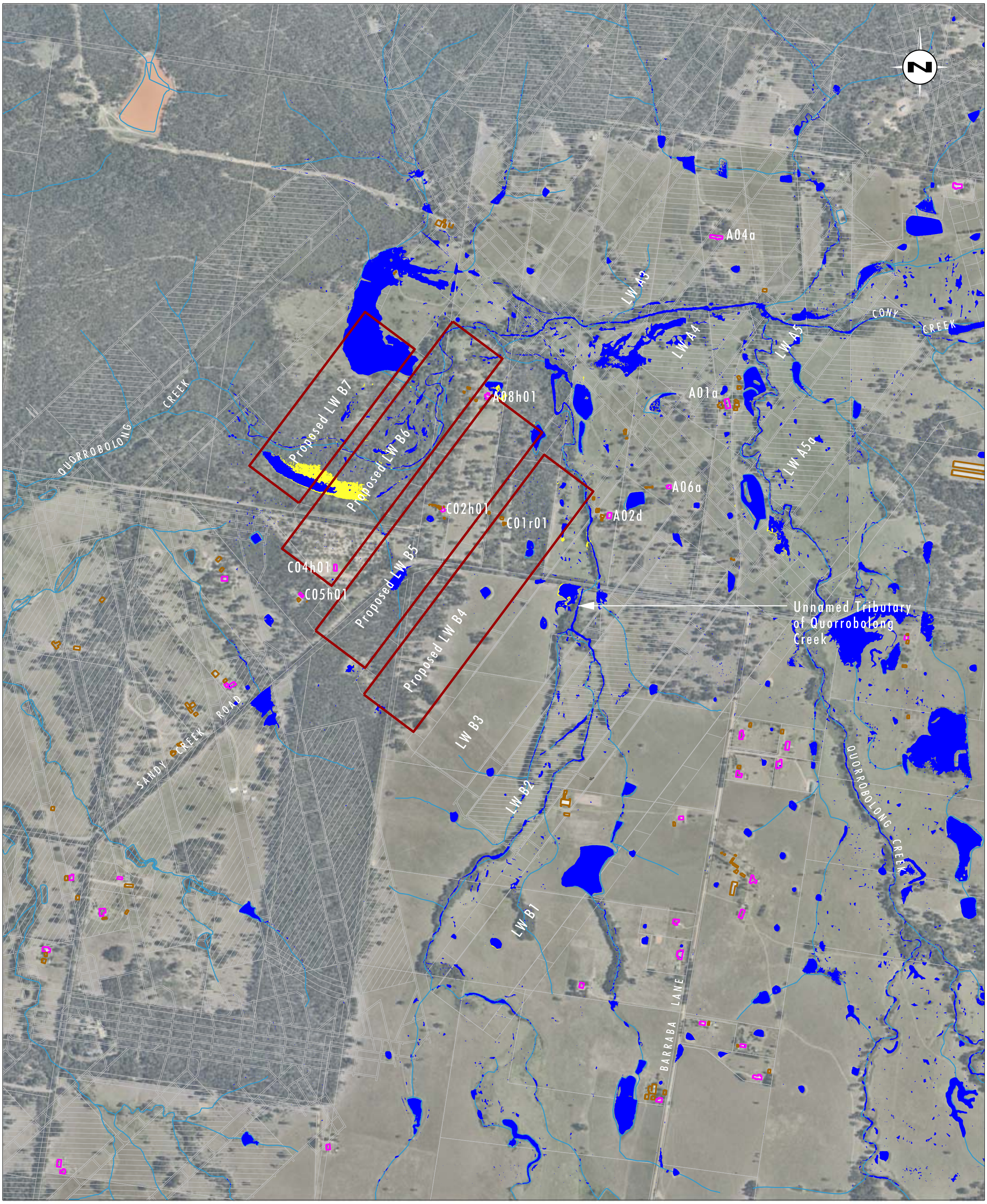


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017), MSEC (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Completed Underground Workings
- Dwelling
- Other Structure
- Remnant Ponding Approved Mining Scenario
- Remnant Ponding Proposed Mining Scenario

FIGURE 6.4

Remnant Ponding Comparison of Approved and Proposed Mining Scenario

File Name (A4): R01/3900_087.dgn
20170515 14.05

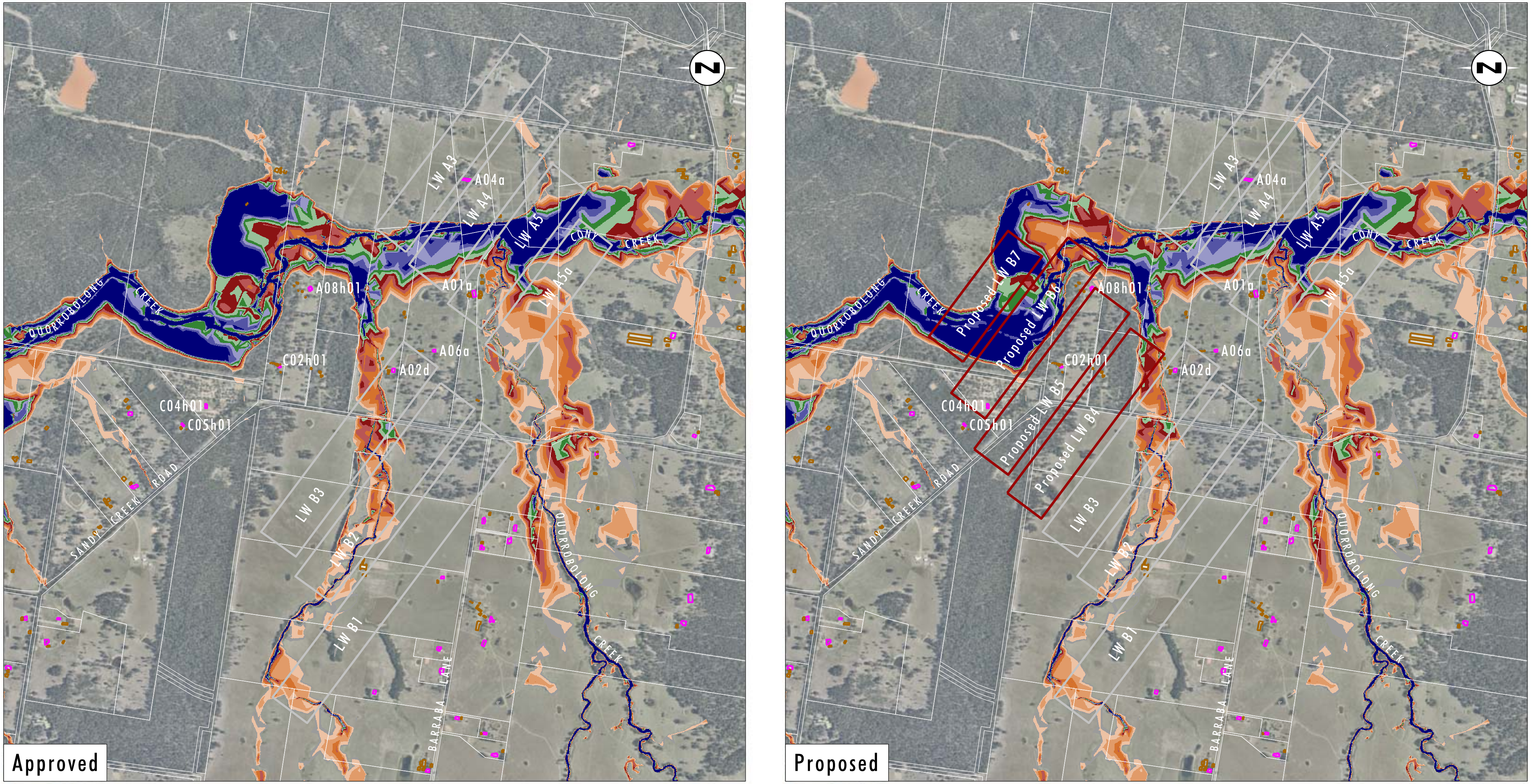


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017), MSEC (2017)

0 0.5 1.0 1.5km
1:30 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-5a and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE 6.5

Maximum Modelled Flood Depth for 1% AEP Storm Event

File Name (A4): R01/3900_086.dgn
20170515 14.15

6.3.3.3 Changes to Flow Velocities

The modelling indicates that with the LWB4-B7 Modification the flow velocities in Quorrobolong Creek and the unnamed tributary will have localised increases and decreases for all modelled storm events.

Modelling also indicates that the absolute maximum and minimum peak flow velocities along both Quorrobolong Creek and the unnamed tributary with the proposed modification will remain within similar ranges to those modelled for the approved mining scenario.

Based on a review of site inspection photographs and analysis of the modelling results, the calculated tractive stresses for the proposed modification lie within the ranges modelled for Quorrobolong Creek and the unnamed tributary for the approved mining scenario. As such it is considered that the changes to velocities and tractive stresses are within the natural capacity/variability of the creek system.

Modelling indicates that the absolute maximum and minimum peak flow velocities out of channel for both Quorrobolong Creek and the unnamed tributary with the proposed modification will remain similar to those modelled for the approved mining scenario. As such, similar to in channel flows above, it is considered that the maximum flow velocities will remain within non-scouring ranges for the 100%, 5% and 1% AEP storm events and the PMF event, as a result of the LWB4-B7 Modification.

6.3.3.4 Changes to Freeboard at Dwellings

Modelling indicates there will be some changes (both increases and decreases) to the freeboard at ten dwellings during the 1% AEP flood event and/or PMF event, however there will be no flooding of dwellings. Modelling indicates that no dwellings will have their freeboard reduced below the flood planning level (1% AEP flood event plus 500 mm freeboard) as a result of the LWB4-B7 Modification.

6.3.3.5 Flood Hazard Categories

The modelled changes to flood hazard categories and flood extents as a result of the LWB4-B7 Modification are considered to be negligible (refer to **Figure 6.6**). No access routes to private properties will be adversely affected as a result of the proposed modification for the 1% AEP flood event. A small portion of the existing access route to one dwelling may be inundated during the PMF event, however the dwelling will remain flood free and will not be isolated. In addition, there is an existing alternate access from this dwelling to Sandy Creek Road which mitigates this potential impact.

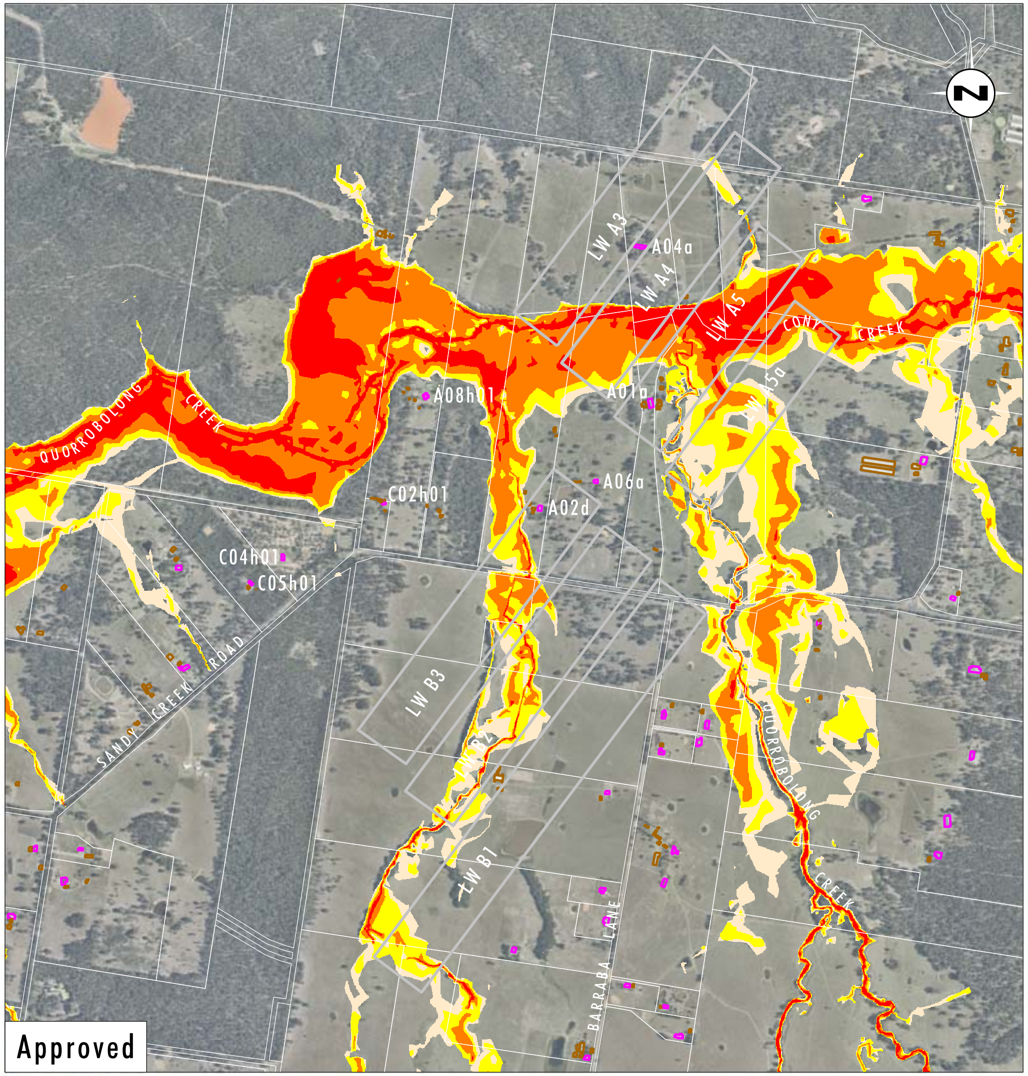
Analysis of the flood modelling results indicates no changes will occur to the flood hazard category at Sandy Creek Road during the 1% AEP or PMF storm event, with the road remaining impassable to vehicles during either event. The analysis also indicates that the flood hazard category will decrease from the “vehicles unstable” category to “walking and vehicle access” for the 5% AEP storm event under the proposed mining scenario.

In addition, modelling predicts a decrease in the duration when Sandy Creek Road is flooded:

- from approximately 3 hours 25 minutes to approximately 2 hours 40 minutes with the proposed modification during the 5% AEP storm event

- from approximately 4 hours 45 minutes to approximately 4 hours 15 minutes with the proposed modification during the 1% AEP storm event, and

- from approximately 25 hours 25 minutes to approximately 23 hours 50 minutes with the proposed modification during the PMF event.



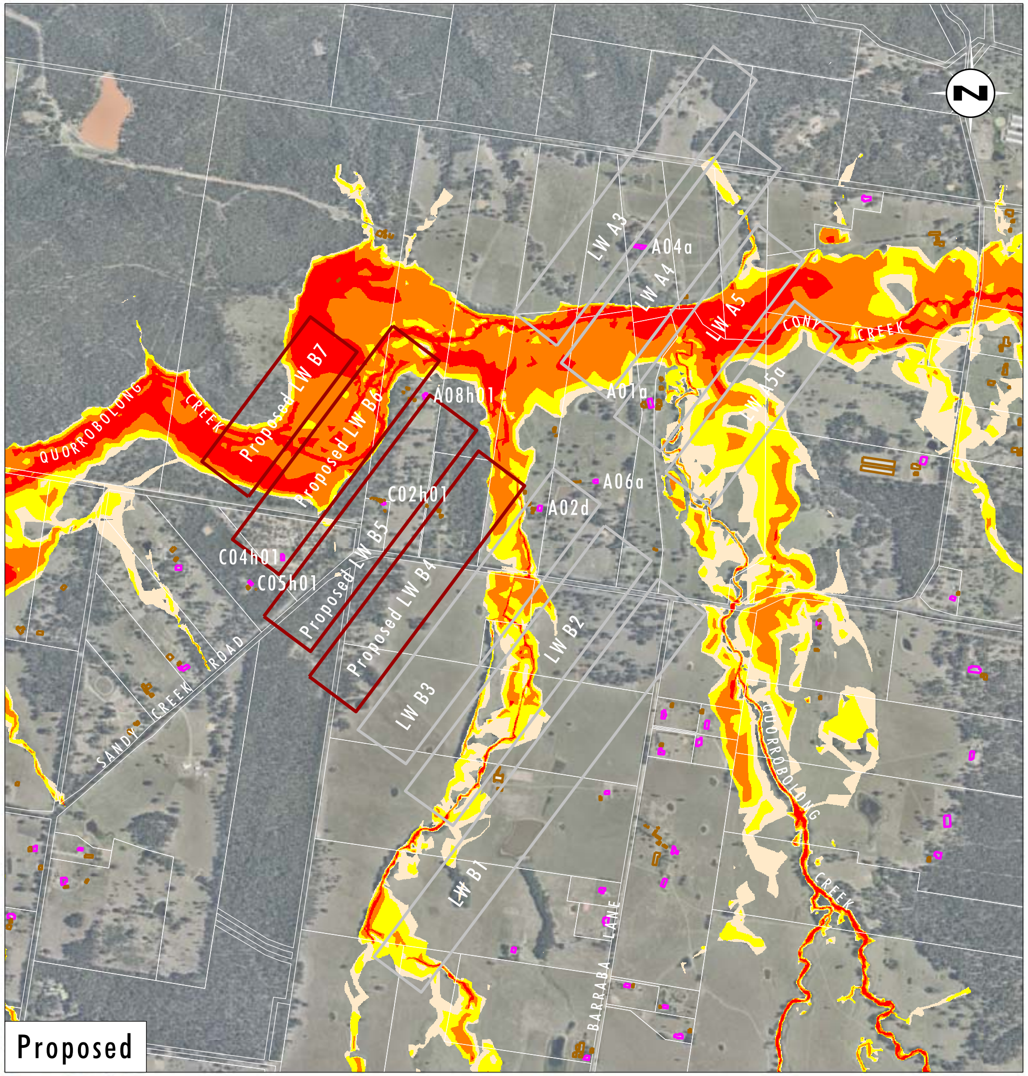


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017), MSEC (2017)

0 0.5 1.0 1.5km
1:30 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-5a and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE 6.6

Maximum Flood Hazard Category for 1% AEP Storm Event

6.3.4 Surface Water Management and Monitoring

Austar currently implements a range of surface water management and monitoring measures across the Austar Coal Mine, as outlined in the Austar Site Water Management Plan (Austar 2013b). Previous experience of mining in this locality has not identified any adverse impacts on watercourses associated within underground longwall mining. There has also not been any scouring or erosion issues observed within or surrounding watercourses associated with previous mining.

The main area that is likely to be affected by changes to the flood response under the proposed mining scenario is the section of Quorrobolong Creek downstream of the junction with Cony Creek, from the northern most end of LWB6 downstream to the southernmost end of LWB7, with changes predicted to both peak flood depths and flow velocities. To ensure there are no significant impacts as a result of velocity induced scouring or erosion, a channel stability monitoring program will be implemented in those reaches where velocity and tractive stress changes have been predicted by the modelling.

Austar will prepare a Water Management Plan to address potential impacts to the water resources within the LWB4-B7 Modification Area as part of the Extraction Plan process, which will include an appropriate surface water and channel stability monitoring program.

6.4 Groundwater

A comprehensive groundwater assessment for the Austar Coal Mine was prepared by Ian Forster of Connell Wagner in October 2007. This assessment is supported by a verification review of groundwater impacts following the completion of LWA5 in the Stage 2 mining area undertaken by Aurecon in 2013, and by groundwater monitoring undertaken within the Stage 2 and Stage 3 mining areas.

While the LWB4-B7 Modification is not expected to result in any material changes in relation to groundwater impacts from those described for previous mining within the Austar Coal Mine, a qualitative assessment of potential impacts of the proposed modification has been undertaken by Dundon Consulting Pty Limited. The Groundwater Assessment includes a description of the existing hydrogeological environment, the potential impacts of the LWB4-B7 Modification, the groundwater licensing requirements and recommended groundwater management and monitoring measures. The Groundwater Assessment is provided in **Appendix 4** and a summary of the findings is presented below.

6.4.1 Existing Groundwater Resources

The main sources of water that make up the groundwater regime within the Austar Coal Mine and surrounding area are:

- the localised alluvial aquifer system associated with Quorrobolong Creek and its tributaries
- non-alluvial hard rock aquifers comprising principally of the coal seams and to a lesser extent, fractured zones within the upper parts of the Branxton Formation, and
- water stored within previous underground mine voids.

Groundwater within the alluvial aquifer in the LWB4-B7 Modification Area is part of the Congewai Creek Management Zone of the Upper Wollombi Water Source and is regulated by the *Water Management Act 2000* under the Hunter Unregulated and Alluvial WSP.

The non-alluvial groundwater is regulated under the North Coast Fractured and Porous Rock WSP.

6.4.1.1 Alluvial Aquifer System

The alluvial aquifer system comprises very poorly developed alluvial deposits within the floodplain of Quorrobolong Creek and its tributaries. The estimated areal extent of the alluvial deposits associated with Quorrobolong Creek is shown on **Figure 6.7**. Quorrobolong Creek and its tributaries comprise a series of ephemeral drainage lines which only flow after consistent or heavy rainfall. The alluvium associated with these surface drainage features in the vicinity of the LWB4-B7 Modification Area is generally shallow and low yielding (Connell Wagner, 2007).

Austar has installed four shallow monitoring bores (AQD1073, WBH1, WBH2 and WBH3) in the vicinity of Quorrobolong Creek to the northeast of the LWB4-B7 Modification Area and one shallow monitoring bore (MB03) in the vicinity of the unnamed tributary of Quorrobolong Creek within the LWB4-B7 Modification Area (refer to **Figure 6.7**). Bore logs confirm that the alluvial aquifer associated with Quorrobolong Creek and its tributaries is limited in extent and depth. The groundwater quality is variable, and is susceptible to elevated salinities in periods of low or no rainfall recharge.

The alluvial water source has limited potential for beneficial use as a water supply for stock, domestic or other consumptive purposes and there are no known users of the alluvial water source within or surrounding the LWB4-B7 Modification Area.

6.4.1.2 Non Alluvial Hard Rock Aquifer System

'Porous rock' aquifers within the Permian hard rocks in the vicinity of the LWB4-B7 Modification Area are limited to the Branxton Formation and the Greta Coal Seam.

The Branxton Formation comprises a thick sequence of sedimentary rock overlying the Greta Coal Measures. Due to the strong and massive nature of the sandstone within the Branxton Formation and its very low interstitial permeability ($<10^{-3}$ m/d), there are few if any major water bearing zones present. Nevertheless, zones of jointing or fracturing associated with major faults may form localised aquifers. Further, shallow water bearing zones have been locally identified to occur within the first 100 metres of this formation. The formation has very low vertical permeability, and there is very little potential for leakage between any water-bearing zones or aquifers.

The importance of the shallow water bearing zones of the Branxton Formation as a water source is likely to be minimal as the water quality is poor (generally greater than 10,000 μS/cm EC) and low yielding (generally less than 1 L/s). One private stock bore (registered bore GW054676) that sought to target the shallow water bearing zones of the Branxton Formation within the modification area has been filled in because it was considered by the landowner to have no beneficial use value due to its low yield of saline groundwater.

The coal seams represent the main water bearing zone within the Greta Coal Measures due to the presence of cleats and fractures in the coal which make them more permeable when compared to the interburden strata. However, the importance of the Greta Coal Seam as an aquifer is generally minimal due to the poor water quality and limited yield potential.

6.4.1.3 Water Stored in Former Mine Voids

There are a number of former mine workings (voids) within the area surrounding the Austar Coal Mine that are partially filled with water. Austar currently utilises some of these voids to store excess mine water in accordance with water management strategies described in the approved Austar Site Water Management Plan. The quality of water within these old mine workings is extremely poor and has limited beneficial use potential.

6.4.2 Groundwater Assessment Methodology

As shown by **Figure 1.2**, the proposed LWB4-B7 panels are completely surrounded by interconnected longwall panel areas of the Austar Coal Mine. Due to the extent of surrounding mine workings, and, in particular the location of LWB1-B3 immediately to the south and downdip of the proposed LWB4-B7 panels, there will be minimal groundwater remaining within the Greta Seam in the location of LWB4-B7, with this area already substantially depressurised following the extraction of LWB2 and LWB3.

Consequently, the additional impacts from the proposed modification overall are anticipated to be quite small. No increase in groundwater inflows is anticipated, and all water takes would be able to be accounted through existing licensing held by Austar. No adverse impacts on the alluvial groundwater have been observed to date, including the main alluvial floodplain of Quorrobolong Valley which directly overlies extracted longwall panels LWA3 to LWA5a, where monitoring bores have shown no change to groundwater levels associated with the mining of these four panels.

Accordingly, as there have been no adverse impacts on groundwater from mining to date, and due to the substantial depressurisation of the Greta Seam in this location, the incremental impacts associated with the proposed modification are expected to be negligible. On this basis, Dundon Consulting Pty Limited considered that the use of a numerical groundwater model was not warranted for the proposed modification. This is further supported by a consideration of the expected magnitude of incremental impacts due to the proposed modification, as discussed in the following sections, which are considered to be of a similar order or less than the typical uncertainty range associated with numerical groundwater models. Consequently, Dundon Consulting Pty Limited used an empirical approach to assess the groundwater impacts of the proposed modification, as used for previous impact assessments undertaken for Austar Coal Mine.

The incremental impacts associated with the proposed modification are discussed in the following sections.

6.4.3 Groundwater Impact Assessment

The LWB4-B7 Modification will extract coal from the Greta Seam resulting in rock fracturing above the extracted seam and deformation of the overlying strata. This can lead to increased horizontal and vertical permeability as a result of bending, fracturing, joint opening and bed separation.

At the Austar Coal Mine, the combination of large depths of cover and the bridging properties of the thick sandstones of the Branxton Formation limit the upward extent of connected fracturing above the extracted longwall panels to around 85 to 150 metres, with discontinuous fracturing above LWB4-B7 predicted to extend to between 235 to 355 metres above the seam. With depths of cover above the seam of 400 to 505 metres, discontinuous fracturing is not expected to reach the ground surface or the base of alluvium. Consequently, near surface groundwater within the alluvium is not predicted to be impacted by the LWB4-B7 Modification.

Based on worst case predictions, it is possible that discontinuous fracturing may extend marginally into the shallow water bearing zones within the uppermost 100 metres of the Braxton Formation where the depth of cover is less than 455 metres. However, fracturing within this zone will not result in an increase in vertical hydraulic conductivity and will not result in direct hydraulic connection with the goaf, with any changes in this zone only affecting horizontal hydraulic conductivity.

The potential impacts of the LWB4-B7 Modification on mine water inflows, groundwater levels, groundwater recharge, groundwater quality, water users and groundwater dependent ecosystems have been assessed and found to be minimal. These impacts are discussed further in the following sections.

6.4.3.1 Mine Water Inflows

Mine inflows at the Austar Coal Mine are complex, and include water released from the coal measures and water stored in voids in abandoned former mine workings adjacent to the Austar Coal Mine. Water from the former mine workings enter the Austar Coal Mine workings primarily through the Greta Coal Seam, which makes it difficult to distinguish from the contribution coming from dewatering of the coal seam and the floor and roof sediments. The most recent assessment of groundwater inflow to the mine undertaken by Aurecon (2013) indicates that base level of water inflow was on a slow increasing trend over time.

Based on the observed impact associated with previous mining at the Austar Coal Mine, it is expected that the proposed modification will result in minimal increase in total water inflow to the mine, as the proposed panels are up dip from the current LWB1-B3 panels and as a result LWB4-B7 panels will already be substantially depressurised.

6.4.3.2 Impacts on Groundwater Levels/Pressure

Alluvium

The proposed longwalls partly underlie alluvium associated with Quorrobolong Creek and an unnamed tributary of Quorrobolong Creek (refer to **Figure 6.7**).

Austar has previously undermined this alluvial area with minimal observed impact, providing confidence that the proposed extraction from LWB4 to LWB7 will have no noticeable impact on the alluvial groundwater resources.

Monitoring undertaken of the alluvium associated with the unnamed tributary of Quorrobolong Creek during and following the extraction of LWB2 showed no influence on water levels from mining. Previous mining of LWA4 and LWA5 within the Stage 2 mining area undermined the alluvium of Cony Creek and alluvial monitoring bores AQD1073A, WBH1, WBH2 and WBH3 with no observable drawdown of water levels in the near surface alluvial groundwater.

Subsidence will result in the development of broad shallow subsidence troughs in the alluvial floodplain. Where these subsidence troughs coincide with the shallow alluvium, there will likely be an initial drop in groundwater levels, as the base of the alluvium will subside by a similar magnitude to the ground surface. This predicted initial decline in water level is likely to quickly rise to re-establish equilibrium with the adjacent sections of the alluvium outside the subsidence zone. This will result in a greater thickness of saturated alluvium and a shallower depth to the water table within the subsidence troughs, with the water table re-establishing at about the same absolute elevation (in metres AHD) as pre-extraction conditions.

Apart from this small localised beneficial impact, no noticeable change in groundwater levels is likely to be observed in the alluvial aquifer following completion of the proposed modification and no adverse effects on baseflow contributions from the aquifer are predicted.

umwelt

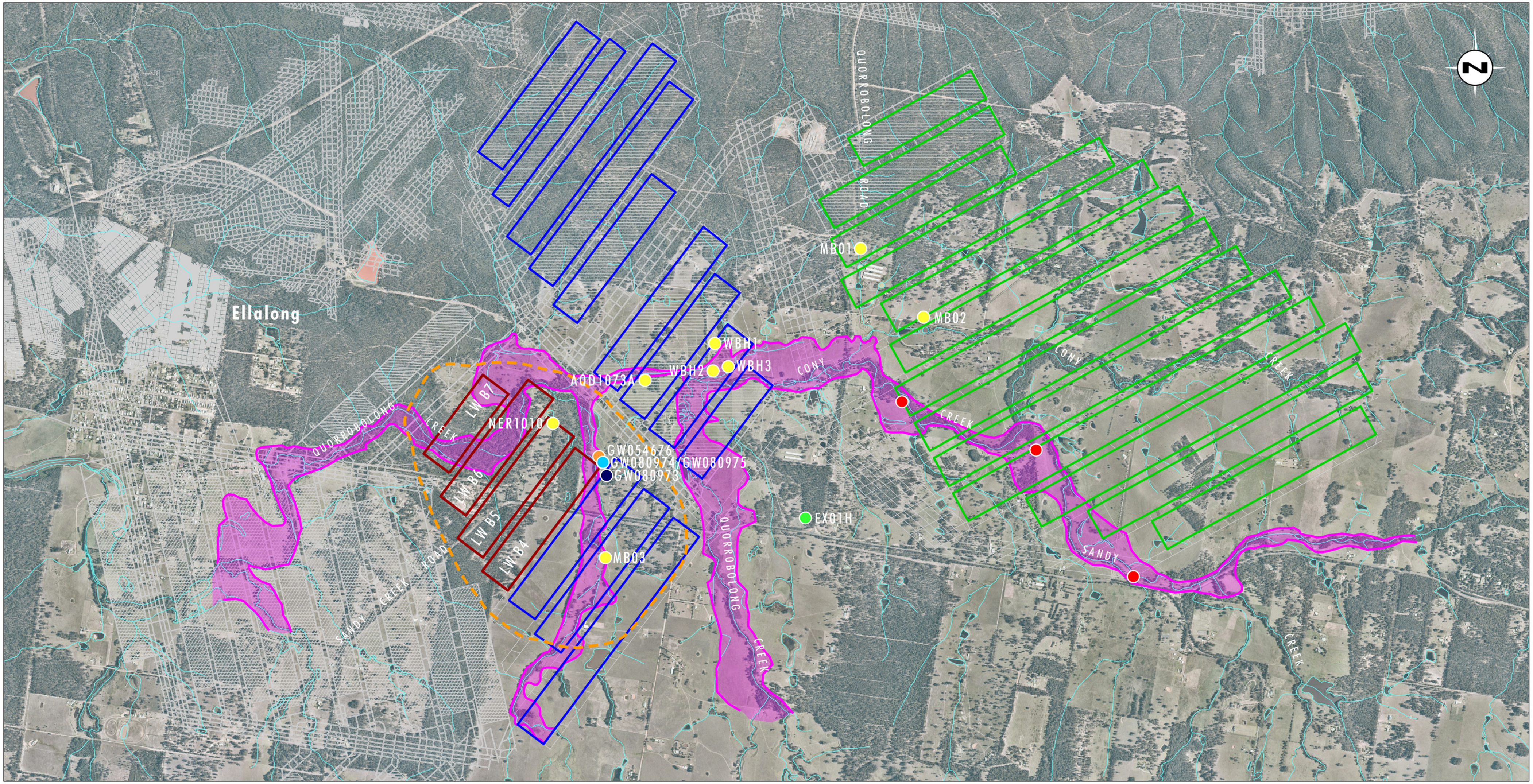


Image Source: Nearmap (Jan 2017)
Data Source: Austar Coal Mine (2015)

0 0.5 1.0 2.0km
1:40 000

Legend

- Stage 3 Longwall Panels (PA08_0111)
- Bellbird South Stage 1, Stage 2, Southland and LWB1-B3 Longwall Panels (DA 29/95)
- Proposed LWB4-B7 Longwall Panels (DA 29/95)
- Completed Underground Workings
- Estimated Alluvial Area
- LWB4-B7 Modification Area
- DPI Water Groundwater Monitoring Bore Location
- DPI Water Groundwater Bore Location - Filled
- Private Stock Bore Location - Filled
- Existing Austar Monitoring Location
- Approved Future Stage 3 Groundwater Monitoring Site
- Vibrating Wire Piezometer

FIGURE 6.7

Estimated Extent of Alluvium and Groundwater Monitoring and Bore Locations

File Name (A4): R01/3900_088.dgn
20170515 14.26

Branxton Formation

The bulk of the sediments overlying the Greta Seam are from the Branxton Formation. The main water-bearing zones within the Branxton Formation are within the first 50 metres or so below the base of weathering. The upper 100 metres or so of the Branxton Formation has been targeted at times by local landowners in the Quorrobolong Valley as a potential water supply source. The only such bore near the proposed Modification Area (registered bore GW054676) produced a low yield of saline groundwater, and the bore has been filled in because it was considered by the landowner to have no beneficial use value.

The uppermost 100 metres of the Branxton Formation is at least 300 metres above, and up to 405 metres above the Greta Seam, and is therefore well above the predicted 150 metres maximum height of connected fracturing from the extraction of LWB4-B7, based on experience from extensometers above LWA1 and LWA2, and predictions by MSEC (refer to **Appendix 2**).

Based on worst case predictions, discontinuous fracturing above LWB4-B7 is predicted to extend to between 235 to 355 metres above the seam. Therefore, it is possible that discontinuous fracturing may extend marginally into shallow water bearing zones within the uppermost 100 metres of the Braxton Formation where the depth of cover is less than 455 metres. However, fracturing within this zone will not result in an increase in vertical hydraulic conductivity and will not result in direct hydraulic connection with the goaf, with any changes in this zone only affecting horizontal hydraulic conductivity. Nevertheless, based on prior experience above LWA1 and LWA2, groundwater within the Braxton Formation is expected to be at most only minimally impacted by the proposed modification.

Coal Measures and Greta Seam

The Greta Coal Measures, including the Greta Seam, are already substantially depressurised in the vicinity of the LWB4-B7 Modification Area due to previous mining activity. Only marginal additional depressurisation is expected as a result of the proposed modification, with no beneficial users affected.

6.4.3.3 Surface Streamflows and Groundwater Recharge

Impacts on surface streamflows are predicted to be negligible. As there are predicted to be no measureable impacts on the near surface groundwater in the alluvium, groundwater recharge will be unaffected by the proposed modification.

6.4.3.4 Groundwater Quality

There is not predicted to be any adverse impact on water quality within the alluvium as a result of the proposed modification, as the zones of connected and discontinuous fracturing do not extend to the height of the alluvium. As discussed in **Section 6.4.3.2**, the height of discontinuous fracturing may extend into the uppermost 100 metres of the Branxton Formation, and could therefore cause temporary impacts on groundwater in that zone, however these impacts would be limited to possible changes in the direction or rate of flow and is not expected to affect water quality in the Branxton Formation or any other aquifer.

6.4.3.5 Impacts on Water Users

There are no registered private groundwater bores targeting the alluvium within the vicinity of the LWB4-B7 Modification Area, which is considered a reflection of the very limited yield potential of this groundwater source in that area. Additionally it is considered that the potential for the proposed modification to impact on the alluvium is negligible.

There are a small number of monitoring bores which target groundwater in the upper parts of the Branxton Formation (uppermost 100 metres or so), operated by Austar Coal Mine and DPI Water. No private bores currently target this aquifer in the vicinity of the modification area, with the only registered private stock bore, GW054676, having been backfilled by the owner due to its low yield and poor water quality (refer to **Figure 6.7**).

In the unlikely event that damage occurs to DPI Water monitoring bores in the vicinity of the modification area, the bores will be repaired or replaced as required in consultation with DPI Water (refer to **Section 7.6**).

6.4.3.6 Groundwater Dependent Ecosystems

Riparian vegetation within the LWB4-B7 Modification Area is considered likely to be at least partially dependent upon shallow alluvial groundwater sources during periods of reduced surface water flow; these communities include Riparian Swamp Oak Open Forest and Riparian Cabbage Gum Open Forest (refer to **Section 6.5.1**). There are no known groundwater dependent ecosystems (GDEs) dependent on groundwater from the Branxton Formation or the Greta Coal Measures within or adjacent to the LWB4-B7 Modification Area.

As discussed in **Section 6.4.3**, the predicted heights of either connected or discontinuous fracturing above the Greta Seam as a result of subsidence are significantly less than the depth of cover above the Greta Seam. Therefore impacts on either the shallow surficial groundwater or on stream baseflows as a result of the LWB4-B7 modification will be negligible. Accordingly, no impacts on any GDEs dependent on the surficial groundwater or on groundwater baseflow are predicted to occur.

6.4.4 NSW Aquifer Interference Policy

The predicted groundwater impacts associated with the LWB4-B7 Modification have been assessed against the NSW Aquifer Interference Policy which requires any mining activity to consider 'Minimal Impact Considerations' with respect to groundwater sources. The NSW Aquifer Interference Policy considers two categories of groundwater sources, being 'highly productive' and 'less productive'.

Both the alluvial and porous rock groundwater sources within the LWB4-B7 Modification Area are considered 'less productive' sources as they do not meet the water quality and yield requirements for 'highly productive' groundwater sources. An assessment against the relevant NSW Aquifer Interference Policy minimum impact criteria is provided in **Table 6.3**.

Table 6.3 Assessment against NSW Aquifer Interference Policy Minimum Impact Criteria

Relevant Minimum Impact Criteria	LWB4-B7 Modification
Less than 10% variation in the water table, 40 metres from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule of the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*	The closest high priority groundwater dependent ecosystem or high priority culturally significant site listed in Schedule 4 of the Hunter Unregulated and Alluvial WSP is located more than 30 kilometres away from the LWB4-B7 Modification Area. The proposed modification will not impact the water table at that distance.

Relevant Minimum Impact Criteria	LWB4-B7 Modification
A maximum 2 metres decline at any water supply work	The closest registered privately owned bore is GW054676 located just inside the LWB4-B7 Modification Area, which targeted a shallow water bearing zone in the Branxton Formation. The landowner has advised that this bore has been decommissioned and backfilled. There are no other registered privately owned bores within the zone of potential impact on groundwater levels or quality from the LWB4-B7 Modification.
No mining activity to be within 200 metres laterally from the top of high bank or 100 metres vertically beneath of a highly connected surface water source that is defined as a 'reliable water supply'	There are no highly connected surface water sources as defined by the NSW Aquifer Interference Policy and Water Management Regulations within 200 metres laterally or 100 metres vertically of the proposed longwalls. Nor are there any water sources that represent a 'reliable water supply' as defined by the NSW Aquifer Interference Policy and Upper Hunter SRLUP.
Any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity	The quality of water within the alluvium/colluvium aquifer is variable and there is no known current use of the surficial groundwater. The LWB4-B7 Modification is therefore not expected to further limit potential beneficial uses of this potential water supply. The generally poor quality of groundwater within the upper parts of the Branxton Formation means that it has limited beneficial use potential. The predicted negligible impact from the proposed modification will not inhibit any potential future use of that aquifer system. Groundwater in the deeper parts of the Branxton Formation and the Greta Coal Measures is poor, and therefore has very low potential for future beneficial use other than for coal mining operations.

The alluvial/colluvial aquifer associated with Quorrobolong Creek and its tributaries within the LWB4-B7 Modification Area is not characterised as a 'highly productive' groundwater source or a highly connected surface water source, as defined by the NSW Aquifer Interference Policy. The lack of registered bores within the area also indicates that the alluvial aquifer in the vicinity of the LWB4-B7 Modification has limited use as a water supply for stock, domestic or other consumptive purpose. On this basis, it is considered that the proposed modification adequately satisfies the minimal impact considerations for "less productive" groundwater sources defined by the NSW Aquifer Interference Policy.

6.4.5 Groundwater Licencing

Groundwater impacts associated with the Austar Coal Mine involve water take from the 'Porous Rock' groundwater source only.

The water take from the 'porous rock' water source for the currently approved mine plan is estimated to be up to approximately 730 ML/y. The LWB4-B7 Modification is predicted to result in a minimal change to the total water take from this source.

Austar holds 770 ML of porous rock groundwater entitlements (bore licences 20BL171481, 20BL173349, and 20BL173350) which is sufficient to account for the estimated water take of up to 730 ML/yr from this water source.

6.4.6 Groundwater Management and Monitoring

Groundwater will continue to be monitored within the Stage 2, Stage 3 and LWB1-B3 mining areas in accordance with the existing Site Water Management Plan (Austar, 2013b), LWB1-B3 Extraction Plan Water Management Plan (Austar 2016a), EL6598 Groundwater Monitoring and Modelling Plan (RPS, 2014) and Environmental Monitoring Program (Austar, 2013c).

The following additional groundwater management and monitoring measures will be incorporated in an Extraction Plan Water Management Plan, consistent with the requirements of the existing approved Austar Site Water Management Plan (Austar 2013b). Austar will:

- Establish one shallow groundwater monitoring bore in the alluvial area of Quorrobolong Creek at a location above LWB6 or LWB7, and monitor the groundwater levels on a regular basis to give an indication of the impact of longwall mining on the groundwater in the alluvium.

- Reconcile groundwater monitoring data against rainfall records to assess whether groundwater level changes are the result of longwall mining impacts, consistent with the requirements of the current approved Austar Site Water Management Plan (Austar, 2013b).

- Review the results of the above monitoring at three monthly intervals and report results annually in accordance with Annual Environmental Management Report requirements, consistent with the requirements of the current approved Austar Site Water Management Plan (Austar, 2013b).

6.5 Ecology

The northern portion of the LWB4-B7 Modification Area supports remnant and regrowth vegetation, in particular along the main drainage line of Quorrobolong Creek. The remainder of the LWB4-B7 Modification Area has been largely cleared for agricultural grazing (refer to **Figure 1.4**). The LWB4-B7 Modification does not involve any additional surface development and therefore will have no direct impact on vegetation as a result of clearing. The potential impacts of the proposed modification on flora and fauna are therefore limited to potential indirect impacts associated with subsidence.

In order to assess the potential ecological impacts of the LWB4-B7 Modification, an ecological assessment has been prepared by Umwelt. The assessment built on the ecological survey and assessment completed for the LWB1-B3 Modification (Umwelt 2015), with additional targeted field survey of the LWB4-B7 Modification Area over a period of 3 days in December 2016 and March 2017. The survey sought to classify and map vegetation communities and fauna habitats and included targeted threatened flora and fauna species searches. The ecological assessment is included as **Appendix 5**, with a summary of the assessment provided below.

6.5.1 Existing Environment

6.5.1.1 Flora

A total of 220 flora species were recorded, of which 175 species are native and 45 are introduced. A full list of the flora species recorded is provided in **Appendix 5**.

Of the flora species identified, three are listed as threatened species, being the netted bottlebrush (*Callistemon linearifolius*), small-flower grevillea (*Grevillea parviflora subsp. parviflora*) and heath wrinklewort (*Rutidosis heterogama*). Locations of threatened species are provided on **Figure 6.8.**

No endangered flora populations were identified occurring within the LWB4-B7 Modification Area and based upon the habitats identified, none are expected to occur.

6.5.1.2 Vegetation Communities

Seven vegetation communities were identified within the LWB4-B7 Modification Area (refer to **Figure 6.8**). The extent of each vegetation type and its conservation status is presented in **Table 6.4**. Each of the vegetation communities identified in **Table 6.4** is described in greater detail in **Appendix 5**.

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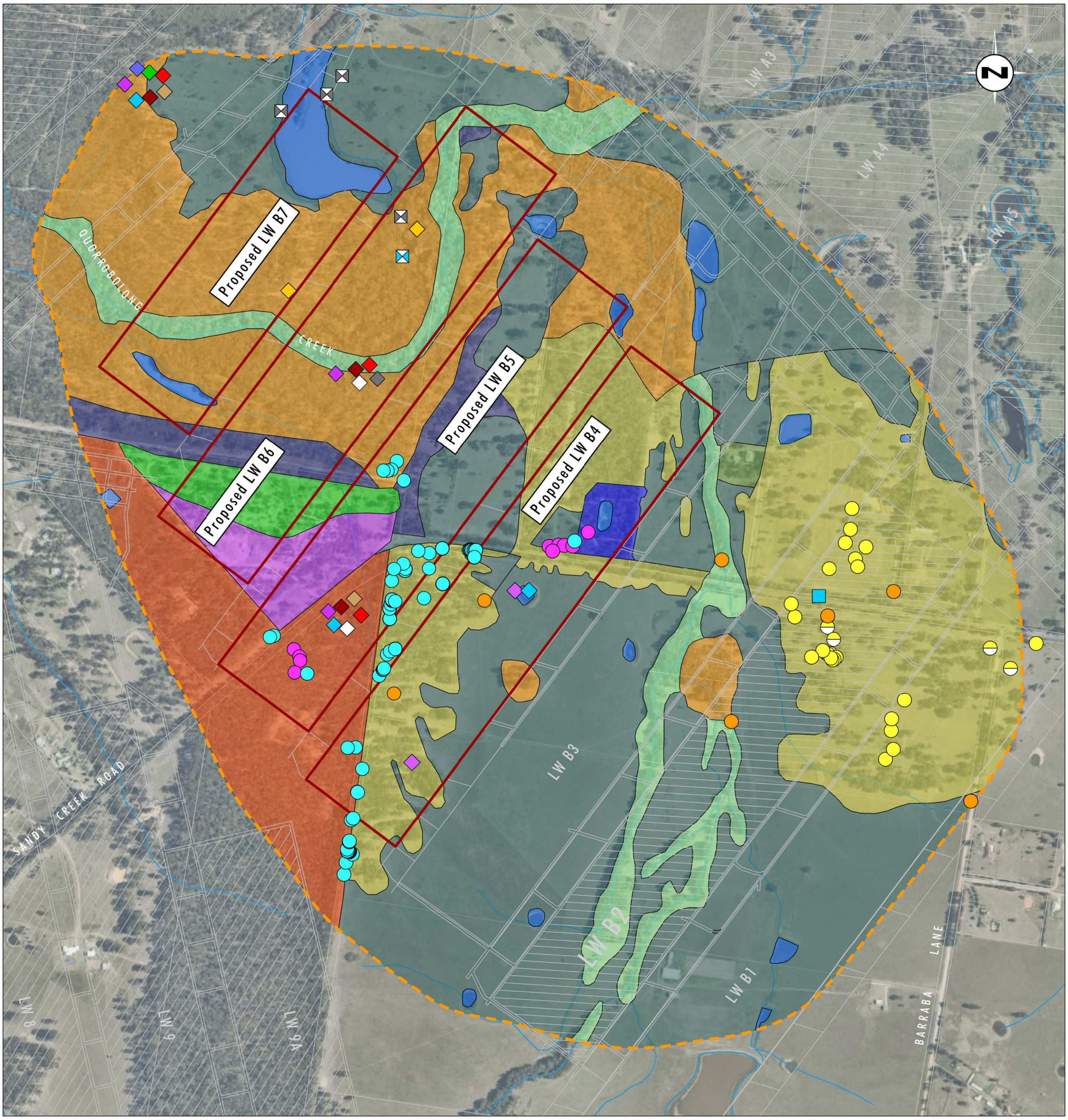

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)
Note: PR - Probable, SG - Species Group, D - Definite

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Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- Drainage Line
- Cadastral Boundary
- Modified Grassland
- Planted Vegetation
- Water Body
- Riparian Swamp Oak Open Forest

River Flat Eucalyptus Forest EEC:
- Riparian Cabbage Gum Open Forest

Lower Hunter Spotted Gum-Ironbark Forest EEC:
- Coastal Foothills Transition Forest
- Coastal Foothills Transition Forest - underscrubbed
- Spotted Gum Ironbark Forest
- Modified Spotted Gum Ironbark Forest
- Spotted Gum Ironbark Forest - underscrubbed

Potential Quorrobolong Scribbly Gum Woodland EEC:
- Melaleuca Shrubland with Emergent Eucalypts
- East-coast freetail-bat (Definite)
- Eastern bentwing-bat (Species Group)
- Eastern cave bat (Species Group)
- Eastern false pipistrelle (Species Group)
- Grey-crowned babbler (eastern subspecies)
- Grey-crowned babbler nests
- Grey-headed flying-fox
- Large-eared pied bat
- Greater broad-nosed bat (Species Group)
- Little bentwing-bat (Species Group)
- Little bentwing-bat (Probable)
- Squirrel glider
- Southern myotis (Species Group)
- Varied sittella
- White-bellied sea eagle
- White-bellied sea eagle Nest
- Yellow-bellied sheathtail-bat (Probable)
- *Callistemon linearifolius*
- *Grevillea parviflora* subsp. *parviflora*
- *Rutidosis heterogama*

FIGURE 6.8

Vegetation Communities and Threatened Species Results

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Table 6.4 Vegetation Communities within the LWB4-B7 Modification Area

Community Name	Status	Approximate Extent (ha)
Vegetation Communities		
Riparian Swamp Oak Open Forest	-	18.1
Riparian Cabbage Gum Open Forest	River-flat Eucalypt Forest EEC (TSC Act)	56.7
Coastal Foothills Transition Forest	Lower Hunter Spotted Gum – Ironbark Forest EEC (TSC Act)	7.4
Coastal Foothills Transition Forest – underscrubbed		4.9
Spotted Gum - Ironbark Forest		24.3
Modified Spotted Gum - Ironbark Forest		62.0
Spotted Gum Ironbark forest -Underscrubbed		5.6
Melaleuca Shrubland with Emergent Eucalypts	Potential Quorrobolong Scribbly Gum Woodland EEC (TSC Act)[1]	1.6
Grassland	-	115.8
Planted Vegetation	-	0.7
Non Vegetated Areas		
Water Bodies	-	6.5
Total		**303.7**

[1] Potential EEC however could not be confirmed without further detailed sampling.

Two confirmed and one potential threatened ecological community (TEC) were identified in the LWB4-B7 Modification Area being River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC (River-flat Eucalypt Forest EEC), the Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin Bioregion EEC (Lower Hunter Spotted Gum – Ironbark Forest EEC) and potential Quorrobolong Scribbly Gum Woodland in the Sydney Basin Bioregion EEC (potential Quorrobolong Scribbly Gum Woodland EEC). These EECs are listed under the TSC Act. No TECs were identified in the LWB4-B7 Modification Area that were consistent with listings under the EPBC Act. The details of these EECs as they occur within the LWB4-B7 Modification Area are provided in greater detail in the **Appendix 5**.

6.5.1.3 Fauna

A total of 123 fauna species were recorded in the LWB4-B7 Modification Area, including 11 frog species, 11 reptile species, 74 bird species and 27 mammal species. A complete list of the species recorded during the field surveys is provided in **Appendix 5**.

Of the 123 fauna species identified within the LWB4-B7 Modification Area, a total of 15 were threatened including:

- three threatened bird species listed as vulnerable under the TSC Act, the grey-crowned babbler (*Pomatostomus temporalis temporalis*), varied sittella (*Daphoenositta chrysoptera*) and white-bellied sea eagle (*Haliaeetus leucogaster*)

- eleven threatened mammal species listed as vulnerable under the TSC Act, the grey-headed flying fox (*Pteropus poliocephalus*), squirrel glider (*Petaurus norfolcensis*), little bentwing-bat (*Miniopterus australis*), eastern bentwing-bat (*Miniopterus schreibersii oceanensis*), east-coast freetail-bat (*Mormopterus norfolkensis*), yellow-bellied sheath-tail bat (*Saccolaimus flaviventris*), eastern falsistrelle (*Falsistrellus tasmaniensis*), southern myotis (*Myotis macropus*), eastern cave bat (*Vespadelus troughtoni*), large-eared pied bat (*Chalinolobus dwyeri*) and greater broad-nosed bat (*Scoteanax rueppellii*). The large-eared pied bat (*Chalinolobus dwyeri*) and grey-headed flying-fox (*Pteropus poliocephalus*) are also listed as vulnerable under the EPBC Act

- although not recorded during surveys undertaken for the proposed modification, a single record of the koala (*Phascolarctos cinereus*) has been identified on the OEH database within the LWB4-B7 Modification Area. The koala is listed as vulnerable under both the TSC Act and the EPBC Act.

The locations of threatened fauna species recorded in the LWB4-B7 Modification Area are shown on **Figure 6.8**. A range of potentially occurring threatened fauna species were also identified on the basis of the presence of potential habitat and local records.

6.5.1.4 Threatened Species and Threatened Ecological Communities

A summary of the threatened species and TECs identified as occurring within the LWB4-B7 Modification Area or with the potential to be impacted by the proposed modification is provided in **Table 6.5**.

Table 6.5 Threatened Species and Threatened Ecological Communities Occurring within or Potentially Impacted by the LWB4-B7 Modification

Threatened Species or TEC	Legal Status		Status Within LWB4-B7 Modification Area
	TSC Act	EPBC Act	
heath wrinklewort (*Rutidosis heterogama*)	V	V	Confirmed occurrence
netted bottle brush (*Callistemon linearifolius*)	V	-	Confirmed occurrence
small-flower grevillea (*Grevillea parviflora subsp. parviflora*)	V	V	Confirmed occurrence
Green and golden bell frog (*Litoria aurea*)	E	V	Potential to occur
green-thighed frog (*Litoria brevipalmata*)	V	-	Potential to occur
grey-crowned babbler (*Pomatostomus temporalis temporalis*)	V	-	Confirmed occurrence
varied sittella (*Daphoenositta chrysoptera*)	V	-	Confirmed occurrence
white-bellied sea eagle (*Haliaeetus leucogaster*)	V	-	Confirmed occurrence

Threatened Species or TEC	Legal Status		Status Within LWB4-B7 Modification Area
	TSC Act	EPBC Act	
Australian bittern (*Botaurus poiciloptilus*)	E	E	Potential to occur
Black bittern (*Ixobrychus flavicollis*)	V	-	Potential to occur
Black-necked stork (*Ephippiorhynchus asiaticus*)	E	-	Potential to occur
Australian painted snipe (*Rostratula australis*)	E	E	Potential to occur
Freckled duck (*Stictonetta naevosa*)	V	-	Potential to occur
swift parrot (*Lathamus discolor*)	E	CE	Potential to occur
regent honeyeater (*Anthochaera phrygia*)	CE	CE	Potential to occur
Japanese snipe (*Gallinago hardwickii*)	-	MIG	Potential to occur
Sharp-tailed sandpiper (*Calidris acuminata*)	-	MIG	Potential to occur
Common greenshank (*Tringa nebularia*)	-	MIG	Potential to occur
grey-headed flying fox (*Pteropus poliocephalus*),	V	V	Confirmed occurrence
squirrel glider (*Petaurus norfolcensis*)	V	-	Confirmed occurrence
koala (*Phascolarctos cinereus*)	V	V	Wildlife Atlas database record of occurrence
little bentwing-bat (*Miniopterus australis*)	V	-	Confirmed occurrence
eastern bentwing-bat (*Miniopterus schreibersii oceanensis*)	V	-	Confirmed occurrence
east-coast freetail-bat (*Mormopterus norfolkensis*)	V	-	Confirmed occurrence
yellow-bellied sheath-tail bat (*Saccolaimus flaviventris*)	V	-	Confirmed occurrence
eastern falsistrelle (*Falsistrellus tasmaniensis*)	V	-	Confirmed occurrence
southern myotis (*Myotis macropus*)	V	-	Confirmed occurrence
eastern cave bat (*Vespadelus troughtoni*)	V	-	Confirmed occurrence
large-eared pied bat (*Chalinolobus dwyeri*)	V	V	Confirmed occurrence
greater broad-nosed bat (*Scoteanax rueppellii*)	V	-	Confirmed occurrence
Lower Hunter Spotted Gum – Ironbark Forest EEC	TEC	-	Confirmed occurrence
River-flat Eucalypt Forest EEC	TEC	-	Confirmed occurrence

Threatened Species or TEC	Legal Status		Status Within LWB4-B7 Modification Area
	TSC Act	EPBC Act	
potential Quorrobolong Scribbly Gum Woodland EEC	TEC	-	Confirmed occurrence

Note CE critically endangered
E: endangered
MIG: migratory
TEC: threatened ecological community
V: vulnerable

6.5.1.5 Habitat

Four habitat types were identified within the LWB4-B7 Modification Area, including Riparian, open forest, grassland and dam/waterbody habitats. There are currently four critical habitat declarations in NSW that are listed under the TSC Act. None of these areas are within or in proximity to the LWB4-B7 Modification Area.

Connectivity within the LWB4-B7 Modification Area is high in a north-south alignment along the eastern boundary and low-moderate in an east-west alignment (with the majority of the area subject to historical clearing and agriculture). Vegetation occurring in the north-west shows connectivity to a large remnant of vegetation associated with Quorrobolong Creek; however internal connectivity in the south-east comprises highly fragmented riparian vegetation along the unnamed tributary of Quorrobolong Creek.

6.5.1.6 Aquatic Ecology

Assessment of aquatic habitat characteristics and potential fish habitat was undertaken along the length of Quorrobolong Creek and its unnamed tributary within the LWB4-B7 Modification Area. In general, the aquatic habitats within the north of the modification area are of higher quality than those in the south (generally differentiated by Sandy Creek Road), with the northern areas subject to fewer disturbances as a result of cattle grazing. The upstream reaches of Quorrobolong Creek have a greater diversity of native emergent as well as macrophytic aquatic vegetation as well as greater habitat diversity present (such as snags). However at the time of survey these higher quality areas were not flowing and largely consisted of large standing pools. Quorrobolong Creek itself within the northern upstream areas of the LWB4-B7 Modification Area was considered relatively un-impeded and was classified as providing Class 2 or moderate fish habitat. The large farm dam water body in the north of the LWB4-B7 Modification Area provides good quality fish habitat.

Southern watercourses (unnamed tributary of Quorrobolong Creek mostly occurring south of Sandy Creek Road) contained moderate amounts of woody debris and tree roots which would provide moderate habitat and refugia for aquatic fauna. However are more susceptible to trampling by cattle. The unnamed tributary of Quorrobolong Creek has several barriers to fish passage in the LWB4-B7 Modification Area, mostly in the form of sand/silt bars and was assessed as providing Class 3 or minimal fish habitat. All watercourses are slow-moving due to low flows and as such riffles in general were rare.

No threatened aquatic species listed as threatened under the TSC Act, EPBC Act or FM Act were identified or considered likely to occur in the LWB4-B7 Modification Area.

6.5.1.7 Groundwater Dependent Ecosystems

As discussed in **Section 6.4.1**, there are three main sources of groundwater present within and surrounding the LWB4-B7 Modification Area:

- shallow alluvial aquifers associated with Quorrobolong Creek and its unnamed tributary
- non- alluvial hard rock aquifers within the coal seams and factured zones within the upper parts of the Branxton Formation
- water stored within previous underground mine voids.

There are no known GDEs within the LWB4-B7 Modification Area that rely on groundwater within the non-alluvial hard roack aquifers or on groundwater within underground mine voids.

As discussed in **Section 6.4.1**, it is likely that the riparian vegetation comprising Riparian Swamp Oak Open Forest and Riparian Cabbage Gum Open Forest is at least partially dependent upon shallow alluvial groundwater sources during periods of reduced surface water flow. The Bureau of Meteorology (BoM) Atlas of Groundwater Dependent Ecosystems identifies the areas north of Sandy Creek Road as comprising vegetation that has “moderate potential for groundwater interaction” these areas are reflective of the former identified vegetation communities.

The BoM Atlas identified Congewai Creek and Ellalong Lagoon as the only known GDEs (or partial GDEs) in the vicinity of the LWB4-B7 Modification Area. Ellalong Lagoon occurs approximately 3.5 kilometres west of the proposed LWB4-B7 Modification Area and Congewai Creek occurs more than 5 kilometres west and south of the LWB4-B7 Modification Area. Neither of these GDEs occur within the LWB4-B7 Modification Area and based on predictions of the subsidence, flooding and groundwater impact assessment reports, the proposed modification will not adversely impact these mapped GDEs. There are no high priority GDEs identified in the Hunter Unregulated and Alluvial WSP within the LWB4-B7 Modification Area.

6.5.2 Ecological Impact Assessment

6.5.2.1 Potential Impacts on Biodiversity Values of the Proposed Modification

The LWB4-B7 Modification does not involve any additional surface development and therefore will have no direct impact on vegetation as a result of clearing. The potential impacts of the proposed modification on flora and fauna are therefore limited to potential indirect impacts associated with subsidence such as surface cracking, subsidence remediation works or changes in the hydrological regime.

Subsidence Related Surface Cracking and Remediation

The subsidence assessment findings conclude that the potential for surface cracking associated with the LWB4-B7 Modification is low due to the depth of mining (minimum 400 metres), the small magnitude of predicted ground curvatures and strains and the absence of any steep slopes or cliffs within the modification area.   Remediation of subsidence related surface cracking is therefore unlikely to be required.

This conclusion is supported by subsidence monitoring evidence within the Stage 2, Stage 3 and LWB1-B3 areas, where there has been no significant or visible surface cracking above previously extracted longwalls A3 to A8 or LWB2.

Subsidence Related Hydrological Changes

The proposed modification will result in the undermining of the main channel of Quorrobolong Creek and an unnamed tributary of Quorrobolong Creek. Quorrobolong Creek and its unnamed tributary have been directly undermined previously within the Ellalong Colliery, Stage 2 and LWB1-B3 areas, with no significant surface cracking or loss of surface water flow observed within the creek system following undermining.

Monitoring has also not identified any adverse impact on riparian vegetation within the Austar Coal Mine as a result of previous underground mining.

Based on the findings of the subsidence assessment (refer to **Appendix 2**) and flooding and drainage assessment (refer to **Appendix 3**) it is considered unlikely that there would be a net loss of water from the streams within the LWB4-B7 Modification Area resulting from the extraction of the proposed longwalls.

In the unlikely event that surface cracking does occur within drainage lines, cracking is likely to naturally fill with surface soils during subsequent flow events, should this not occur remedial measures may be required at the completion of mining.

The flooding and drainage assessment undertaken for the LWB4-B7 Modification identified potential minor changes to the extent of remnant ponding around some existing flow paths and farm dams (refer to **Figure 6.4**). These minor changes to the extent of remnant ponding occur within low lying areas that are already subject to periodic inundation during periods of high rainfall.

As shown on **Figure 6.4,** there are two key areas where the extent of remnant ponding is predicted to increase from current levels, being:

- approximately 0.1 hectares of ponding around an existing farm dam within an area of modified Grassland to the north of LWB5; and

- approximately 1.5 hectares of additional ponding upstream of an overflow channel from Quorrobolong Creek at the southern end of LWB6 and LWB7 within an area of Riparian Cabbage Gum Open Forest (River-flat Eucalypt Forest EEC (TSC Act)).

No impacts to ecological values are anticipated as a result of increased ponding within the 0.1 hectares of modified Grassland. However, further assessment was undertaken to determine the potential impacts of increased ponding within the 1.5 hectares area of Riparian Cabbage Gum Open Forest, including additional analysis of ponding frequency, duration and additional survey effort within this community. This analysis predicted that the additional 1.5 hectares area of remnant ponding within Riparian Cabbage Gum Open Forest to the south of Quorrobolong Creek is expected to be present between 30 to 156 days per year, depending on rainfall, with ponding to a depth of approximately 0.5 metres expected.

River-flat Eucalypt Forest (NSW Scientific Committee 2004) is described as having the following relevant attributes:

- *Associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplain; and*

- *The composition of River-flat Eucalypt Forest on Coastal Floodplains is primarily determined by the frequency and duration of waterlogging and the texture, nutrient and moisture content of the soil.*

By its definition, this vegetation community naturally occurs on areas subject to periodic inundation and can have a variable floristic composition dependent upon the level of waterlogging that a particular area is subject to. Although the localised ponding will potentially increase in duration and frequency in this area, this vegetation type is well-suited to coping with periods of regular water inundation. It is anticipated that increased ponding will have some implications for the understorey vegetation composition, which will likely increase with time towards species that are more capable of enduring sustained periods of inundation, such as sedges and rushes, however will not change the actual vegetation community itself and the overall quality should remain broadly consistent and no tree death is anticipated to occur.

Based on the findings of the flooding and drainage assessment and groundwater assessment, the potential for the proposed modification to result in secondary impacts on ecological values as a result of changes in hydrology is therefore considered low.

6.5.2.2 Impacts on Threatened Species and Threatened Ecological Communities

An assessment of the potential impacts of the LWB4-B7 Modification on each of the threatened species and ecological communities listed in **Table 6.5** was undertaken (refer to **Appendix 5**). This assessment concluded that due to the LWB4-B7 Modification not resulting in any direct clearing of vegetation and the minimal subsidence impacts predicted at the surface, it is unlikely to have a significant impact on vegetation (including threatened species and TECs) or habitats of any threatened species listed under the TSC or EPBC Act.

6.5.2.3 Impacts on Groundwater Dependent Ecosystems

The only potential GDE identified within the LWB4-B7 Modification Area is riparian vegetation, which is likely to be at least partially dependent upon shallow alluvial groundwater sources during periods of reduced surface water flow. An assessment of the potential impacts of the proposed modification on the alluvial groundwater resources within the modification area has been undertaken (refer to **Section 6.4**). As discussed in **Section 6.4.3**, the predicted heights of either connected or discontinuous fracturing above the Greta Seam as a result of subsidence are significantly less than the depth of cover above the Greta Seam. Therefore impacts on either the shallow alluvial groundwater or on stream baseflows as a result of the LWB4-B7 Modification will be negligible. Accordingly, no impacts on any GDEs dependent on the alluvial groundwater or on groundwater baseflow are predicted to occur.

This conclusion is supported by the results of previous monitoring of the impacts of mining within the Austar Coal Mine, which has identified no observable impact on alluvial aquifers or riparian vegetation as a result of mining (Austar 2014).

The potential impacts of changes in flooding and remnant ponding behaviour on riparian vegetation has also been assessed (refer to **Section 6.5.2.1**) and found that any changes to surface water hydrology within the modification area is unlikely to result in significant adverse impacts to these communities.

The LWB4-B7 Modification is therefore unlikely to result in a significant adverse impact on GDEs present within the modification area.

6.5.3 Ecological Mitigation and Management

6.5.3.1 Biodiversity Management Plan

Prior to the commencement of secondary extraction of LWB4-B7, Austar will prepare a Biodiversity Management Plan (BMP) for approval that includes the LWB4-B7 Modification Area as part of the Extraction Plan process. The BMP will identify baseline information on ecological values within the extraction plan area, the potential impacts to those aspects associated with the proposed modification and outline an ecological monitoring program for the extraction plan area. While there is not predicted to be any significant adverse impact to ecological features within the LWB4-B7 Modification Area and subsidence remediation is not expected to be required, the BMP will include contingency measures for subsidence remediation works in the unlikely event that subsidence remediation works are required.

6.5.3.2 Ecological Monitoring Program

An ecological monitoring program will be prepared as part of the BMP. The monitoring program will include baseline monitoring to allow identification of any subsidence or required land remediation impacts on threatened species, populations, their habitats or EEC and will be designed in a manner consistent with the existing ecological monitoring program for the LWB1-B3 area (Austar 2016a) and with current OEH policy.

The ecological monitoring program will include ecological monitoring (where access to private landholdings allow) of:

- River-flat Eucalypt Forest EEC vegetation (occurring within the predicted 1.5 hectare area of ponding)
- Lower Hunter Spotted Gum – Ironbark Forest EEC vegetation
- Potential Quorrobolong Scribbly Gum Woodland EEC vegetation.

At least one monitoring site will be established in each EEC (subject to landholder access). In line with current monitoring requirements, monitoring will be undertaken on an annual basis for areas of Lower Hunter Spotted Gum – Ironbark Forest and areas of potential Quorrobolong Scribbly Gum Woodland.

Bi-annual (six monthly) monitoring will be undertaken for the River-flat Eucalypt Forest monitoring site in order to more closely monitor the influence of any changes in ponding on the understorey vegetation composition of this community.

Should the results of EEC monitoring surveys reveal sufficient reason to conduct further surveys of threatened species populations; the monitoring program will be appropriately adapted.

6.6 Aboriginal Cultural Heritage

As previously described, the LWB4-B7 Modification does not involve any additional surface development and the potential impacts of the proposed modification on Aboriginal cultural heritage are limited to indirect impacts associated with subsidence.

In order to assess the potential archaeological impacts of the LWB4-B7 Modification from subsidence, an Aboriginal Cultural Heritage and Archaeological Assessment has been prepared for the LWB4-B7 Modification Area by Umwelt in consultation with the registered Aboriginal parties (RAPs) for the modification. The LWB4-B7 Modification Area incorporates portions of the previously assessed LWB1-B3 Modification Area (Umwelt 2015), therefore the archaeological survey and cultural heritage assessment findings from the LWB1-B3 Modification have been considered where appropriate.

The assessment is included as **Appendix 6** with a summary of the findings provided below.

6.6.1 Background

The Austar Coal Mine has been subject to a number of previous Aboriginal cultural heritage assessments and investigations as part of previous Stage 2, Stage 3 and LWB1-B3 consents and approvals. Aboriginal cultural heritage issues are managed in accordance with an existing approved Aboriginal Cultural Heritage Management Plan (Austar 2017) developed as a condition of PA 08_0111 and the Bellbird South Consent. The ACHMP provides a consolidated framework for the management of Aboriginal cultural heritage and mitigation strategies for the Austar Coal Mine.

A search of the Aboriginal Heritage Information Management System (AHIMS) database was undertaken on 7 February 2017 and identified 84 Aboriginal archaeological sites within an area of approximately 14 kilometres (east-west) by 11 kilometres (north-south) surrounding the LWB4-B7 Modification Area. One of the 84 previously recorded Aboriginal cultural heritage sites and/or objects is located within the LWB4-B7 Modification Area. This site (AHIMS #37-6-3398), a stone artefact scatter, is located within the area previously assessed as part of the LWB1-B3 Modification. The locations of known archaeological sites within and surrounding the LWB4-B7 Modification Area are shown on **Figure 6.9**.

6.6.2 Consultation with Registered Aboringinal Parties

Consultation with Aboriginal parties regarding the proposed modification was undertaken in accordance with the *National Parks and Wildlife Regulation 2009* and the Aboriginal cultural heritage consultation requirements for proponents (DECCW 2010). Twenty Aboriginal parties registered an interest in ongoing consultation regarding the Austar Coal Mine and were consulted regarding this modification. The consultation process included the provision of a draft methodology for the Aboriginal Cultural Heritage Assessment Report for comment; participation in a survey of the modification area where specific feedback in relation to the cultural values of the modification area was sought (**refer to Section 6.6.5.2**); and provision of the draft Aboriginal Cultural Heritage Assessment Report for review and input, including in relation to cultural values.

6.6.3 Survey Methodology

A targeted pedestrian survey of the LWB4-B7 Modification Area was undertaken over a period of three days on 9 and 10 February and 21 March 2017, with 10 RAP representatives participating at different times during the survey. The southern portion of the LWB4-B7 Modification Area (comprising approximately 140 hectares) has been subject to a previous archaeological survey and assessment in 2015 (Umwelt 2015) and therefore was excluded from the survey area, leaving a total of approximately 160 hectares subject to the current survey.

A description of each survey unit and location is detailed in **Appendix 6**. Ground visibility and exposure was typically low across the entire LWB4-B7 Modification Area. This is largely due to the presence of vegetation (grass and/or leaf litter) across the majority of the survey units, which in turn obscured visibility.

The exception to this was Survey Unit 3. This survey unit contained active holding yards for goats, resulting in increased visibility and localised sheetwash erosion. Levels of exposure within the survey units did not exceed 10 per cent and primarily reflected the effects of sheetwash erosion and the presence of vehicle access tracks.

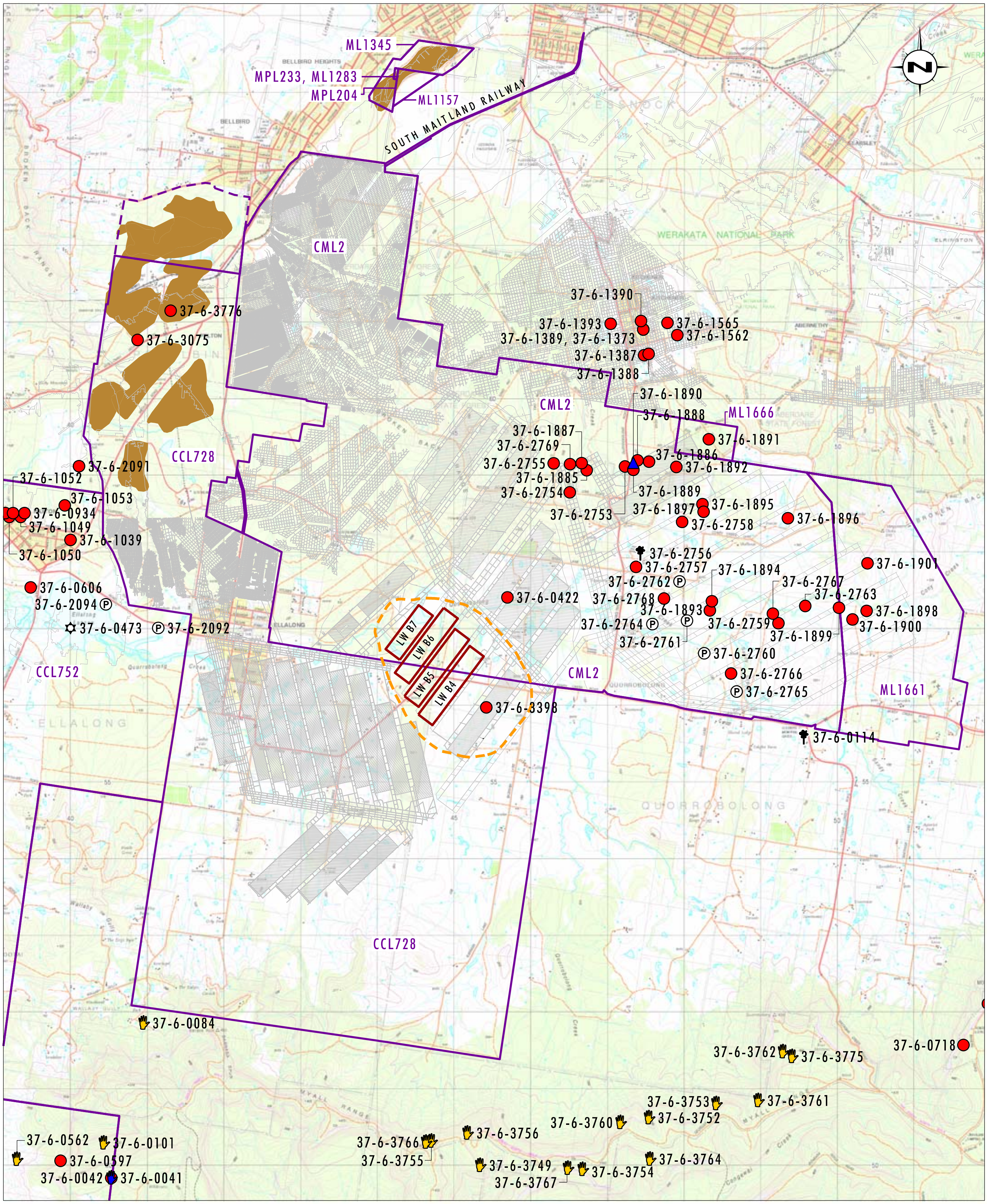

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016), AHIMS (2017)

Legend

- Proposed LWB4-B7 Longwall Panels (DA 29/95)
- LWB4-B7 Modification Area
- Approved Reject Emplacement Areas
- Completed Underground Workings
- Mining Lease Boundary
- Austar owned CHPP Land
- Artefact
- PAD
- Artefact/Grinding Groove
- Art
- Aboriginal Ceremony and Dreaming
- Art/Grinding Groove/Artefact
- Modified Tree

FIGURE 6.9

Location of AHIMS Registered Sites

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6.6.4 Survey Results

A total of 13 new Aboriginal archaeological sites were identified, of which one (ACM45) is located outside the LWB4-B7 Modification Area (refer to **Figure 6.10**). These sites consisted of isolated artefacts and artefact scatters, with only two sites (ACM38 and ACM40) containing more than five artefacts. The distribution and contents of these sites is relatively comparable to the outcomes of previous archaeological investigations within the Austar Coal Mine and surrounds. No grinding grooves or scarred trees were identified within the LWB4-B7 Modification Area and no areas of outcropping sandstone were present within Quorrobolong Creek or its unnamed tributary.

Based on the criteria for the assessment of archaeological potential, the majority of the LWB4-B7 Modification Area has low archaeological potential. The exceptions to this are the valley flats bordering Quorrobolong Creek (moderate potential), slopes within 100 metres of the main channel of Quorrobolong Creek and identified overflow channels and the spur crest in Survey Unit 9 (all of which have low to moderate archaeological potential).

6.6.5 Significance Assessment

6.6.5.1 Archaeological Significance

All sites identified within the LWB4-B7 Modification Area are within landscape contexts and have contents that are common within the local context and are represented at other locations within the Austar Coal Mine. Consequently, all sites have low value for rarity and representativeness. This has some flow on effect for educational value. In addition, all sites other than ACM38 and ACM40 contain less than five artefacts. ACM38 and ACM40, while containing slightly higher numbers of artefacts, are located on privately owned land with no public access. All sites are therefore assessed as having low educational potential.

In terms of research potential, ACM38 and ACM40 are identified as having potential to be associated with additional sub-surface deposits however the extent of disturbance within these sites is such that it is unlikely that these deposits will retain stratigraphic integrity. These sites are therefore assessed to have low-moderate potential to contribute to our understanding of how Aboriginal people lived in this area.

All sites within the LWB4-B7 Modification Area are assessed as having low archaeological significance, with the exception of ACM38 and ACM40, which have low to moderate archaeological significance.

The assessment of significance for areas of archaeological potential (within which there are no visible Aboriginal objects) is inherently difficult as any such assessment can only be based on the nature of the evidence that the area may contain. For this reason, the assessment of significance of areas of archaeological potential remains a provisional assessment of potential significance only and is linked almost entirely to the research potential of the site. That is, areas of moderate archaeological potential have a provisional assessment of moderate archaeological significance, with areas of low to moderate potential having low to moderate significance.

6.6.5.2 Aboriginal Cultural Significance

Throughout the assessment process, registered Aboriginal parties were invited to provide information regarding the cultural significance of the LWB4-B7 Modification Area, the landscape features, archaeological sites and areas of archaeological potential that it contains. Aboriginal stakeholder representatives who participated in the survey identified that Quorrobolong Creek is a key water resource within the area and has high cultural value for both its natural aspects and its association with archaeological evidence. Maintaining the health of watercourses within the LWB4-B7 Modification Area was seen as very important to ensure protection of natural and cultural values.

Input provided by registered Aboriginal parties confirmed the high cultural significance of the local landscape, along with any sites (recorded or unrecorded) within the surrounding area. Quorrobolong Creek was considered to hold high importance and cultural significance to the Aboriginal Community. Specific reference was also made to the cultural values associated with Ellalong Lagoon (which is outside the LWB4-B7 Modification Area).

6.6.6 Impact Assessment

The LWB4-B7 Modification does not involve any additional surface development and therefore will have no direct impact on archaeological sites as a result of land clearing or disturbance. The potential impacts of the proposed modification on archaeological sites are therefore limited to indirect impacts associated with subsidence, including potential surface cracking, subsidence remediation works or hydrological changes.

Due to the depth of mining within the LWB4-B7 Modification Area (minimum 400 metres), and the small magnitude of predicted ground curvatures and strains, surface cracking is not expected to occur. This is supported by monitoring evidence within the Stage 2, Stage 3 and LWB1-B3 mining areas, where there has been no significant or visible surface cracking above previously extracted longwalls A3 to A8 or LWB2.

Any surface cracking that does occur is expected to be minor and isolated and unlikely to directly or adversely impact the Aboriginal archaeological sites or areas of archaeological potential identified within the LWB4-B7 Modification Area. Based on previous experience within the broader Austar Coal Mine, remediation of surface cracking is unlikely to be required within the LWB4-B7 Modification Area.

The flooding and drainage assessment concludes that the proposed modification is unlikely to have a significant impact on runoff regimes, bank stability or channel alignment and will not result in scouring or increased erosion of the landscape. The assessment predicts minor changes to remnant ponding around some existing flow paths and farm dams. These minor changes to the extent of remnant ponding occur within low lying areas that are already subject to periodic inundation during periods of high rainfall. Therefore additional periods of inundation in these locations are highly unlikely to result in any additional impact to Aboriginal archaeological sites or areas of archaeological potential that may be present.

6.6.7 Archaeological Management and Monitoring

Given the low likelihood of impact of the proposed modification on identified archaeological sites and areas of archaeological potential, Austar will continue to implement the management strategies that are currently in place at the Austar Coal Mine, as described in the ACHMP. Where relevant, these measures will be extended to the LWB4-B7 Modification Area. Specifically:

- The Austar ACHMP will be updated to include provisions for the monitoring of identified archaeological sites within the LWB4-B7 Modification Area in accordance with the management strategies currently implemented within the Austar Coal Mine.

It is noted that, consistent with existing management strategies outlined in the ACHMP, in the unlikely event that subsidence remediation works are required in the LWB4-B7 Modification Area that will impact on the identified sites or areas of low-moderate or higher archaeological potential, the appropriate due diligence process will be implemented, including seeking any necessary Aboriginal Heritage Impact Permit (AHIP) prior to the commencement of any remediation works. Appropriate mitigation measures for the site to be impacted by the remediation works will be developed as part of the AHIP application process in consultation with the registered Aboriginal parties and in accordance with OEH requirements.

6.7 Historic Heritage

A historical heritage assessment has been prepared for the LWB4-B7 Modification to identify potential impacts on items of known or potential historical heritage. The assessment has been undertaken with consideration of guidelines set out in the NSW Heritage Manual 1996 (Heritage Office and Department of Urban Affairs & Planning), including *Archaeological Assessments, Assessing Heritage Significance, Statements of Heritage Impact* and the principles contained in *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance 2013* (Australia ICOMOS 2013) and the *Historical Archaeology Code of Practice* (Heritage Office 2006).

6.7.1 Historical Context

As part of NSW heritage assessment procedures it is essential to have a full understanding of a site or item based on its historical and physical context. This section of the EA provides a brief historical context for the LWB4-B7 Modification Area and its broader locality, to provide an understanding of the significance of any heritage sites within the LWB4-B7 Modification Area. The historical context prepared as part of the *Historical Heritage Assessment: Austar Coal Mine Project, Stage 3* (Umwelt 2008b) should also be referred to for the full historical context of the Austar Coal Mine.

The history of the Cessnock region is characterised by pastoral estates and a slow intensification of residential development prior to 1892, with mining then becoming increasingly significant to the region's economy and development; particularly from the 1910s. The history of the Quorrobolong area reflects this, with land first taken up as part of pastoral estates in the late 1820s and early 1830s, then being progressively subdivided for further pastoral use. Mining infrastructure in the Quorrobolong area – for the Pelton, Ellalong, Bellbird and Southland Collieries – dates to the 1910s, resulting in the rapid intensification of use of the local region. As a result of this history, the landscape of the LWB4-B7 Modification Area has undergone modification through extensive pastoral grazing and some residential development, with native vegetation cleared and foreign grasses introduced (Umwelt 2008b).

The LWB4-B7 Modification Area has been utilised for pastoralism and agriculture since the early nineteenth century. The area encompassing the LWB4-B7 Modification Area was originally part of a number of land grants, several of which were between 100 and 2000 acres. Large land grants across the Cessnock, Ellalong and Quorrobolong parishes included those of local landowners such as Jacob Josephson, George Thomas Palmer, John Browne and John Scholey. Smaller land grants of 20 to 40 acres were taken up across all three parishes with reserves set aside for mining purposes also located within the LWB4-B7 Modification Area.

The coal mining industry has played an important role in the development of the wider area since early settlement and has been one of the primary economic and social drivers in the area. In particular, the South Maitland Coalfields played a dominant role in the development of Newcastle and the lower Hunter Valley region. These coalfields have been a constant contributing factor in the establishment of settlement and industry with the local area since the nineteenth century.

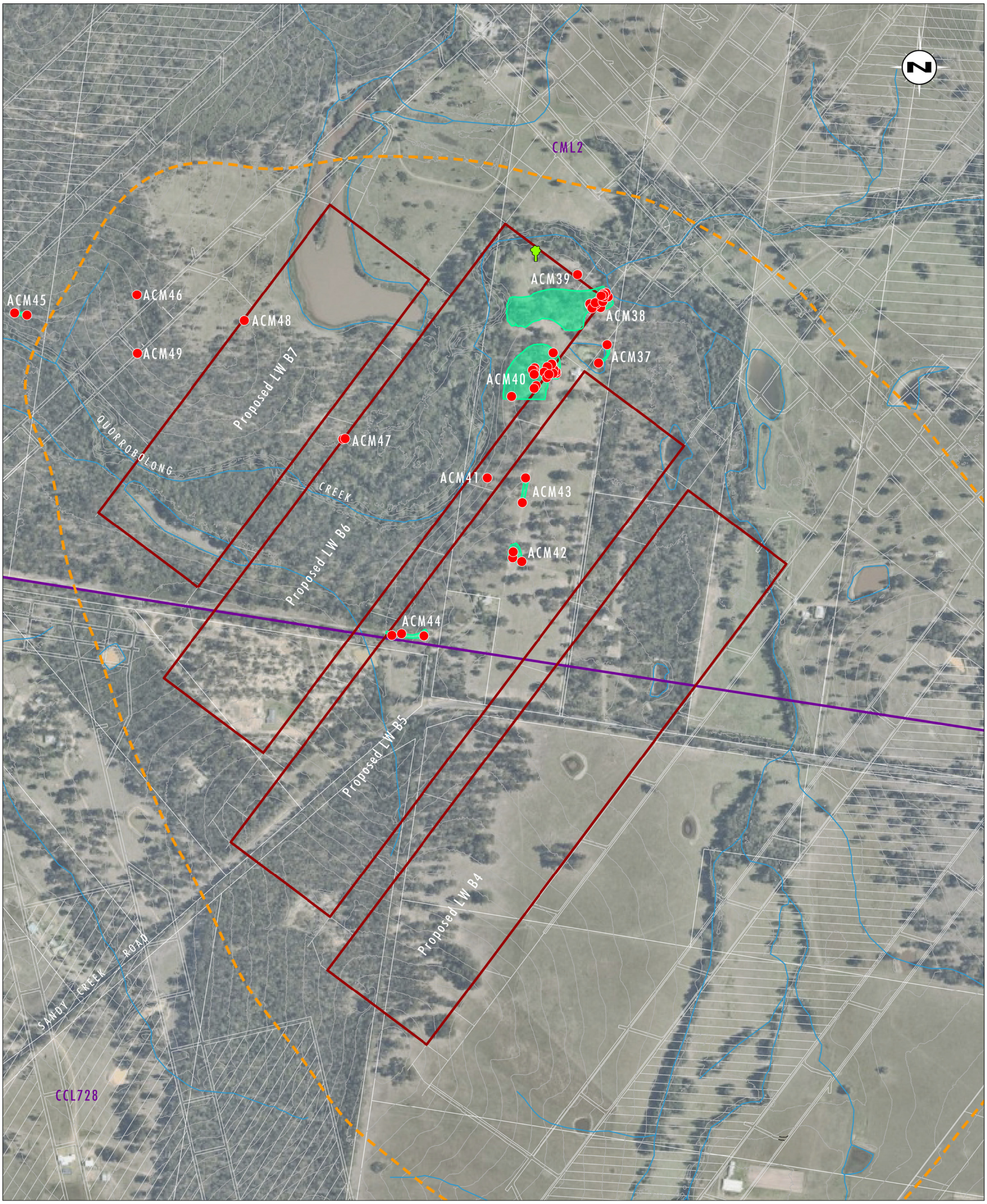

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)
Note: Contour Interval 2m

0 100 250 500m
1:10 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Mining Lease Boundary
- Complete Underground Workings
- Archaeological Site Area
- Artefact Location
- Tree with Non-cultural Scarring

FIGURE 6.10

Location of Newly Recorded Aboriginal Archaeological Sites within LWB4-B7 Modification Area

File Name (A4): R01/3900_098.dgn
20170516 9.02

6.7.2 Heritage Searches

As part of the historical heritage assessment of the LWB4-B7 Modification Area, a review of relevant heritage databases was undertaken including:

- Cessnock Local Environment Plan (LEP) 2011.
- NSW State Heritage Register
- State Heritage Inventory
- Australian Heritage Database (including Commonwealth and National Heritage lists and the Register of the National Estate).

The database review identified one locally listed heritage item located partially within the north-western portion of the LWB4-B7 Modification Area. A small portion of the extensive listing comprising the Collieries of the South Maitland Coalfields/Greta Coal Measures locally listed Item I215 is located within the north-western portion of the LWB4-B7 Modification Area (refer to **Figure 6.11**). The Collieries of the South Maitland Coalfields/Greta Coal Measures is listed under Schedule 5 of the Cessnock LEP 2011 as being of local heritage significance and comprises multiple sites throughout the Cessnock local government area.

6.7.3 Site Visit

A visual inspection of the LWB4-B7 Modification Area was undertaken on 7 and 8 February 2017 by Joshua Madden, Senior Archaeologist Umwelt. No structures relating to the Collieries of the South Maitland Coalfields/Greta Coal Measures locally listed item (I215) were identified during the site inspection, however a number of remnant rural infrastructure items were identified including a former timber cattle yard and a former brick creek crossing (refer to **Plate 6.1** – **Plate 6.3**). The heritage significance of these structures is assessed in **Section 6.7.4**.

Plate 6.1 View of the former cattle yard within the LWB4-B7 Modification Area

Plate 6.2 View northeast overlooking dam and location of former crossing

© Umwelt, 2017

Plate 6.3 Close up of the bricks used for the crossing

© Umwelt, 2017

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- Cessnock LEP Item I215 - Collieries of the South Maitland Coalfields/Greta Coal Measures

FIGURE 6.11

Listed Heritage Items

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20170515 14.45

6.7.4 Significance Assessment

The Collieries of the South Maitland Coalfields/Greta Coal Measures (item I215) is listed under Schedule 5 of the Cessnock LEP 2011 as being of local heritage significance.

The land in the area of item I215 is owned by Austar Coal Mine and is the site of the former Cessnock No. 1 Colliery (also known as Kalingo Colliery). Infrastructure relating to the Cessnock No. 1 Colliery is located mainly near a mine water management Kalingo Dam, which is currently in use for the Austar Coal Mine. The Cessnock No. 1 infrastructure items are outside the LWB4-B7 Modification Area.

It is noted that the South Maitland Coalfields, being one of Australia's richest coal deposits (at the time), provided the economic base for the region and led to the establishment of a number of towns in the area. The colliery sites are identified as significant as they provide evidence of the former wealth and activity of the area, and also the extent of demolition that occurred to mine complexes in the 1970s.

An assessment of the heritage significance of the former cattle yard and the brick creek crossing found these to be common items of rural infrastructure found across the Hunter Valley region. As such, both of the former cattle yard and the brick creek crossing are not considered to be of either local or state significance as they do not meet the requirements of the State Heritage Inventory on a local or state level.

6.7.5 Impact Assessment

The significance assessment found that the Collieries of the South Maitland Coalfields/Greta Coal Measures is of local heritage significance and no structures relating to the listing were identified within the Modification Area. No other items of heritage significance are located within the LWB4-B7 Modification Area.

The portion of the modification area that is partly located within the mapped area of the Collieries of the South Maitland Coalfields/Greta Coal Measures (Item I215) is very small, and the land is undeveloped and comprises forest vegetation. The LWB4-B7 Modification does not involve any additional surface development and therefore will have no direct impact on the locally listed heritage item. There is also not predicted to be any indirect impacts on the locally listed heritage item as a result of subsidence or alteration of view corridors to or from the listed item. Therefore, the proposed LWB4-B7 Modification will not impact on the significance of The Collieries of the South Maitland Coalfields/Greta Coal Measures.

The LWB4-B7 Modification Area is typical of a rural landscape within the Hunter Valley region. There is not expected to be any perceptible impacts to the open rural nature of the landscape as a result of the modification.

6.7.6 Management Strategies

The LWB4-B7 Modification will not impact on the significance of any known or potential heritage items.

No change to the existing historical heritage management measures outlined in the Austar Historic Heritage Management Plan (Austar 2014) is required for the modification.

6.8 Land Resources and Agriculture

As discussed in **Section 1.3**, one soil landscape type is found within the LWB4-B7 Modification Area, being the Quorrobolong soil landscape (Kovac and Lawrie 1991) (refer to **Figure 1.6**). The main soils within this landscape are prairie soils occurring in drainage depressions and on lower slopes. They are generally poorly drained, have moderate permeability and the upper horizon has moderate erodibility (Kovac and Lawrie 1991). The soils are moderately fertile and the main land use is generally grazing on unimproved pasture.

The land and soil capability mapping undertaken for the Upper Hunter SRLUP 2012 indicates the LWB4-B7 Modification Area is mapped as Class 2, Class 4 and Class 5 Land and Soil Capability (refer to **Figure 6.12**). Class 2 land is considered to be capable of a wide variety of uses such as cropping, grazing, horticulture, forestry or nature conservation. Class 4 and 5 land is considered to be land capable of a variety of land uses, such as cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry and nature conservation (OEH 2012). The definition for each class identified is provided in **Table 6.6**

Table 6.6 Land and Soil Capability Classes (OEH 2012)

LSC Class	General Definition
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)	
2	Very high capability land (slight but significant limitation): Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
4	Moderate capability land: Land has moderate to high limitations for high impact land uses. Will restrict land management options for regular, high impact land uses such as cropping, high intensity grazing and horticulture. These limitations can only be managed by specialized management practices with a high level of knowledge, expertise, inputs, investment and technology.
5	Moderate-low capability land: Land has high limitations for high impact uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long term degradation.

Assessment of the potential subsidence impacts on the land surface and hydrological regime conclude that the risk of surface cracking is low, as is the potential for adverse impacts on water availability or erosion. Given the minimal impacts predicted to the land surface and hydrological regime, it is unlikely that the LWB4-B7 Modification would have any impact on the current or future land and soil capability of the LWB4-B7 Modification Area.

Visual monitoring of the land surface within the LWB4-B7 Modification Area will be undertaken before, during and following mining to determine the need for any subsidence management or remediation measures, as described in **Section 6.2.4** and **Section 7.1**. The objective of any subsidence management or remediation measures would be to return the land to pre-mining condition or better.

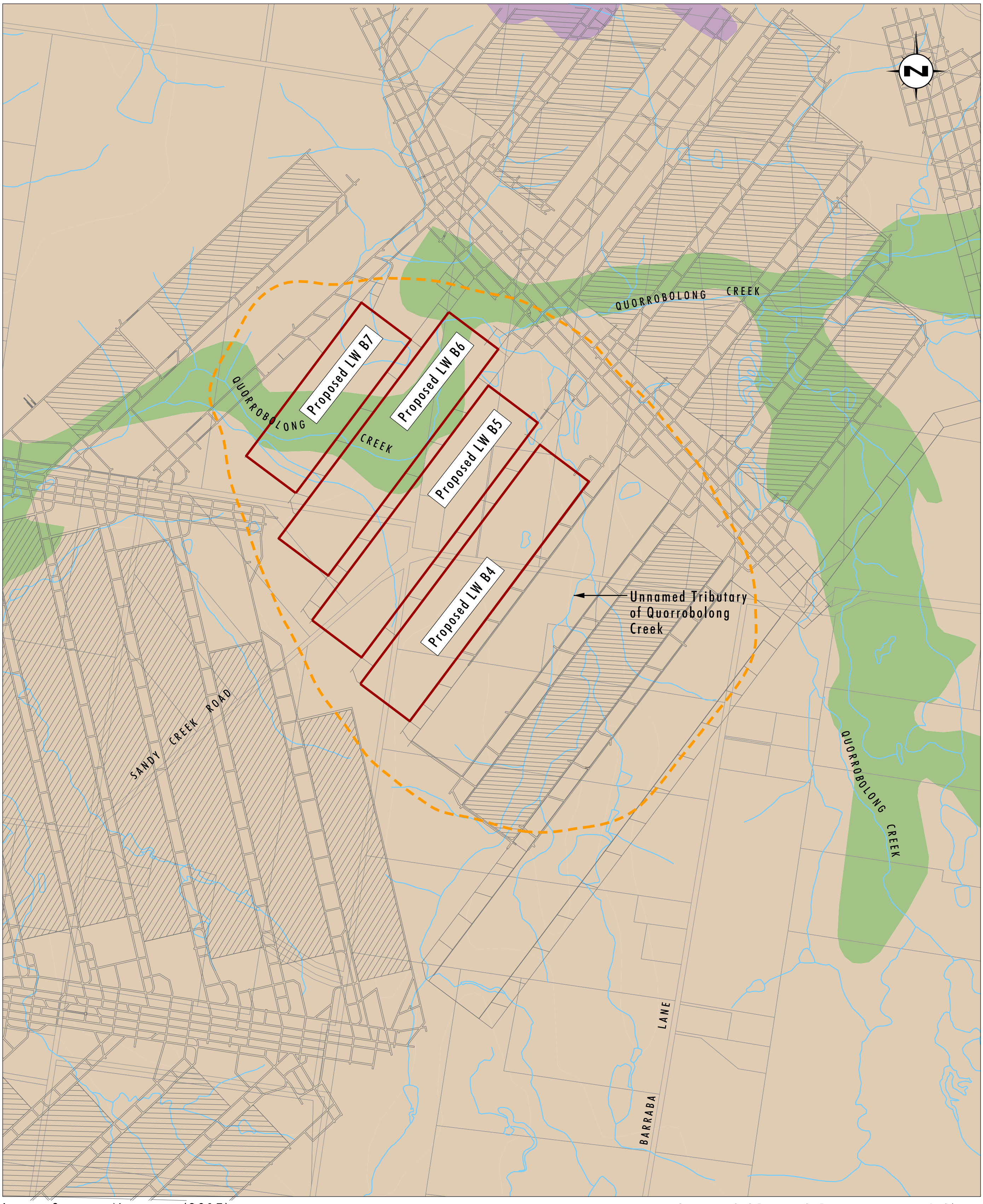

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016), NSW Department of Environment, Climate Change and Water (2010)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Class 2 - Suitable for Regular Cultivation
- Class 4 - Suitable for Grazing with Occasional Cultivation
- Class 5 - Suitable for Grazing with No Cultivation
- Completed Underground Workings
- Drainage Line

FIGURE 6.12

Land Capability

6.8.1 Agricultural Impacts

Portions of the LWB4-B7 Modification Area are currently used for agricultural purposes, including grazing, with some rural residential use. The LWB4-B7 Modification is not expected to restrict the ongoing use of the land for agricultural or rural residential purposes as all residential and rural structures are expected to have manageable minor impacts and the risk of surface cracking is low. Further, the potential for adverse impacts on water availability and farm dams is minimal. There are no registered active private bores located within the LWB4-B7 Modification Area and there is not predicted to be any significant impact on the storage capacities of farm dams. In the unlikely event that the proposed modification were to result in cracking or leakage of water from a farm dam wall, this could be readily repaired. Land is expected to remain safe for continued grazing and agricultural use throughout mining (refer to **Section 6.2**).

Visual monitoring of the natural and built features within the LWB4-B7 Modification Area will be undertaken before, during and following mining to determine the need for any subsidence management measures, as described in **Section 6.2.4**.

Any subsidence related impacts to rural buildings, fences or farm dams will be repaired in accordance with individual Built Features Management Plans to be prepared in consultation with potentially affected landholders.

6.8.2 Compatibility with Surrounding Land Uses

The LWB4-B7 Modification Area is located within a rural environment. The dominant land use within and surrounding the modification area is grazing and mining, with some rural residential use. The small township of Ellalong is located approximately 2 kilometres west of the LWB4-B7 Modification Area and the villages of Kitchener and Pelton are located approximately 4 kilometres to the northeast and northwest respectively (refer to **Figure 1.1**).

As previously discussed, the LWB4-B7 Modification does not involve any additional surface development and due to the predicted minimal impacts on the ground surface associated with subsidence, is unlikely to have any adverse impacts on current land uses. Austar Coal Mine has coexisted with existing and previous land uses since it recommenced mining in Bellbird South in 2005 and the LWB4-B7 Modification is also considered compatible with existing surrounding land uses.

6.8.3 Management and Monitoring

The predicted impact of subsidence on land and agricultural resources is minimal, with impacts likely to be less than that previously experienced in the Stage 2 and Stage 3 LTCC extracted areas. Based on this outcome, Austar will continue to implement the management strategies currently in place at the Austar Coal Mine, consistent with those outlined in the approved LWB1-B3 Extraction Plan Land Management Plan (Austar, 2016a). An Extraction Plan Land Management Plan that includes the LWB4-B7 Modification Area will be prepared as part of the Extraction Plan process for LWB4-B7.

6.9 Greenhouse Gas and Energy Assessment

A detailed greenhouse gas and energy assessment (GHGEA) has been prepared for the LWB4-B7 Modification by Umwelt. The findings of the GHGEA are provided below.

6.9.1 Assessment Methodology

The GHGEA framework is based on the methodologies and emission factors contained in the National Greenhouse Accounts Factors 2016. The assessment framework also incorporates the principles of The Greenhouse Gas Protocol 2004.

The Greenhouse Gas Protocol (The Protocol) provides an internationally accepted approach to greenhouse gas accounting. The Protocol provides guidance on setting reporting boundaries, defining emission sources and dealing with issues such as data quality and materiality. The Protocol defines three 'Scopes' of emissions for greenhouse gas accounting and reporting purposes. These scopes are briefly outlined below (WRI/WBCSD 2004):

Scope 1 emissions are direct emissions which occur from sources owned or controlled by the proponent, over which they have a high level of control (such as fuel use).

Scope 2 emissions are those generated from purchased electricity consumed by the proponent, which can be easily measured and can be influenced through energy efficiency measures. Scope 2 emissions physically occur at the facility where electricity is generated (i.e. the power station).

Scope 3 emissions are indirect emissions that are a consequence of the activities of the proponent, but occur at sources owned or controlled by another reporting entity (e.g. outsourced services). Scope 3 emissions can include emissions generated upstream of the facility by providers of energy, materials and transport. Scope 3 emissions can also include emissions generated downstream of the facility by providers of product transport.

Scope 1 and 2 emissions were calculated based on the methodologies and emission factors provided by the National Greenhouse Accounts Factors 2016 (DEE 2016). Consistent with the National Inventory Report 2012 (DIICCSRTE 2014), ventilation fugitive emissions were forecast using an implied emissions factor, which was derived from site specific National Greenhouse and Energy Reporting data.

Scope 3 emissions associated with product transport were calculated based on emission factors contained in the National Greenhouse Gas Inventory: Analysis of Recent Trends and Greenhouse Gas Indicators (AGO 2007). Other Scope 3 emissions were calculated using methodologies and emission factors contained in the National Greenhouse Accounts Factors 2016 (DEE 2016).

6.9.2 Assessment Assumptions

To complete the greenhouse gas and energy calculations, the following assumptions were made consistent with existing and approved operations at Austar Coal Mine (noting that operations may vary up to approved limits in response to operational requirements):

- the LWB4-B7 Modification will recover an additional 3.65 million ROM tonnes of coking coal over three years
- diesel use intensity, electricity use intensity and fugitive emissions intensity of the LWB4-B7 Modification will be similar to Austar Coal Mine's operations between July 2012 and June 2016
- product yield will average 90 per cent
- average methane percentage of ventilations will not exceed 0.1%, and therefore will not trigger the use of post mining fugitive emission factors

- the rail distance from Austar Coal Mine to Newcastle is approximately 75 kilometres
- all product railed to Newcastle will be exported and shipped an average distance of 9,500 kilometres
- 10,000 tonne of product per annum will be trucked to Newcastle and shipped 1,095 kilometres to Tasmania, consistent with existing approvals
- the return road distance to Newcastle is 100 kilometres
- diesel will be supplied from Newcastle.

6.9.3 Assessment Results

The greenhouse emissions associated with the LWB4-B7 Modification were calculated as follows:

- approximately 315,000 tonnes carbon dioxide equivalent (t CO_2-e) of Scope 1 emissions from combusting diesel and releasing fugitive emissions
- approximately 132,000 t CO2-e of Scope 2 emissions from consuming electricity
- approximately 9,480,000 t CO2-e of Scope 3 emissions generated by third parties who transport and consume coal products.

Scope 3 emissions dominate the greenhouse gas emissions attributable to the LWB4-B7 Modification. Approximately 95 per cent of the proposed modification's greenhouse gas emissions will occur either upstream or downstream of the Austar Coal Mine and outside the direct operational control of Yancoal. Approximately 5 per cent of the greenhouse gases associated with the LWB4-B7 Modification is related to on-site energy use and fugitive emissions (Scope 1 and 2 emissions).

Scope 1 emissions are expected to contribute 3.2 per cent of total emissions due to the relatively low diesel demands of an underground mine and the relatively low methane content of the coal reserves within the Austar Coal Mine. The coal reserves within the Austar Coal Mine are part of the Newcastle Coalfields, which generally exhibit lower fugitive emissions than the Southern, Hunter and Bowen Coalfields (National Inventory Report 2011). The average methane gas content of ventilation emissions from the Austar Coal Mine during 2015/16 was approximately 0.048% (Austar 2016b).

6.9.3.1 Energy Use

The LWB4-B7 Modification is forecast to require approximately 701,000 gigajoules (GJ) of energy from diesel and grid electricity.

The industry average energy use for underground coal mines in Australia ranges between 140 and 490 Megajoules (MJ)/Product tonne (Energetics 2009). The energy use intensity of the LWB4-B7 Modification is expected to average 213 MJ/Product tonne, which sits within the normal operating range for Australian underground coal mines.

6.9.4 Impact Assessment

The greenhouse gas emissions generated by the LWB4-B7 Modification have the potential to impact the physical environment and the greenhouse gas reduction objectives of national and international governing bodies. The following assessment makes the distinction between environment impacts and impacts on policy objectives.

6.9.4.1 Impact on the Environment

The LWB4-B7 Modification's greenhouse gas emissions will have a disperse impact as they are highly mobile and are generated up and down the supply chain. The accumulation of greenhouse gases or carbon in 'carbon sinks' is the primary impact of greenhouse gas emissions. Since the industrial revolution, anthropogenic greenhouse gas emissions have accumulated in three major carbon sinks - the ocean (30%), terrestrial plants (30%) and the atmosphere (40%) (BOM and CSIRO, 2014).

The accumulation of greenhouse gases in the atmosphere is an important driver of global warming; sea level rise and climate change (IPCC 2013). Sea level rise and climate change may have many ramifications for the natural and built environment. The accumulation of greenhouse gases in the ocean is an important driver of ocean acidification (IPCC 2013).

The LWB4-B7 Modification's direct emissions are forecast to be approximately 105,000 t CO_2–e per annum.

To put the LWB4-B7 Modification's emissions into perspective, under current policy settings, global greenhouse gas emissions are forecast to reach 56,200,000,000 t CO_2-e per annum by 2025 (UNEP 2016). During operation, the LWB4-B7 Modification will contribute approximately 0.00019 per cent to global emissions per annum (based on its projected Scope 1 emissions). The Scope 2 and 3 emissions associated with the LWB4-B7 Modification will be generated by greenhouse gas sources outside the LWB4-B7 Modification boundary and are attributable to other projects / facilities.

6.9.4.2 Impact on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) define climate change as a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties, and persists for an extended period, typically decades or longer (IPCC 2007).

Climate change is caused by changes in the energy balance of the climate system. The energy balance of the climate system is driven by atmospheric concentrations of greenhouse gases and aerosols, land cover and solar radiation (IPCC 2007).

Climate change models forecast many different climate change impacts, which are influenced by future greenhouse gas emission scenarios. Climate change forecasts also vary significantly from region to region.

A qualitative assessment of climate change requires a regional reference and future emission trajectory assumptions. The LWB4-B7 Modification, in isolation, is unlikely to influence global emission trajectories. Future emission trajectories will largely be influenced by global scale issues such as; technology, population growth and greenhouse gas mitigation policy. NSW climate change projections have been modelled by the NSW and ACT Regional Climate Modelling (NARCliM) project. NARCliM has modelled climate change projections for 2030 and 2070, using the IPCC high emissions A2 emission trajectory scenario. The A2 scenario assumes (IPCC 2000):

- Relatively slow demographic transition and relatively slow convergence in regional fertility patterns.
- Relatively slow convergence in inter-regional GDP per capita differences.
- Relatively slow end-use and supply-side energy efficiency improvements (compared to other storylines).
- Delayed development of renewable energy.

- No barriers to the use of nuclear energy.

The LWB4-B7 Modification is consistent with the A2 emissions trajectory scenario; therefore the climate change projections developed by NARCliM seem a reasonable basis for a qualitative climate change impact assessment. NARCliM makes the following climate change projections for NSW:

- Maximum temperatures are projected to increase
- Minimum temperatures are projected to increase
- The number of hot days will increase
- The number of cold nights will decrease
- Rainfall is projected to decrease in spring and winter
- Rainfall is projected to increase in summer and autumn
- Average fire weather is projected to increase in summer and spring
- Number of days with severe fire danger is projected to increase in summer and spring (Adapt NSW 2016).

The extent to which global emissions and atmospheric concentrations of greenhouse gases have a demonstrable impact on climate change will be largely driven by the global response to reducing total global emissions that includes all major emission sources and sinks.

6.9.4.3 Impact on Policy Objectives

The United Nations Framework Convention on Climate Change (UNFCCC) is the leading international forum for setting climate change targets and objectives. In 2015 the UNFCCC successfully negotiated an international climate change agreement between 195 countries (the Paris Agreement). The Paris Agreement aims to:

- hold the increase in the global average temperature to well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels
- increase the ability [of nations] to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production, and
- make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

The Paris Agreement seeks to meet its objectives by developing programs and mechanisms that:

- require participating Parties to prepare and communicate greenhouse gas mitigation contributions. Parties are expected to set mitigation targets for 2020, and then develop new targets every five years. Each successive target is expected to represent a larger mitigation effort than the previous target
- promote climate change resilience and adaptation
- provide mitigation and adaptation funding to developing countries

- foster mitigation and adaptation technology transfer between Parties, and
- require participating Parties to report progress towards their mitigation contributions on an annual basis.

Australia's commitment to the Paris Agreement includes reducing greenhouse gas emissions by 26 – 28 per cent, on 2005 levels, by 2030 (Commonwealth of Australia, 2015). To meet the requirements of the Paris Agreement, Australia will also have to develop interim targets for 2020 and 2025.

While the LWB4-B7 Modification is likely to increase the mitigation effort required to reach the 2020 target to some minor extent, the LWB4-B7 Modification itself is unlikely to prevent the Federal Government achieving its national greenhouse gas targets.

6.9.5 Greenhouse Gas and Energy Management and Monitoring

Austar has incorporated measures into the proposed modification's design which aim to minimise potential greenhouse gas emissions and improve energy efficiency. The proposed modification requires only minimal additional mine development works and utilises existing infrastructure. Through this efficiency of mine development, the modification inherently minimise greenhouse gas emissions from the mining operations.

The Austar Coal Mine Air Quality and Greenhouse Gas Management Plan reviewed potential for fugitive methane emission management controls for pre-drained coal mine waste gas and ventilation air methane. Technologies such as flaring, methane capture, on-site energy production and thermal flow reversal reactors were all evaluated in 2013, however, the naturally low methane concentrations available in coal mine waste gas and ventilation streams challenged the technical feasibility of all technologies (Austar 2013).

Managing energy use is the primary greenhouse gas management control option at the Austar Coal Mine (Austar 2013). Austar will continue to seek operational energy use efficiencies where commercially feasible.

6.10 Cumulative Impacts

The assessment of environmental impacts undertaken for the LWB4-B7 Modification is provided in **Sections 6.1** to **6.9** above. The LWB4-B7 Modification is located within an area surrounded by previous underground mine workings. The potential subsidence impacts of the proposed modification on natural and built features have been assessed and found to be less than those previously experienced in the Stage 2 and Stage 3 LTCC extracted areas. The cumulative impacts of the subsidence associated with the LWB4-B7 Modification Area have been assessed in the context of approved mining within the LWB1-B3 and Stage 3 areas and predicted cumulative subsidence has been found to be less than that predicted for approved Stage 2 and Stage 3 mining areas. Houses and other built infrastructure, including rural buildings, are predicted to remain safe, serviceable and compatible with existing land uses.

The flood modelling results presented in the flooding and drainage assessment (refer to **Section 6.3** and **Appendix 3**) has included consideration of the cumulative impact of all approved mining within the LWB1-B3, Stage 2 and Stage 3 areas in the flood modelling, ensuring consideration of the cumulative landform changes associated with mining in these areas. The cumulative impacts of the LWB4-B7 Modification with all approved mining have been found to be minimal.

The groundwater assessment summarised in **Section 6.4** considers the potential cumulative impacts of previous underground mining in the region when assessing the potential impact on groundwater and found the potential for adverse impact to also be minimal.

The ecological assessment presented in **Section 6.5** concludes that the LWB4-B7 Modification is unlikely to result in a significant impact on vegetation or the habitats of threatened fauna species. Therefore the potential cumulative impact of the LWB4-B7 Modification on the ecological values of the area is not expected to be significant.

The assessment of impacts on Aboriginal cultural heritage presented in **Section 6.5** concludes the LWB4-B7 Modification is unlikely to impact on the archaeological sites identified within the modification area and is therefore unlikely to result in an increase in the cumulative impact on Aboriginal cultural heritage within the area.

The cumulative impact of the LWB4-B7 Modification with surrounding historical and approved mining activities has been considered in the context of land and agricultural capability (refer to **Section 6.8**). Given the minimal land surface and hydrological impacts predicted, it is unlikely to impact on the current or future land and soil capability of the modification area and is considered compatible with existing agricultural, rural residential and mining land uses within the modification area.

The greenhouse gas emissions generated by the proposed modification have been assessed cumulatively in the context of national and global emissions. Consideration of the impact of these emissions on climate change, national policy objectives and international objectives found the proposed modification is unlikely to prevent the Federal Government achieving its objectives.

Overall, the cumulative impact of the LWB4-B7 Modification is considered to be low.

7.0 Summary of Management and Monitoring

7.1 Subsidence

7.1.1 Austar will submit an Extraction Plan for LWB4-B7 for approval by the Secretary of the Department of Planning and Environment prior to the commencement of secondary extraction of LWB4-B7. The Extraction Plan will incorporate the following management plans:

- Water Management Plan
- Land Management Plan
- Biodiversity Management Plan
- Built Features Management Plan
- Subsidence Monitoring Program
- Public Safety Management Plan.

7.1.2 Where a potential subsidence impact is identified on private property, Austar will prepare a Built Features Management Plan in consultation with the property owner. This plan will clearly outline potential impacts of mining on the property and the management and remediation measures to be implemented.

7.1.3 Subsidence management measures to be implemented as part of the proposed modification will include (where access to private landholdings allow):

- subsidence monitoring lines to be located as determined as part of the Extraction Plan process
- visual assessment of natural features before, during and following mining to detect any subsidence impacts such as surface cracking, irregularities in the subsidence profile, erosion, changes in drainage patterns or loss of water from drainage structures
- detailed subsidence monitoring in accordance with DPE – Resources and Energy requirements
- remediation and rehabilitation of subsidence impacts will be carried out, where required, as soon as practicable following subsidence using methods specified in the Extraction Plan
- building structures located within the LWB4-B7 Modification Area will be inspected by a structural engineer prior to and after undermining and appropriate management measures implemented

- farm dams or water bores within the LWB4-B7 Modification Area will be monitored during and following undermining to ensure they remain in a safe and serviceable condition. Remediation works will be undertaken as required by the Subsidence Advisory NSW in consultation with the landowner

- in the event of any significant loss of water from a privately-owned farm dam, Austar will provide an alternate source of water, as required, until the dam is repaired.

7.1.4 Austar will, prior to undermining of Sandy Creek Road, prepare and implement a Built Features Management Plan to manage any subsidence impacts on the roads and associated culverts in consultation with Cessnock City Council.

7.1.5 Austar will prepare management plans in consultation with relevant service providers (Ausgrid, Telstra), for the protection of infrastructure and services within the LWB4-B7 Modification Area to ensure these remain in a safe and serviceable condition throughout the mining period. These plans will be prepared as part of the Extraction Plan prior to undermining of the services in the LWB4-B7 Modification Area.

7.1.6 Austar will prepare and implement a Built Features Management Plan with DPI Water to manage any subsidence impacts on DPI Water monitoring bores in consultation with DPI Water.

7.2 Surface Water and Drainage

7.2.1 Austar will prepare a Water Management Plan that includes the LWB4-B7 Modification Area for approval as part of the Extraction Plan process, in consultation with DPI Water.

7.2.2 Drainage lines will be monitored and any subsidence related impacts effectively remediated, where access is granted, such that there is no significant impact on downstream water users and environmental flows. The Water Management Plan to be prepared as part of the Extraction Plan process will guide the monitoring and management of subsidence impacts and drainage line remediation works on surface water systems, where required. The Water Management Plan will include:

- a monitoring program, including a channel stability monitoring program for those reaches of Quorrobolong Creek where velocity and tractive stress changes have been predicted by the modelling

- a program to complete drainage remediation works in a timely manner where required, post-subsidence

- rehabilitation objectives for drainage line remediation works (if required) such that the rehabilitated drainage lines maintain a similar channel form and sinuosity to the pre-mining environment.

7.2.3 Monitoring results will be reported annually in the Annual Environmental Management Report.

7.3 Groundwater

7.3.1 A groundwater monitoring program will be implemented for the LWB4-B7 Modification as outlined in **Appendix 4.** The groundwater monitoring program will be reflected in the Extraction Plan Water Management Plan and will include:

- continued monitoring of water level and water quality in shallow piezometers within the Stage 2 and LWB1-B3 mining area in accordance with the existing Site Water Management Plan (Austar 2013b) and Environmental Monitoring Program (Austar 2013c)
- Establishment of one shallow groundwater monitoring bore in the alluvial area of Quorrobolong Creek at a location above LWB6 or LWB7, and monitoring of water level and electrical conductivity (EC) on a regular basis
- reconcile groundwater monitoring data against rainfall records to assess whether groundwater level changes are the result of longwall mining impacts
- review of the results of groundwater monitoring on a three-monthly basis and report results annually in accordance with Annual Environmental Management Report requirements, consistent with the requirements of the existing Site Water Management Plan (Austar 2013b).

7.3.2 In the unlikely event that damage occurs to DPI Water monitoring bores in the vicinity of the modification area, the bores would be repaired or replaced as required in consultation with DPI Water.

7.4 Ecology

7.4.1 Austar will prepare a Biodiversity Management Plan that includes the LWB4-B7 Modification Area for approval as part of the Extraction Plan process.

7.4.2 Ecological monitoring will be undertaken of the River-flat Eucalypt Forest EEC vegetation occurring within the predicted additional 1.5 hectares area of ponding; Lower Hunter Spotted Gum – Ironbark Forest EEC and potential Quorrobolong Scribbly Gum Woodland EEC vegetation (subject to landholder access being granted).

7.4.3 Ecological monitoring will be undertaken of the heath wrinklewort (*Rutidosis heterogama*) population, small-flower grevillea (*Grevillea parviflora subsp. parviflora*) population and the netted bottlebrush (*Callistemon linearifolius*) population, where EEC monitoring indicates further surveys of threatened flora species populations is required.

7.5 Heritage

7.5.1 Austar will continue to implement the management strategies that are currently in place at the Austar Coal Mine, including those in the ACHMP (Austar 2017). The ACHMP will be updated to include provisions for the monitoring of identified archaeological sites within the LWB4-B7 Modification Area.

7.6 Land Resources and Agriculture

7.6.1 Austar will prepare a Land Management Plan that includes the LWB4-B7 Modification Area for approval as part of the Extraction Plan process.

7.7 Greenhouse Gas and Energy

7.7.1 Austar will continue to seek operational energy use efficiencies, where commercially feasible, in accordance with the existing Austar Coal Mine Air Quality and Greenhouse Gas Management Plan.

7.8 Vibration

7.8.1 Austar will continue to implement the vibration management strategies that are currently in place at the Austar Coal Mine, including those in the existing Austar Noise and Vibration Management Plan. Vibration monitoring will be undertaken to monitor the potential vibration impacts of the LWB4–B7 Modification, subject to landholder access.

7.9 Community

7.9.1 Austar will continue to operate the established Community Consultative Committee. Austar will provide the Community Consultative Committee with regular information regarding the environmental management performance of the LWB4-B7 Modification and any relevant matters regarding community relations.

7.9.2 Austar will notify relevant landholders prior to the commencement of any secondary extraction that could potentially impact their property, in accordance with agreed communication protocols set out in an individual Built Features Management Plan. Regular updates will also be provided as part of the Extraction Plan process.

7.9.3 Austar will maintain a 24 hour per day community information and complaint line.

7.9.4 Austar will provide regular updates of mine development and monitoring on the Austar Coal Mine website.

7.10 Environmental Management, Monitoring and Reporting

7.10.1 In addition to specific reporting requirements that may described in the Extraction Plan for LWB4-B7 (should the modification be approved), Austar will incorporate a summary of the subsidence monitoring results into the Annual Environmental Management Report for Austar Coal Mine.

8.0 Conclusion

This section provides a conclusion discussing the justification for the proposed modification, taking into consideration the environmental impacts of the proposal and the suitability of the site, to assist the consent authority to determine whether or not the proposed modification is in the public interest.

8.1 Environmental Impacts

The potential environmental impacts of the LWB4-B7 Modification have been identified through a preliminary environmental risk assessment process involving:

- assessment of the site characteristics
- review of existing expert technical assessments, management plans and historical monitoring data
- consultation with government agencies and the community
- expert technical advice.

The key issues identified were the subject of comprehensive technical assessment to identify and assess the potential impacts of the LWB4-B7 Modification on the existing environment and community. The results of these assessments are detailed in **Section 6**.

The detailed impact assessments undertaken for the LWB4-B7 Modification conclude that the proposed modification is likely to result in minimal environmental impacts. This is primarily due to the following factors:

- the characteristics of the site
- the depth of cover to proposed mining areas (minimum of 400 metres)
- the panel dimensions and extraction height (about 3.4 metres)
- experience to date in monitoring and management of subsidence in the Stage 2, Stage 3 and LWB1-B3 mining areas
- predicted subsidence parameters and impacts from conventional longwall mining will be less than those previously experienced in Stage 2 and Stage 3 LTCC extracted areas.

8.2 Suitability of the Site

The LWB4-B7 Modification Area is located in an area of existing mining leases with an extensive history of underground mining. Access to the LWB4-B7 Modification Area is provided by existing underground mine workings and coal extracted from LWB4-B7 can be transported and processed utilising existing infrastructure within the Austar Coal Mine.

The LWB4-B7 Modification Area is located beneath a mix of Austar owned land, privately owned rural land, and Crown landholdings. The primary land use within and surrounding the modification area is agricultural grazing, with six private rural dwellings located within the area. The topography of the land is generally characterised by low undulating hills and creek flats, with no steep slopes or cliffs. The LWB4-B7 Modification does not involve any additional surface development and due to the predicted minimal impacts on the ground surface associated with subsidence, is unlikely to have any adverse impacts on current land uses. Existing management and monitoring programs will be extended to the LWB4-B7 Modification Area in order to identify and manage potential impacts on these land uses.

8.3 Ecologically Sustainable Development

Ecologically Sustainable Development (ESD) is one of a number of objectives of the EP&A Act and is defined by Section 6(2) of the *Protection of the Environment Administration Act 1991*. ESD requires the integration of economic and environmental considerations in decision making processes. ESD can be achieved through the implementation of the following principles and programs:

- the precautionary principle
- inter-generational equity
- conservation of biological diversity and ecological integrity
- improved valuation, pricing and incentive mechanisms.

These principles which are discussed further in **Sections 8.3.1** to **8.3.4** have been incorporated into planning and assessment of the LWB4-B7 Modification.

8.3.1 The Precautionary Principle

Environmental assessment involves the prediction of potential environmental outcomes of a development. The precautionary principle reinforces the need to take risk and uncertainty into account, especially in relation to threats of irreversible environmental damage.

A preliminary environmental risk analysis was undertaken for the LWB4-B7 Modification to identify key areas for further impact assessment. The results of the risk assessment are summarised in **Section 6.1**. A review of appropriate mitigation measures and strategies was also undertaken as a part of the detailed impact assessment process. The Precautionary Principle has therefore been applied to the assessment of the LWB4-B7 Modification through:

- careful design and review of the proposed modification
- identification of the potential impacts and the likelihood and consequences of these impacts
- identification of management and mitigation measures that are designed to address the potential environmental impacts of the proposed modification
- implementation of monitoring and reporting mechanisms for the modification.

Mitigation and monitoring measures will be set out in the Extraction Plan and associated management plans. Where residual risks are identified, contingency controls have been considered and will be further refined during preparation of the Extraction Plan for the LWB4-B7 Modification Area.

8.3.2 Intergenerational Equity

Intergenerational equity is based on the principle that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations. The principles of intergenerational equity are addressed by the LWB4-B7 Modification through the development and implementation of management and mitigation measures that are designed to address the potential environmental impacts of the proposed modification.

8.3.3 Conservation of Biological Diversity

A detailed assessment of the ecological and biodiversity impacts of the LWB4-B7 Modification has been undertaken and concluded that the proposed modification will result in minimal adverse impact to the land surface or ecological values of the area.

Austar will continue to implement the management measures currently in place within the Austar Coal Mine, and those proposed as part of a LWB4-B7 Biodiversity Management Plan, to minimise potential impacts on the ecological values of the modification area. Environmental monitoring will be undertaken to determine whether the environmental control measures are operating effectively and enable timely detection of issues and implementation of appropriate management measures if and where required.

8.3.4 Valuation and Pricing of Resources

The efficient and non-wasteful management of resources to maximise the welfare of society, both now and for future generations is central to ESD. The modification maximises the efficient use and management of resources through maximising resource utilisation and the recovery of coal that is readily accessible within existing mining leases and with relatively minimal additional development time and cost. In addition the modification maximises the use of existing infrastructure and facilities.

8.4 Conclusion

Austar proposes to modify the Bellbird South Consent to allow the transfer and processing of coal from four additional longwalls within the Austar Coal Mine. This EA has been prepared to support the LWB4-B7 Modification application under section 75W of the EP&A Act.

The LWB4-B7 Modification is proposed in order to provide business continuity for the Austar Coal Mine in the medium term. The modification will facilitate the recovery of approximately 3.65 Mt of additional ROM coal and maximises the use of existing infrastructure and facilities. The LWB4-B7 Modification is located within an area surrounded by historical mine workings and will be supported by existing surface infrastructure.

The detailed impact assessments undertaken for the LWB4-B7 Modification conclude that the proposed modification is likely to result in minimal environmental impacts. This is primarily due to the significant depth of cover above the coal seam and panel dimensions, the overlying site characteristics and proposed implementation of existing subsidence monitoring, management and mitigation measures.

The LWB4-B7 Modification is not anticipated to have a significant adverse impact on the land surface, natural or built features or on existing land uses within the modification area.

This EA demonstrates that with the continued implementation of existing management and mitigation measures, the proposed modification can proceed within acceptable environmental standards.

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10.0 Abbreviations

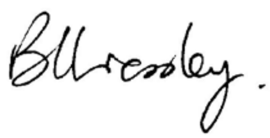
µS/cm	Micro siemens per centimetre
AEMR	Annual Environmental Monitoring Report
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
Austar	Austar Coal Mine Pty Ltd
BoM	Bureau of Meteorology
BMP	Biodiversity management plan
CCL	Consolidated Coal Lease
CHPP	Coal Handling and Preparation Plant
DA	Development Application
EA	Environmental Assessment
EEC	Endangered ecological community
EC	Electrical conductivity
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPA	NSW Environment Protection Authority
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
EPL	Environment Protection Licence
ESD	Ecologically Sustainable Development
GDE	Groundwater dependent ecosystem
GHGEA	Greenhouse Gas and Energy Assessment
ha	Hectare
ICOMOS	International Council on Monuments and Sites
IPCC	Intergovernmental Panel on Climate Change
Km	kilometres
LEP	Local Environmental Plan

LGA	Local Government Area
L/s	Litres per second
LTCC	Longwall Top Coal Caving
LW	Longwall
m	metres
mm	millimetres
MJ	Mega joule
ML	Mining Lease
MOP	Mining Operations Plan
MSEC	Mine Subsidence Engineering Consultants
Mt	Million tonnes
Mtpa	Million tonnes per annum
NT Act	Commonwealth Native Title Act 1993
OEH	NSW Office of Environment and Heritage
PA	Project Approval
PMF	Probable Maximum Flood
PoEO Act	NSW Protection of the Environment Operations Act 1997
RMS	Roads and Maritime Services
ROM	Run of Mine
SEPP	State Environmental Planning Policy
SRLUP	Strategic Regional Land Use Plan
TEC	Threatened ecological community
Umwelt	Umwelt (Australia) Pty Limited
UNFCCC	United National Framework Convention on Climate Change
WM Act	NSW Water Management Act 2000
WSP	Water Sharing Plan
Yancoal	Yancoal Australia Limited

APPENDIX 1

EA Statement of Authorship, Schedule of Lands and Project Team

Statement of Authorship

EA prepared by	
Name:	Barbara Crossley, Director
Qualifications:	Bachelor of Natural Resources (Honours)
Address:	Umwelt (Australia) Pty Limited 75 York Street Teralba NSW 2284
In respect of:	LWB4-B7 Modification of Bellbird South Consent as described in the accompanying Environmental Assessment
Applicant Name:	Austar Coal Mine Pty Ltd
Applicant Address:	Middle Road Paxton NSW 2325
Land to be developed:	See Schedule of Lands attached.
Proposed Development:	LWB4-B7 Modification of Bellbird South Consent as described in the accompanying Environmental Assessment.
Environmental Assessment	An Environmental Assessment is attached.
Certification	I certify that I have prepared the contents of this environmental assessment and to the best of my knowledge: it is in accordance with the relevant provisions of the *Environmental Planning and Assessment Act 1979*, and it is true in all material particulars and does not, by its presentation or omission of information, materially mislead.
Signature:	
Name:	Barbara Crossley
Date:	26 May 2017

Schedule of Lands

This modification application relates to the following land parcels and lease areas located within the LWB4-B7 Modification Area.

Lot	DP
249	755225
18	779060
1	726039
1291	1113215
1292	1113215
4	709474
5	709474
6	709474
41	850188
42	850188
2	775718
1	775718
30	849031
31	849031
201	1136015
2	819222
100	255530
13	866231
A	161957
Part Sandy Creek Road	
Part Barraba Lane	
Part of Consolidated Coal Lease 728	
Part of Consolidated Mining Lease No 2	

Umwelt (Australia) Pty Limited - EA Preparation	
Barbara Crossley, Director B Nat Res (Hons)	Project Director, Environmental Assessment
Gabrielle Allan, Principal Environmental Consultant B Env Sc	Project Manager, Environmental Assessment
Melissa Harrow, Senior Environmental Engineer B Eng (Environmental) (Hons)	Surface Water Assessment
Ruslan Batirov, Environmental Engineer Dip Hydrology Eng	Surface Water Assessment
Susan Shield, Manager Water Resources Engineering* B Eng (Hons)	Surface Water Assessment technical review
Rebecca Vere, Principal Ecologist B Sc (Hons), M Env Management	Ecological Impact Assessment
Chloe Parkins, Ecologist B Env Sc	Ecological Impact Assessment
Nicola Roche, Manager Cultural Heritage B Arts (Anthopology) (Hons)	Aboriginal Cultural Heritage and Archaeological Assessment
Joshua Madden, Senior Archaeologist B Arts (Arch)	Aboriginal Cultural Heritage and Archaeological Assessment
Tim Adams, Principal Archaeologist - Historical Heritage B Arts (Hons) Arch	Historical Heritage Assessment
Malcolm Sedgwick, Principal Consultant - Energy and Greenhouse Gas B Sc, MBA	Greenhouse Gas and Energy Assessment
Rebecca Abbott, Drafting Coordinator	Drafting and Graphic Design

* completed project under contact

Other Specialist Investigations	
Mine Subsidence Engineering Consultants	Subsidence Predictions and Impact Assessment
Peter Dundon	Groundwater Assessment

The assistance of the following Austar and Yancoal personnel during the preparation of this EA is gratefully acknowledged. In addition, personnel from Austar provided details regarding the proposed modification and participated in the consultation process.

Yancoal Australia Limited and Austar Coal Mine Pty Ltd	
Mark Jacobs (Yancoal)	General Manager - Environment & Community
Michael Moore (Yancoal)	Manager - Environmental Standards
Gary Mulhearn (Austar)	Environment & Community Manager
Daniel Lee (Yancoal)	Regional Registered Surveyor NSW

APPENDIX 2

Subsidence Predictions and Impact Assessment

REPORT: SUBSIDENCE PREDICTIONS AND IMPACT ASSESSMENTS

msec
mine subsidence
ENGINEERING CONSULTANTS

Austar Coal Mine:

Longwalls B4 to B7

Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Modification Application for Longwalls B4 to B7 at the Austar Coal Mine

DOCUMENT REGISTER

Revision	Description	Author	Checker	Date
01	Draft Issue	JB	-	9th Feb 17
02	Draft Issue	JB	PD	4th Apr 17
A	Final Issue	JB	PD	10th Apr 17

Report produced to: Support the Modification Application for Longwalls B4 to B7 to be issued to the Department of Planning and Environment.

Associated reports:

MSEC275 (Revision C) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Austar Longwalls A3 to A5 in Support of a SMP Application (February 2007).

MSEC417 (Revision C) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of the Proposed Longwall A5A in Stage 2 at the Austar Coal Mine (July 2010).

MSEC309 (Revision D) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Austar Longwalls A6 to A17 in Support of a Part 3A Application (September 2008).

MSEC484 (Revision A) – Stage 3 – Longwalls A7 to A19 – Subsidence Predictions and Impact Assessments for Natural Features and Surface Infrastructure in Support of a Modification to the Development Consent (May 2011).

MSEC769 (Revision A) – Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Environmental Assessment for a Section 75W Modification Application for the Inclusion of the Proposed Longwalls B1 to B3 at the Austar Coal Mine (October 2015).

MSEC833 (Revision A) – Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan for Longwalls B1 to B3 at the Austar Coal Mine (April 2016).

Background reports available at *www.minesubsidence.com*:-

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Damage to Building Structures (Revision A)

EXECUTIVE SUMMARY

Austar Coal Mine Pty Limited (Austar) has completed the extraction of Longwalls A1 and A2 in Stage 1, Longwalls A3 to A5A in Stage 2 and Longwalls A7 and A8 in Stage 3 of the Austar Coal Mine (the Mine) using Longwall Top Coal Caving (LTCC) mining techniques. Austar has approval to extract Longwalls B1 to B3 in the Bellbird South mining Area and, to date, has completed the extraction of Longwall B2 using conventional longwall mining techniques.

Austar is seeking approval to modify the existing Development Consent (DA 29/95) under Section 75W of the EP&A Act, to facilitate the extraction of four additional longwalls in the Bellbird South mining area, referred to as Longwalls B4 to B7 (LWB4 to LWB7), using conventional longwall mining techniques. The proposed longwalls are located immediately to the north-west of the approved Longwalls B1 to B3 and is a continuation of that series. The locations of the existing and the proposed longwalls in the Greta Seam are shown in Drawing No. MSEC869-01.

The predicted conventional subsidence parameters for the proposed longwalls have been obtained using the Incremental Profile Method. The subsidence model has been calibrated and reviewed using the available ground monitoring data above the previously extracted longwalls at the Mine. The maximum predicted mine subsidence movements due to the extraction of the proposed Longwalls B4 to B7 are: 1,350 mm vertical subsidence; 5.5 mm/m tilt (i.e. 0.55 %, or 1 in 180); 0.05 km^{-1} hogging curvature (20 km minimum radius) and 0.06 km^{-1} sagging curvature (17 km minimum radius).

The Study Area has been defined, as a minimum, as the surface area enclosed by a 26.5° angle of draw line from the extents of the proposed Longwalls B4 to B7 and by the predicted additional 20 mm subsidence contour resulting from the extraction of these proposed longwalls. Other features that could be subjected to far-field or valley related movements and could be sensitive to such movements have also been assessed in this report.

A number of natural and built features have been identified within or in the vicinity of the Study Area including: Quorrobolong Creek and ephemeral drainage lines; Sandy Creek Road and Barraba Lane; box culverts and circular culverts; 11 kV powerlines; copper telecommunications cables; rural structures; farm dams; archaeological sites; survey control marks; and houses.

The surface deformations due to the extraction of Longwalls B4 to B7 are expected to be of a minor nature, with crack widths typically less than 10 to 25 mm. No significant or visible surface cracking has been observed above the previously extracted Longwalls A3 to A8 in Stages 2 and 3 and Longwall B2 in the Bellbird South mining area. The built features have been assessed to experience only slight or minor impacts and they are expected to remain in safe and serviceable conditions throughout the mining period.

The assessments provided in this report indicate that the levels of impact on the natural and built features can be managed by the preparation and implementation of subsidence management strategies. It should be noted that more detailed assessments of the impacts of mine subsidence on some features have been prepared by other consultants, experts in their fields, and the findings in this report should be read in conjunction with the findings in all other relevant reports.

Built Features Management Plans have previously been developed for the approved Longwalls B1 to B3. It is recommended that these management plans are reviewed and updated, as required, to incorporate the proposed Longwalls B4 to B7. Monitoring of ground movements is recommended, as subsidence occurs, to compare the observed ground movements with those predicted, and to periodically review the predictions and impact assessments in the light of measured data.

CONTENTS

LIST OF TABLES, FIGURES AND DRAWINGS

Tables

Tables are prefixed by the number of the chapter or the letter of the appendix in which they are presented.

Figures

Figures are prefixed by the number of the chapter or the letter of the appendix in which they are presented.

Drawings

Drawings referred to in this report are included in Appendix E at the end of this report.

Drawing No.	*Description*	*Revision*
MSEC869-01	Overall layout and monitoring	A
MSEC869-02	Layout of Longwalls B1 to B7	A
MSEC869-03	Surface level contours	A
MSEC869-04	Seam floor contours	A
MSEC869-05	Seam thickness contours	A
MSEC869-06	Depth of cover contours	A
MSEC869-07	Natural features	A
MSEC869-08	Surface infrastructure	A
MSEC869-09	Built features	A
MSEC869-10	Predicted additional subsidence contours due to LWB4 to LWB7	A
MSEC869-11	Predicted total subsidence contours due to LWB1 to LWB7	A
MSEC869-12	Predicted total subsidence contours due to LWB1 to LWB7 and existing longwalls	A

1.1. Background

Austar Coal Mine Pty Limited (Austar, the Mine) is located in the Newcastle Coalfield, approximately 10 km south-west of the township of Cessnock. The Mine has completed the extraction of Longwalls A1 and A2 in Stage 1, Longwalls A3 to A5A in Stage 2 and Longwalls A7 and A8 in Stage 3 using longwall top coal caving mining techniques. Austar has approval to extract the future Longwalls A9 to A19 in Stage 3 at the Mine.

Austar has approval for the extraction of Longwalls B1 to B3 (LWB1 to LWB3) using conventional longwall mining techniques within the Bellbird South mining area. These longwalls are located to the south of the previously extracted longwalls in Stage 2 at the Mine and to the east of the existing Longwalls 1 to 9A at the Ellalong Colliery. At the time of this report, the Mine had completed the extraction of Longwall B2 and is in the process of extracting Longwall B3.

Mine Subsidence Engineering Consultants (MSEC) was previously commissioned by Austar to prepare subsidence predictions and impact assessments for Longwalls B1 to B3. Report Nos. MSEC769 (Rev. A) and MSEC833 (Rev. A) which supported the Modification Application and the Extraction Plan for these longwalls.

Austar is seeking approval to modify the existing Development Consent (DA 29/95) under Section 75W of the EP&A Act, to facilitate the extraction of four additional longwalls in the Bellbird South mining area, referred to as Longwalls B4 to B7 (LWB4 to LWB7). The proposed longwalls are located on the north-western side of the approved Longwalls B1 to B3 and are a continuation of this longwall series. The locations of the approved and the proposed longwalls at the Mine are shown in Drawing No. MSEC869-01.

MSEC has now been commissioned by Austar to provide:

- subsidence predictions for Longwalls B4 to B7, including the cumulative movements due to the previously extracted and approved adjacent longwalls;
- subsidence predictions for each of the natural and built features in the mining area;
- impact assessments, in conjunction with other specialist consultants, for each of these natural and built features; and
- recommended management strategies and monitoring for Longwalls B4 to B7.

This report has been prepared to support the Modification Application for Longwalls B4 to B7 which will be submitted to the Department of Planning and Environment (DP&E). In some cases, this report will refer to other sources of information on specific natural and built features. This report, therefore, should be read in conjunction with the other relevant documents associated with this application.

Chapter 1 of this report provides a general introduction to the study, which also includes a description of the mining geometry and geological details of the area.

Chapter 2 defines the Study Area and provides a summary of the natural and built features within this area.

Chapter 3 provides an overview of longwall mining, mine subsidence parameters and the methods that have been used to predict the mine subsidence for the longwalls.

Chapter 4 provides the maximum predicted subsidence parameters resulting from the extraction of Longwalls B4 to B7, including the cumulative movements due to the adjacent longwalls. The predicted parameters have also been compared with those based on the approved Longwalls B1 to B3.

Chapters 5 and 6 provide the predictions and impact assessments for each of the natural and built features within the mining area. The recommended management strategies and monitoring for these features are also provided in this chapter.

The proposed Longwalls B4 to B7 and the Study Area, as defined in Section 2.1, have been overlaid on an orthophoto of the area, and is shown in Fig. 1.1. The major natural and built features in the vicinity of the proposed longwalls can be seen in this figure.

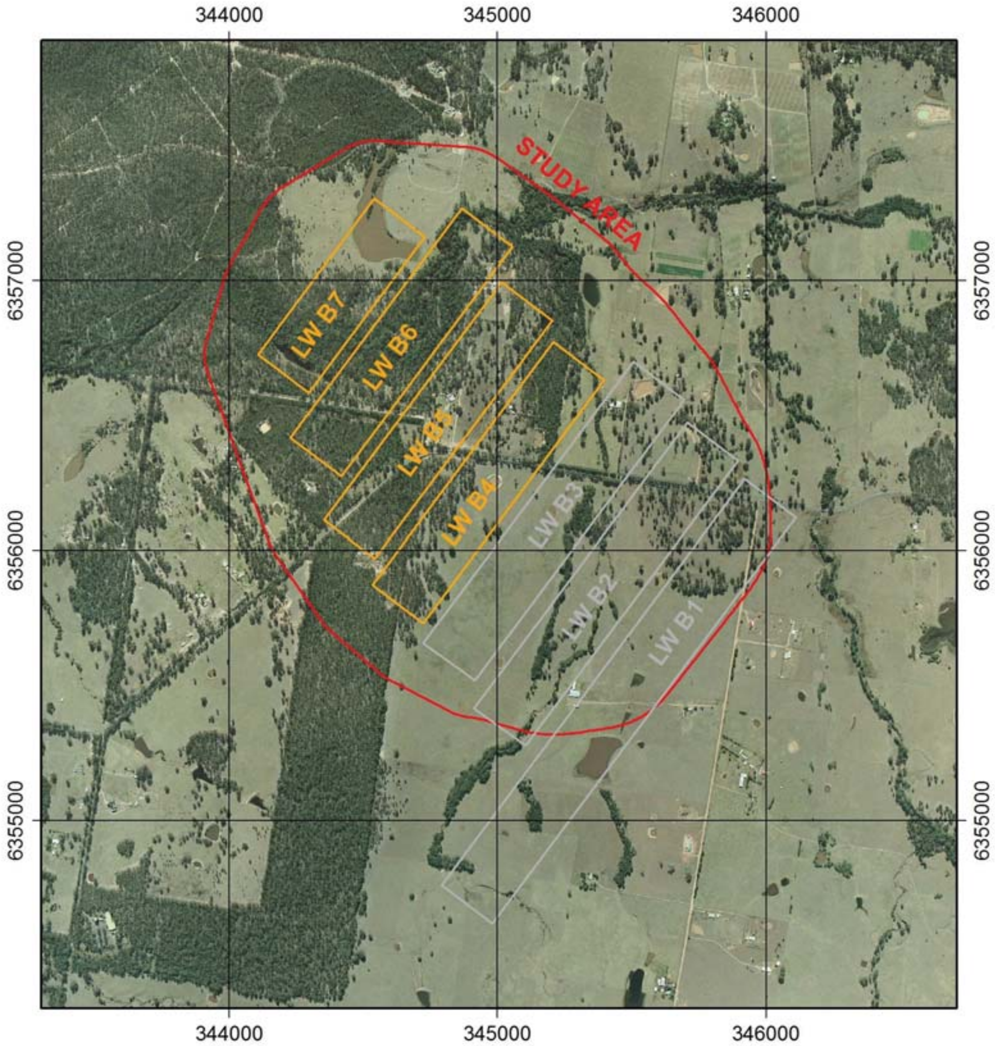


Fig. 1.1 Aerial photograph showing the proposed Longwalls B4 to B7

1.2. Mining geometry

The layout of existing, approved and proposed longwalls in the Greta Seam is shown in Drawings Nos. MSEC869-01 and MSEC869-02. A summary of the dimensions of the proposed Longwalls B4 to B7 is provided in Table 1.1.

Table 1.1 Geometry of the proposed Longwalls B4 to B7

Longwall	Overall void length including installation heading (m)	Overall void width including first workings (m)	Overall tailgate chain pillar width (m)
LWB4	1,125	237	45
LWB5	1,105	237	50
LWB6	1,065	237	45
LWB7	725	237	45

The widths of the longwall extraction faces (i.e. excluding the first workings) are 226 m providing overall void widths (i.e. including the first workings) of 237 m. The lengths of extraction (i.e. excluding the installation headings) are approximately 9 m less than the overall void lengths provided in the above table. The longwalls will be extracted from the south-west towards the north-east (i.e. towards the main headings).

1.3. Surface and seam levels

The natural surface and the Greta Seam are illustrated along Cross-section 1 in Fig. 1.2, which has been taken transverse to the longwalls near their mid-lengths (looking north-east). The location of this cross-section is shown in Drawing Nos. MSEC869-03 to MSEC869-05, in Appendix E.

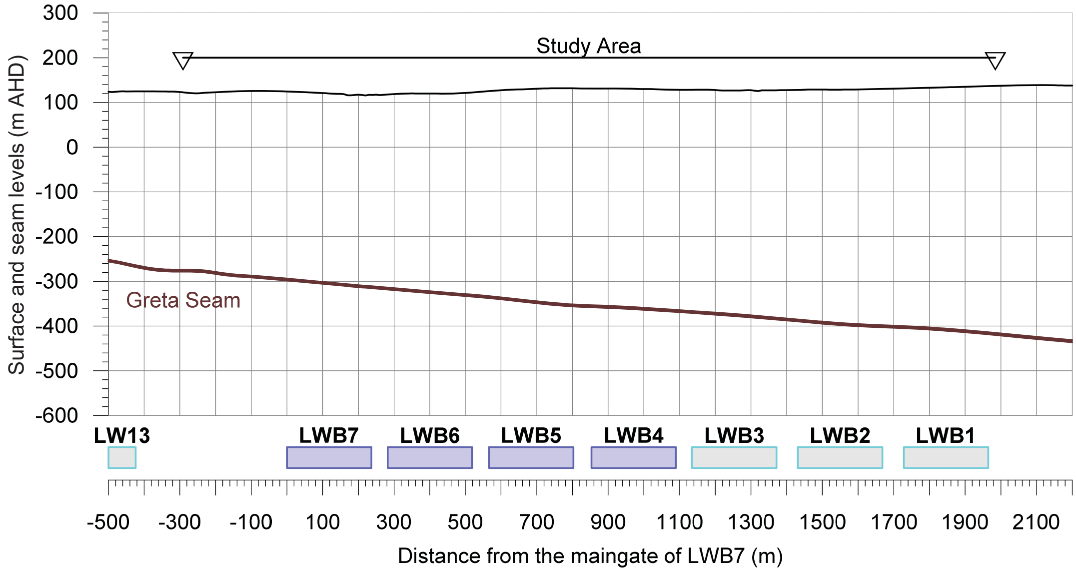


Fig. 1.2 Surface and seam levels along Cross-section 1

The surface level contours are shown in Drawing No. MSEC869-03. There are three small ridgelines located above the western, eastern and northern parts of the mining area. These ridgelines are separated by Quorrobolong Creek in the northern part of the mining area and by an unnamed drainage line in the southern part of the mining area.

The surface levels directly above the proposed longwalls vary from a high point of 160 m above Australian Height Datum (mAHD) above the commencing (i.e. south-western) end of Longwall B4, to a low point of approximately 115 mAHD along Quorrobolong Creek.

The seam floor contours, seam thickness contours and depth of cover contours for the Greta Seam are shown in Drawings Nos. MSEC869-04, MSEC869-05 and MSEC869-06, respectively. The contours are based on the latest information provided by the Mine.

The depth of cover to the Greta Seam directly above the proposed longwalls varies between a minimum of 400 m above the commencing (i.e. south-western) end of Longwall B7 and a maximum of 505 m above the finishing (i.e. north-eastern) end of Longwall B4. The seam floor within the proposed mining area dips from the west to the east, having an average gradient of around 8 %, or 1 in 12.

The thickness of the Greta Seam within the mining area varies between 3.7 and 4.8 m. It is proposed that a constant thickness of 3.4 m will be extracted using conventional longwall mining techniques.

1.4. Geological details

The Austar Coal Mine lies in the Newcastle Coalfield, within the Northern Sydney Basin. A typical stratigraphic section of the Newcastle Coalfield (after Ives et al, 1999, Moelle and Dean-Jones, 1995, Lohe and Dean-Jones, 1995, Sloan and Allman, 1995) is shown in Table 1.2. The strata shown in this table were laid down between the Early Permian and the Middle Triassic Periods.

Table 1.2 Stratigraphy of the Newcastle Coalfield (after Ives et al, 1999, Moelle & Dean-Jones, 1995, Lohe & Dean-Jones, 1995, Sloan & Allan, 1995)

Stratigraphy			Lithology
Group	**Formation**	**Coal Seams**	
Narrabeen Group	Clifton		Sandstone, siltstone, mudstone, claystone
Newcastle Coal Measures	Moon Island Beach	Vales Point Wallarah Great Northern	Sandstone, shale, conglomerate, claystone, coal
	Awaba Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert
	Boolaroo	Fassifern Upper Pilot Lower Pilot Hartley Hill	Conglomerate, sandstone, shale, claystone, coal
	Warners Bay Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert
	Adamstown	Australasian Montrose Wave Hill Fern Valley Victoria Tunnel	Conglomerate, sandstone, shale, claystone, coal
	Nobbys Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone chert
	Lambton	Nobbys Dudley Yard Borehole	Sandstone, shale, minor conglomerate, claystone, coal
	Waratah Sandstone		Sandstone
Tomago Coal Measures	Dempsey		Shale, siltstone, fine sandstone, coal, and minor tuffaceous claystone
	Four Mile Creek		
	Wallis Creek		
Maitland Group	Mulbring Siltstone		Siltstone
	Muree Sandstone		Sandstone
	Branxton		Sandstone, and siltstone
Greta Coal Measures	Paxton	Pelton	Sandstone, conglomerate, and coal
	Kitchener	**Greta**	
	Kurri Kurri	Homeville	
	Neath Sandstone		Sandstone
Dalwood Group	Farley		Shale, siltstone, lithic sandstone, conglomerate, minor marl and coal, and interbedded basalts, volcanic breccia, and tuffs
	Rutherford		
	Allandale		
	Lochinvar		
Seaham Formation			

Longwalls B4 to B7 will be extracted within the Greta Seam, which is located within the Kitchener Formation of the Greta Coal Measures. The overlying strata comprise the Paxton Formation, which consists of interbedded sandstone and siltstone layers up to 20 m thick. The uppermost layer in the Greta Coal Measures is the Pelton Seam, which is less than 0.5 m thick. The underlying strata comprise the Kurri Kurri Conglomerate and the Neath Sandstone. Strong and thick strata consisting of conglomerate and sandstone are typically observed within these formations.

The main sequence overlying the Greta Coal Measures is the Branxton Formation, which is part of the Maitland Group sediments from the mid Permian period. The Maitland Group comprises, in order of deposition, the Branxton Formation, Muree Sandstone and Mulbring Siltstone. The Branxton Formation immediately overlies the Greta Coal Measures and is made up of a substantial thickness of sedimentary rocks. The lithology of the Branxton Formation generally consists of the coarser sandstone and conglomerate rocks at the base of the formation, grading to finer deposits of silty sandstone and siltstone at the top of the formation. The upper part of the formation contains a unit known as *Fenestella Shale* that contains numerous fossils of marine invertebrate fauna.

The Newcastle region is characterised by a complex geological setting, with a great variety of rock types occurring over short lateral and vertical distances (Moelle and Dean-Jones, 1995). Folds, normal faults and dykes dominate the region and generally trend north-west to north-north-west (Lohe and Dean-Jones, 1995).

The surface lithology within the Study Area is shown in Fig. 1.3, which shows the proposed longwalls overlaid on Geological Series Sheet Quorrobolong 9132-2-S, which is published by Department of Mineral Resources (DMR, 1988), now known as the Department of Industry – Division of Resources and Energy. It can be seen from this figure, that the surface lithology within the mining area comprises predominately of areas derived from the Branxton Formation (Pmb and Pmbf) and Quaternary alluvium (Qa).

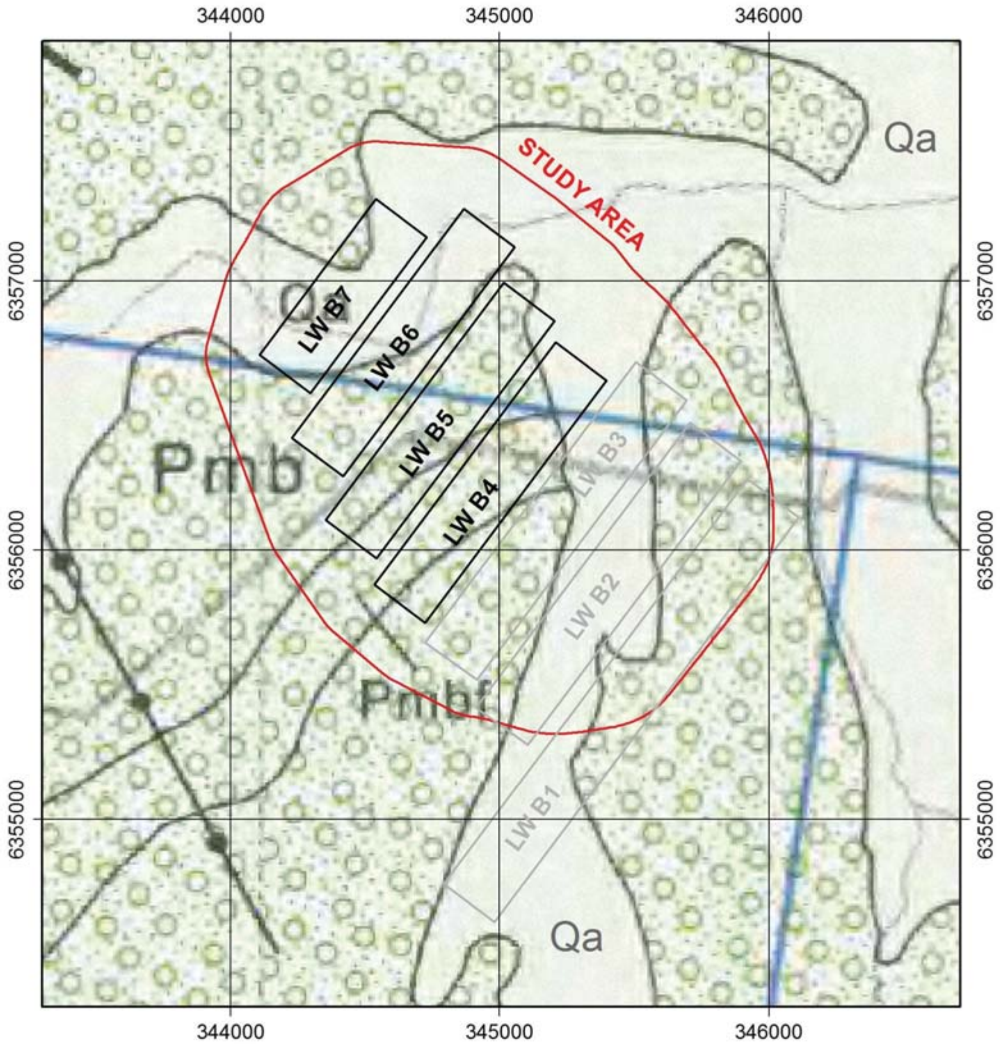


Fig. 1.3 Surface lithology within the Study Area
Geological Series Sheet Quorrobolong 9132-2-S (DMR, 1988)

The major geological zones identified at seam level are shown in Drawings Nos. MSEC869-04 and MSEC869-05. The *Swamp Fault Zone* has been identified near the finishing (i.e. north-eastern) ends of the proposed longwalls. The *Barraba Fault Zone* has also been identified adjacent to the commencing (i.e. south-western) ends of the longwalls. The nature and extents of these faulting zones will be better defined as further geological data is gathered during the development of the first workings and, if necessary, the extents of mining will be reviewed based on this information.

2.1. Definition of the Study Area

The *Study Area* is defined as the surface area that is likely to be affected by the mining of Longwalls B4 to B7 in the Greta Seam at the Mine. The extent of the Study Area has been calculated by combining the areas bounded by the following limits:

- The 26.5° angle of draw line from the extents of Longwalls B4 to B7; and
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour resulting from the extraction of Longwalls B4 to B7.

The depth of cover contours are shown in Drawing No. MSEC869-06. The depth of cover varies between 400 and 505 m directly above the proposed Longwalls B4 to B7. The 26.5° angle of draw line, therefore, has been determined by drawing a line that is a horizontal distance varying between 200 and 253 m around the extents of the longwall voids.

The predicted limit of vertical subsidence, taken as the predicted total 20 mm subsidence contour, has been determined using the Incremental Profile Method, which is described in further detail in Sections 3.5 and 3.6. The angle of draw to the predicted total 20 mm subsidence contour has been calibrated to 30° adjacent to the longitudinal edges of the mining area (i.e. the maingate of the last longwall and tailgate of the first longwall in the series), in order to match those observed over the previously extracted longwalls at the Mine.

The predicted total 20 mm subsidence contour, therefore, is generally located outside the 26.5° angle of draw line adjacent to the longitudinal edges of the longwalls, and is generally located inside the 26.5° angle of draw line adjacent to the commencing and finishing ends of the longwalls. A line has therefore been drawn defining the Study Area, based upon the 26.5° angle of draw line and the predicted total 20 mm subsidence contour, whichever is furthest from the longwalls, and is shown in Drawings Nos. MSEC869-01 and MSEC869-02.

There are areas that lie outside the Study Area that are expected to experience either far-field movements, or valley related upsidence and closure movements. The surface features which are sensitive to such movements have been identified in this report and have been included in the assessments provided in this report.

2.2. Natural features and items of surface infrastructure within the Study Area

The major natural features and items of surface infrastructure within the Study Area can be seen in the 1:25,000 Topographic Map of the area, published by the Central Mapping Authority (CMA), numbered QUORROBOLONG 9132-2-S. The longwalls and the Study Area have been overlaid on an extract of this CMA Map and are shown in Fig. 2.1.

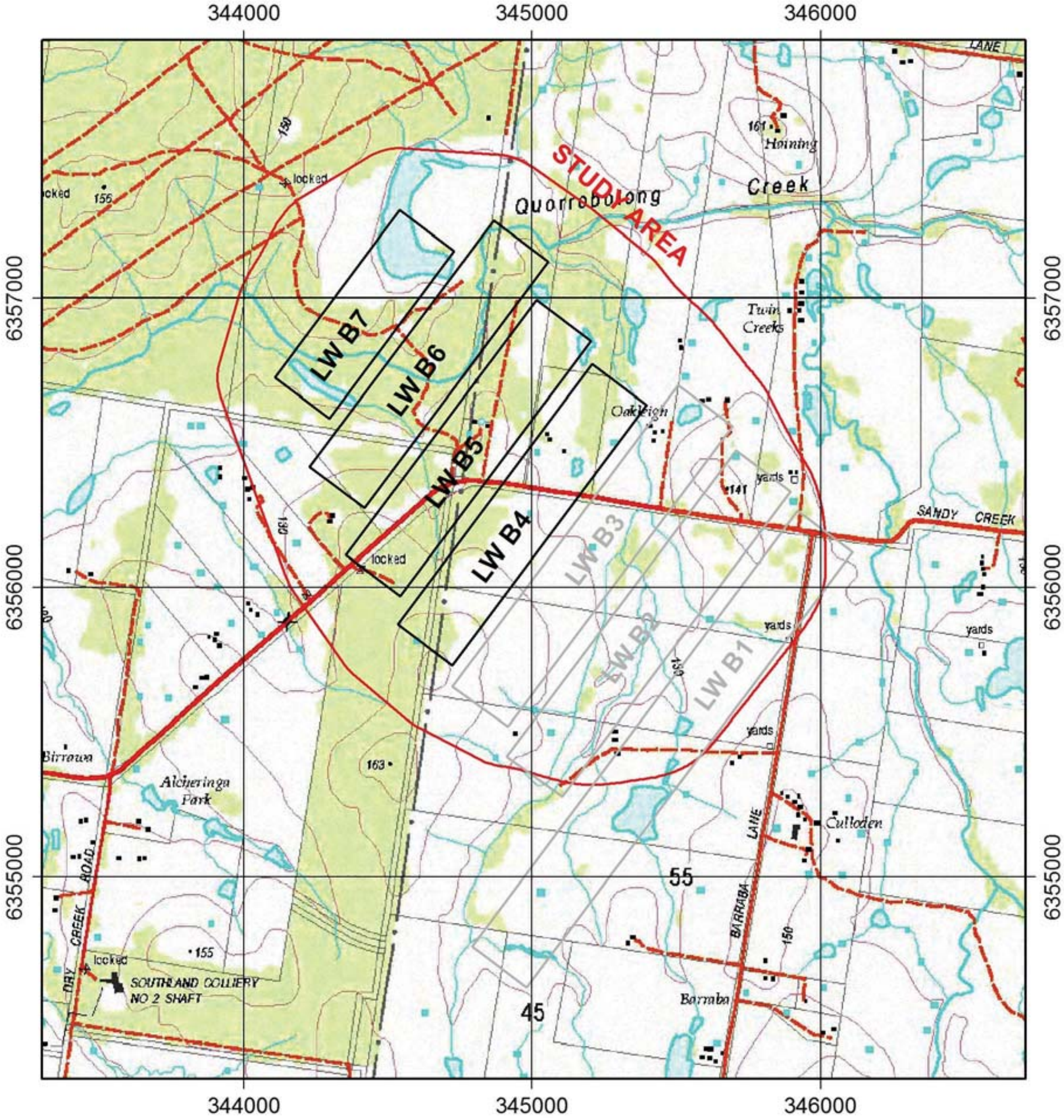


Fig. 2.1 The proposed Longwalls B4 to B7 and the Study Area overlaid on CMA Map No. Quorrobolong 9132-2-S

A summary of the natural and built features within the Study Area is provided in Table 2.1. The locations of these features are shown in Drawings Nos. MSEC869-07 to MSEC869-09. The descriptions of these features are provided in Chapters 5 and 6, as indicated by the Section number in Table 2.1.

Table 2.1 Natural and built features

Item	Within Study Area	Section number reference
NATURAL FEATURES		
Catchment Areas or Declared Special Areas	×	
Rivers or Creeks	✓	5.2
Aquifers or Known Groundwater Resources	✓	5.3
Springs	×	
Sea or Lake	×	
Shorelines	×	
Natural Dams	×	
Cliffs or Pagodas	×	
Steep Slopes	✓	5.4
Escarpments	×	
Land Prone to Flooding or Inundation	✓	5.5
Swamps, Wetlands or Water Related Ecosystems	✓	5.6
Threatened or Protected Species	✓	5.7
National Parks	×	
State Forests	×	
State Conservation Areas	×	
Natural Vegetation	✓	5.7
Areas of Significant Geological Interest	×	
Any Other Natural Features Considered Significant	×	
PUBLIC UTILITIES	×	
Railways	×	
Roads (All Types)	✓	6.1
Bridges	✓	6.2
Tunnels	×	
Culverts	✓	6.3
Water, Gas or Sewerage Infrastructure	×	
Liquid Fuel Pipelines	×	
Electricity Transmission Lines or Associated Plants	✓	6.4
Telecommunication Lines or Associated Plants	✓	6.5
Water Tanks, Water or Sewage Treatment Works	×	
Dams, Reservoirs or Associated Works	×	
Air Strips	×	
Any Other Public Utilities	×	
	×	
PUBLIC AMENITIES	×	
Hospitals	×	
Places of Worship	×	
Schools	×	
Shopping Centres	×	
Community Centres	×	
Office Buildings	×	
Swimming Pools	×	
Bowling Greens	×	
Ovals or Cricket Grounds	×	
Race Courses	×	
Golf Courses	×	
Tennis Courts	×	
Any Other Public Amenities	×	

Item	Within Study Area	Section number reference
FARM LAND AND FACILITIES		
Agricultural Utilisation or Agricultural Suitability of Farm Land	✓	6.6
Farm Buildings or Sheds	✓	6.7
Tanks	✓	6.7
Gas or Fuel Storages	✓	6.8
Poultry Sheds	×	
Glass Houses	×	
Hydroponic Systems	×	
Irrigation Systems	×	
Fences	✓	6.9
Farm Dams	✓	6.10
Wells or Bores	✓	6.11
Any Other Farm Features	×	
INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS		
Factories	×	
Workshops	×	
Business or Commercial Establishments or Improvements	×	
Gas or Fuel Storages or Associated Plants	×	
Waste Storages or Associated Plants	×	
Buildings, Equipment or Operations that are Sensitive to Surface Movements	×	
Surface Mining (Open Cut) Voids or Rehabilitated Areas	×	
Mine Infrastructure Including Tailings Dams or Emplacement Areas	×	
Any Other Industrial, Commercial or Business Features	×	
AREAS OF ARCHAEOLOGICAL OR HERITAGE SIGNIFICANCE	✓	6.12
ITEMS OF ARCHITECTURAL SIGNIFICANCE	×	
PERMANENT SURVEY CONTROL MARKS	✓	6.13
RESIDENTIAL ESTABLISHMENTS		
Houses	✓	6.14
Flats or Units	×	
Caravan Parks	×	
Retirement or Aged Care Villages	×	
Associated Structures such as Workshops, Garages, On-Site Waste Water Systems, Water or Gas Tanks, Swimming Pools or Tennis Courts	✓	6.15 & 6.16
Any Other Residential Features	×	
ANY OTHER ITEM OF SIGNIFICANCE	×	
ANY KNOWN FUTURE DEVELOPMENTS	×	

3.0 OVERVIEW OF MINE SUBSIDENCE AND THE METHOD USED TO PREDICT THE MINE SUBSIDENCE PARAMETERS FOR THE LONGWALLS

3.1. Introduction

This chapter provides an overview of the mine subsidence parameters and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the longwalls. Further details on methods of mine subsidence prediction are provided in the background reports entitled *Introduction to Longwall Mining and Subsidence* and *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*.

3.2. Overview of conventional subsidence parameters

The normal ground movements resulting from the extraction of pillars or longwalls are referred to as conventional or systematic subsidence movements. These movements are described by the following parameters:

- **Subsidence** usually refers to vertical displacement of a point, but subsidence of the ground actually includes both vertical and horizontal displacements. These horizontal displacements in some cases, where the subsidence is small beyond the longwall goaf edges, can be greater than the vertical subsidence. Subsidence is usually expressed in units of *millimetres (mm)*.
- **Tilt** is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1,000.
- **Curvature** is the second derivative of subsidence, or the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (km^{-1})*, but the values of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*.
- **Strain** is the relative differential horizontal movements of the ground. **Normal strain** is calculated as the change in horizontal distance between two points on the ground, divided by the original horizontal distance between them. Strain is typically expressed in units of *millimetres per metre (mm/m)*. **Tensile strains** occur where the distance between two points increases and **Compressive strains** occur when the distance between two points decreases. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20.

  Whilst mining induced normal strains are measured along monitoring lines, ground shearing can also occur both vertically and horizontally across the directions of monitoring lines. Most of the published mine subsidence literature discusses the differential ground movements that are measured along subsidence monitoring lines, however, differential ground movements can also be measured across monitoring lines using 3D survey monitoring techniques.
- **Horizontal shear deformation** across monitoring lines can be described by various parameters including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index. It is not possible, however, to determine the horizontal shear strain across a monitoring line using traditional 2D or 3D monitoring techniques.

  High deformations along monitoring lines (i.e. normal strains) are generally measured where high deformations have been measured across the monitoring line (i.e. shear deformations). Conversely, high deformations across monitoring lines are also generally measured where high normal strains have been measured along the monitoring line.

The **incremental** subsidence, tilts, curvatures and strains are the additional parameters which result from the extraction of each longwall. The **cumulative** subsidence, tilts, curvatures and strains are the accumulated parameters which result from the extraction of a series of longwalls. The **total** subsidence, tilts, curvatures and strains are the final parameters at the completion of a series of longwalls. The **travelling** tilts, curvatures and strains are the transient movements as the longwall extraction face mines directly beneath a given point.

3.3. Far-field movements

The measured horizontal movements at survey marks which are located beyond the longwall goaf edges and over solid unmined coal areas are often much greater than the observed vertical movements at those marks. These movements are often referred to as *far-field movements*.

Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain. These movements generally do not result in impacts on natural features or built environments, except where they are experienced by large structures which are very sensitive to differential horizontal movements.

In some cases, higher levels of far-field horizontal movements have been observed where steep slopes or surface incisions exist nearby, as these features influence both the magnitude and the direction of ground movement patterns. Similarly, increased horizontal movements are often observed around sudden changes in geology or where blocks of coal are left between longwalls or near other previously extracted series of longwalls. In these cases, the levels of observed subsidence can be slightly higher than normally predicted, but these increased movements are generally accompanied by very low levels of tilt, curvature and strain.

Far-field horizontal movements and the method used to predict such movements are described further in Section 4.6.

3.4. Overview of non-conventional subsidence movements

Conventional subsidence profiles are typically smooth in shape and can be explained by the expected caving mechanisms associated with overlying strata spanning the extracted void. Normal conventional subsidence movements due to longwall extraction are easy to identify where longwalls are regular in shape, the extracted coal seams are relatively uniform in thickness, the geological conditions are consistent and surface topography is relatively flat.

As a general rule, the smoothness of the profile is governed by the depth of cover and lithology of the overburden, particularly the near surface strata layers. Where the depth of cover is greater than 400 m, such as is the case within the Study Area, the observed subsidence profiles along monitoring survey lines are generally smooth. Where the depth of cover is less than 100 m, the observed subsidence profiles along monitoring lines are generally irregular. Very irregular subsidence movements are observed with much higher tilts and strains at very shallow depths of cover where the collapsed zone above the extracted longwalls extends up to or near to the surface.

Irregular subsidence movements are occasionally observed at the greater depths of cover along an otherwise smooth subsidence profile. The cause of these irregular subsidence movements can be associated with:

- issues related to the timing and the method of the installation of monitoring lines;
- sudden or abrupt changes in geological conditions;
- steep topography; and
- valley related mechanisms.

Non-conventional movements due to geological conditions and valley related movements are discussed in the following sections.

3.4.1. Non-conventional subsidence movements due to changes in geological conditions

It is believed that most non-conventional ground movements are a result of the reaction of near surface strata to increased horizontal compressive stresses due to mining operations. Some of the geological conditions that are believed to influence these irregular subsidence movements are the blocky nature of near surface sedimentary strata layers and the possible presence of unknown faults, dykes or other geological structures, cross bedded strata, thin and brittle near surface strata layers and pre-existing natural joints. The presence of these geological features near the surface can result in a bump in an otherwise smooth subsidence profile and these bumps are usually accompanied by locally increased tilts, curvatures and strains.

Even though it may be possible to attribute a reason behind most observed non-conventional ground movements, there remain some observed irregular ground movements that still cannot be explained with the available geological information. The term "*anomaly*" is therefore reserved for those non-conventional ground movement cases that were not expected to occur and cannot be explained by any of the above possible causes.

It is not possible to predict the locations and magnitudes of non-conventional anomalous movements. In some cases, approximate predictions for the non-conventional ground movements can be made where the underlying geological or topographic conditions are known in advance. It is expected that these methods will improve as further knowledge is gained through ongoing research and investigation.

In this report, non-conventional ground movements are being included statistically in the predictions and impact assessments, by basing these on the frequency of past occurrence of both the conventional and non-conventional ground movements and impacts. The analysis of strains provided in Section 4.4 includes those resulting from both conventional and non-conventional anomalous movements. The impact assessments for the natural features and items of surface infrastructure, which are provided in Chapters 5 through to 9, include historical impacts resulting from previous longwall mining which have occurred as the result of both conventional and non-conventional subsidence movements.

3.4.2. Non-conventional subsidence movements due to steep topography

Non-conventional movements can also result from downslope movements where longwalls are extracted beneath steep slopes. In these cases, elevated tensile strains develop near the tops of the steep slopes and elevated compressive strains develop near the bases of the steep slopes. The potential impacts resulting from down slope movements include the development of tension cracks at the tops of the steep slopes and compression ridges at the bottoms of the steep slopes.

Further discussions on the potential for down slope movements for the steep slopes within the Study Area are provided in Section 5.3.

3.4.3. Valley related movements

The watercourses within the Study Area may also be subjected to valley related movements, which are commonly observed along river and creek alignments in the Southern Coalfield, but less commonly observed in the Newcastle Coalfield. The reason why valley related movements are less commonly observed in the Newcastle Coalfield could be that the conventional subsidence movements are typically much larger than those observed in the Southern Coalfield and tend to mask any smaller valley related movements which may occur.

Valley bulging movements are a natural phenomenon, resulting from the formation and ongoing development of the valley, as illustrated in Fig. 3.1. The potential for these natural movements are influenced by the geomorphology of the valley.

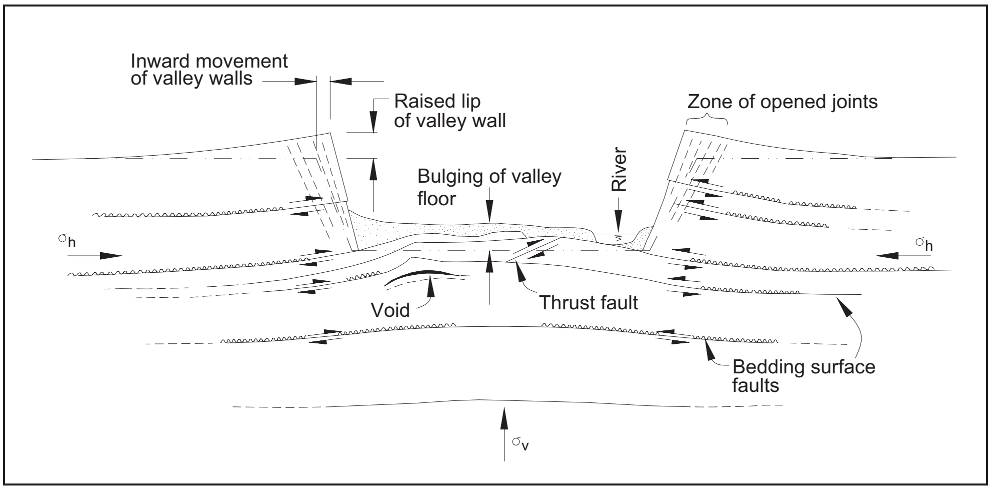


Fig. 3.1 Valley formation in flat-lying sedimentary rocks (after Patton and Hendren 1972)

Valley related movements can be caused by or accelerated by mine subsidence as the result of a number of factors, including the redistribution of horizontal in-situ stresses and down slope movements. Valley related movements are normally described by the following parameters:

- **Upsidence** is the reduced subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.

- **Closure** is the reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides.
- **Compressive strains** occur within the bases of valleys as a result of valley closure and upsidence movements. **Tensile strains** also occur in the sides and near the tops of the valleys as a result of valley closure movements. The magnitudes of these strains, which are typically expressed in the units of *millimetres per metre (mm/m)*, are calculated as the changes in horizontal distance over a standard bay length, divided by the original bay length.

The predicted valley related movements resulting from the extraction of the longwalls were made using the empirical method outlined in ACARP Research Project No. C9067 (Waddington and Kay, 2002). Further details can be obtained from the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at *www.minesubsidence.com*. There are other methods available to predict valley related movements, however, the ACARP method was adopted for this project as it is the most thoroughly used and tested method

3.5. The Incremental Profile Method

The Incremental Profile Method (IPM) was initially developed by Waddington Kay and Associates, now known as MSEC, as part of a study, in 1994 to assess the impacts of subsidence on particular surface infrastructure over a proposed series of longwall panels at Appin Colliery. The method evolved following detailed analyses of subsidence monitoring data from the Southern Coalfield, which was then extended to include detailed subsidence monitoring data from the Newcastle, Hunter and Western Coalfields.

The review of the detailed ground monitoring data from the New South Wales (NSW) Coalfields showed that whilst the final subsidence profiles measured over a series of longwalls were irregular, the observed incremental subsidence profiles due to the extraction of individual longwalls were consistent in both magnitude and shape and varied according to local geology, depth of cover, panel width, seam thickness, the extent of adjacent previous mining, the pillar width and stability of the chain pillar and a time-related subsidence component.

MSEC developed a series of subsidence prediction curves for the Newcastle and Hunter Coalfields, in 1996 to 1998, after receiving extensive subsidence monitoring data from Centennial Coal for the Cooranbong Life Extension Project (Waddington and Kay, 1998). The subsidence monitoring data from many collieries in the Newcastle and Hunter Coalfields were reviewed and, it was found, that the incremental subsidence profiles resulting from the extraction of individual longwalls were consistent in shape and magnitude where the mining geometries and overburden geologies were similar.

Since this time, extensive monitoring data has been gathered from the Southern, Newcastle, Hunter and Western Coalfields of NSW and from the Bowen Basin in Queensland, including: Angus Place, Appin, Awaba, Baal Bone, Bellambi, Beltana, Blakefield South, Bulga, Bulli, Burwood, Carborough Downs, Chain Valley, Clarence, Coalcliff, Cook, Cooranbong, Cordeaux, Corrimal, Cumnock, Dartbrook, Delta, Dendrobium, Donaldson, Eastern Main, Ellalong, Elouera, Fernbrook, Glennies Creek, Grasstree, Gretley, Invincible, John Darling, Kemira, Kestrel, Lambton, Liddell, Mandalong, Metropolitan, Moranbah North, Mt. Kembla, Munmorah, Nardell, Newpac, Newstan, Newvale, Newvale 2, NRE Wongawilli, Oaky Creek, Ravensworth, South Bulga, South Bulli, Springvale, Stockton Borehole, Teralba, Tahmoor, Tower, Wambo, Wallarah, Western Main, Ulan, United, West Cliff, West Wallsend, and Wyee.

Based on the extensive empirical data, MSEC has developed standard subsidence prediction curves for the Southern, Newcastle, Hunter and Western Coalfields. The prediction curves can then be further refined, for the local geology and local conditions, based on the available monitoring data from the area. Discussions on the calibration and review of the IPM at the Mine are provided in Section 3.6.

The prediction of subsidence is a three stage process where, first, the magnitude of each increment is calculated, then, the shape of each incremental profile is determined and, finally, the total subsidence profile is derived by adding the incremental profiles from each longwall in the series. In this way, subsidence predictions can be made anywhere above or outside the extracted longwalls, based on the local surface and seam information.

For longwalls in the Newcastle and Hunter Coalfields, the maximum predicted incremental subsidence is initially determined, using the IPM subsidence prediction curves for a single isolated panel, based on the longwall void width (W) and the depth of cover (H). The incremental subsidence is then increased, using the IPM subsidence prediction curves for multiple panels, based on the longwall series, panel width-to-depth ratio (W/H) and pillar width-to-depth ratio (W_{pi}/H). In this way, the influence of the panel width (W), depth of cover (H), as well as panel width-to-depth ratio (W/H) and pillar width-to-depth ratio (W_{pi}/H) are each taken into account.

The shapes of the incremental subsidence profiles are then determined using the large empirical database of observed incremental subsidence profiles from the Newcastle and Hunter Coalfields. The profile shapes are derived from the normalised subsidence profiles for monitoring lines where the mining geometry and overburden geology are similar to that for the longwalls. The profile shapes can be further refined, based on local monitoring data, which is discussed further in Section 3.6.

Finally, the total subsidence profiles resulting from the series of longwalls are derived by adding the predicted incremental profiles from each of the longwalls. Comparisons of the predicted total subsidence profiles, obtained using the Incremental Profile Method, with observed profiles indicates that the method provides reasonable, if not, slightly conservative predictions where the mining geometry and overburden geology are within the range of the empirical database. The method can also be further tailored to local conditions where observed monitoring data is available close to the mining area.

3.6. Calibration and review of the Incremental Profile Method at Austar Coal Mine

The IPM was originally calibrated for the local conditions at the Mine during the preparation of the Subsidence Management Plan Application for Longwalls A3 to A5 in Stage 2, which was discussed in Section 3.4.1 of Report No. MSEC275.

The calibration was based on the available ground monitoring data at that time, which included: eight monitoring lines above Longwalls SL1 to SL4 and Longwalls 1 to 13A at Ellalong Colliery; and three monitoring lines above Longwalls A1 and A2 in Stage 1 of the Mine.

Initially, the magnitudes and shapes of the observed incremental subsidence profiles along each monitoring line were compared with the back-predicted subsidence profiles obtained using the standard Incremental Profile Method, which is based on the typical Newcastle Coalfield subsidence profiles. The standard IPM was not modified for the presence of any thick massive strata units, which can reduce the sag subsidence directly above the extracted longwalls.

It was found that the values of maximum observed incremental subsidence for the previously extracted longwalls along each of the monitoring lines were less than the values of maximum back-predicted incremental subsidence obtained using the standard Incremental Profile Method. It was also found that the observed incremental subsidence profiles along the monitoring lines were slightly wider, and that the points of maximum observed subsidence were located closer to the longwall tailgates, than for the back-predicted incremental subsidence profiles obtained using the standard Incremental Profile Method.

The reason that the observed subsidence profiles were wider than the predicted profiles and that the maximum observed subsidence was less than the maximum predicted subsidence was the result of the geology of the overburden. The massive sandstones in the overlying Branxton Formation were capable of spanning the extracted voids with minimal sag subsidence and, hence, the observed subsidence profiles and the magnitudes of the observed subsidence were governed, to a large extent, by pillar compression.

The shapes of the back-predicted incremental subsidence profiles along each monitoring line were adjusted to more closely match those observed. No adjustments were made to the magnitudes of the maximum back-predicted incremental subsidence for each longwall. The angle of draw to the predicted total 20 mm subsidence contour, obtained using the Incremental Profile Method, was also calibrated to 30° adjacent to the longitudinal edges of the mining area, to match those observed over the previously extracted longwalls at the colliery.

Subsequent to the calibration undertaken as part of Report No. MSEC275, Austar has extracted Longwalls A3 to A5A in Stage 2, Longwalls A7 and A8 in Stage 3 and Longwall B2 in the Bellbird South mining area. The mine subsidence movements have been monitored along four monitoring lines in above Longwalls A3 to A5A, four monitoring lines above Longwalls A7 and A8 and three monitoring lines above Longwall B2. The comparisons between the observed and predicted movements have been provided in the End of Panel subsidence review reports for each of these longwalls.

The comparisons between the observed and predicted subsidence, tilt and strain have been provided for: Line 1B above Longwalls A1 and A2 in Fig. 3.2; Line A3X above Longwalls A3 to A5A in Fig. 3.3; Line XL3 above Longwalls A7 and A8 in Fig. 3.4; the Crossline above Longwall B2 in Fig. 3.5; and Line B2 above Longwall B2 in Fig. 3.6.

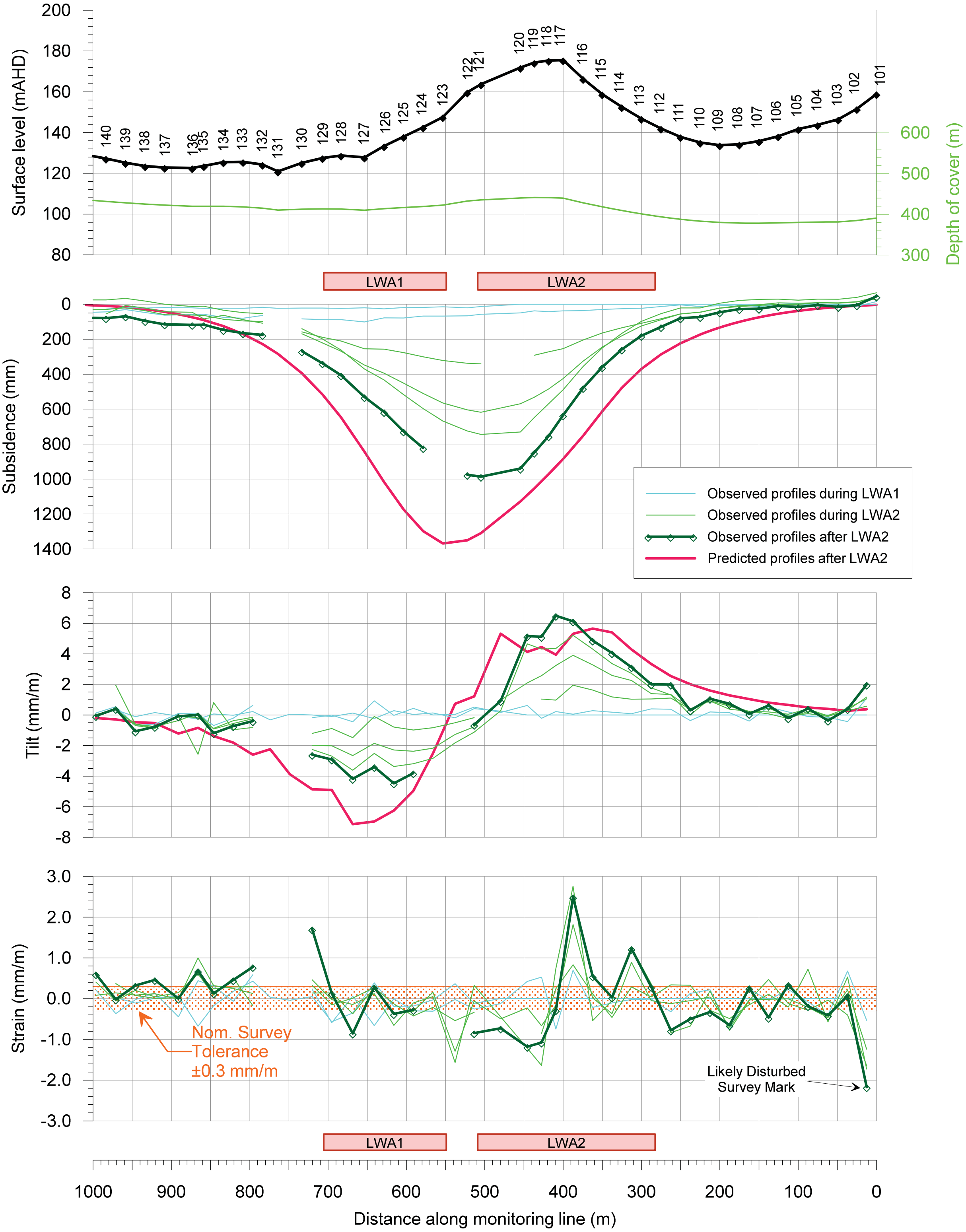


Fig. 3.2 Observed and predicted profiles of subsidence, tilt and strain along Line 1B above Longwalls A1 and A2 in Stage 1

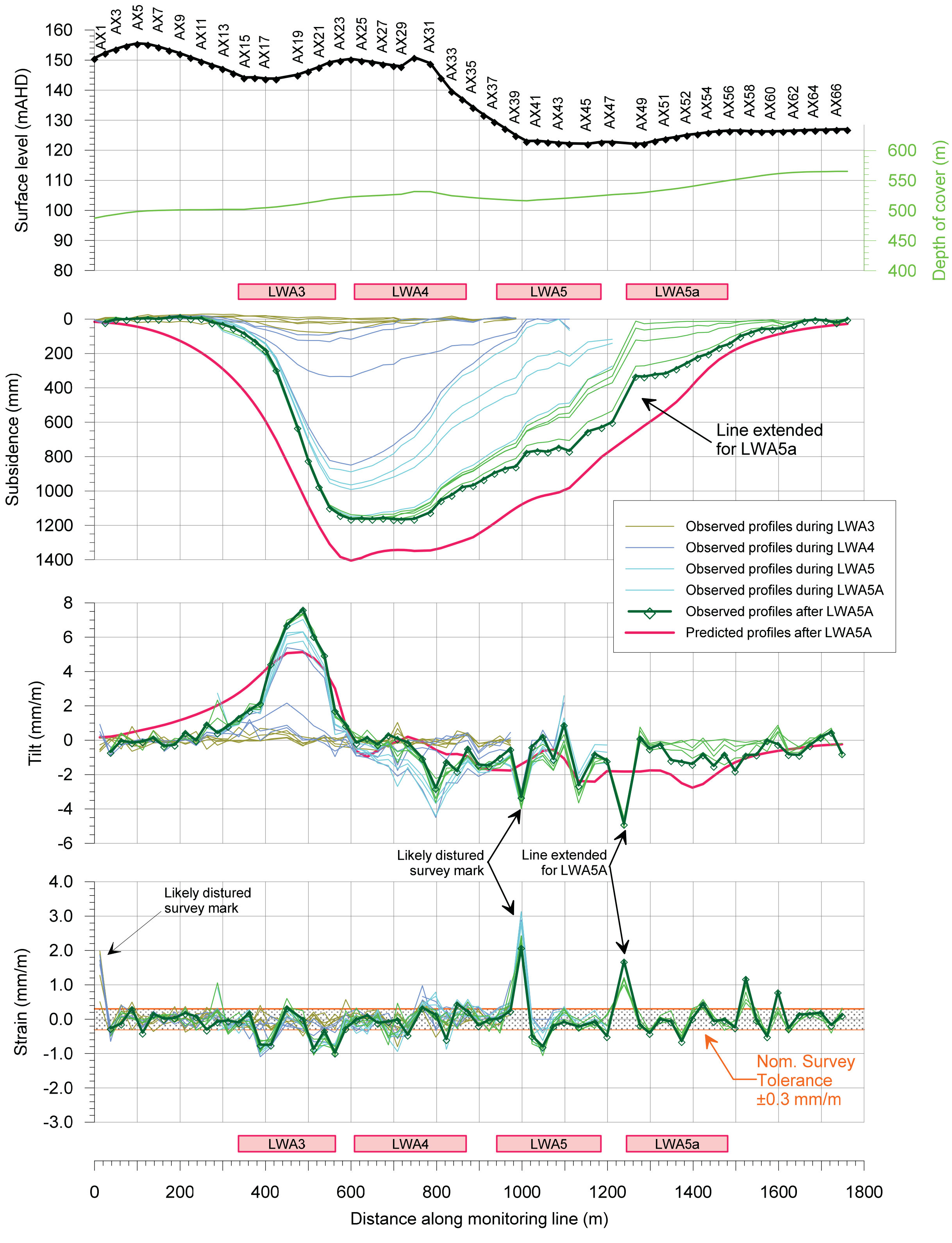


Fig. 3.3 Observed and predicted profiles of subsidence, tilt and strain along Line A3X above Longwalls A3 to A5A in Stage 2

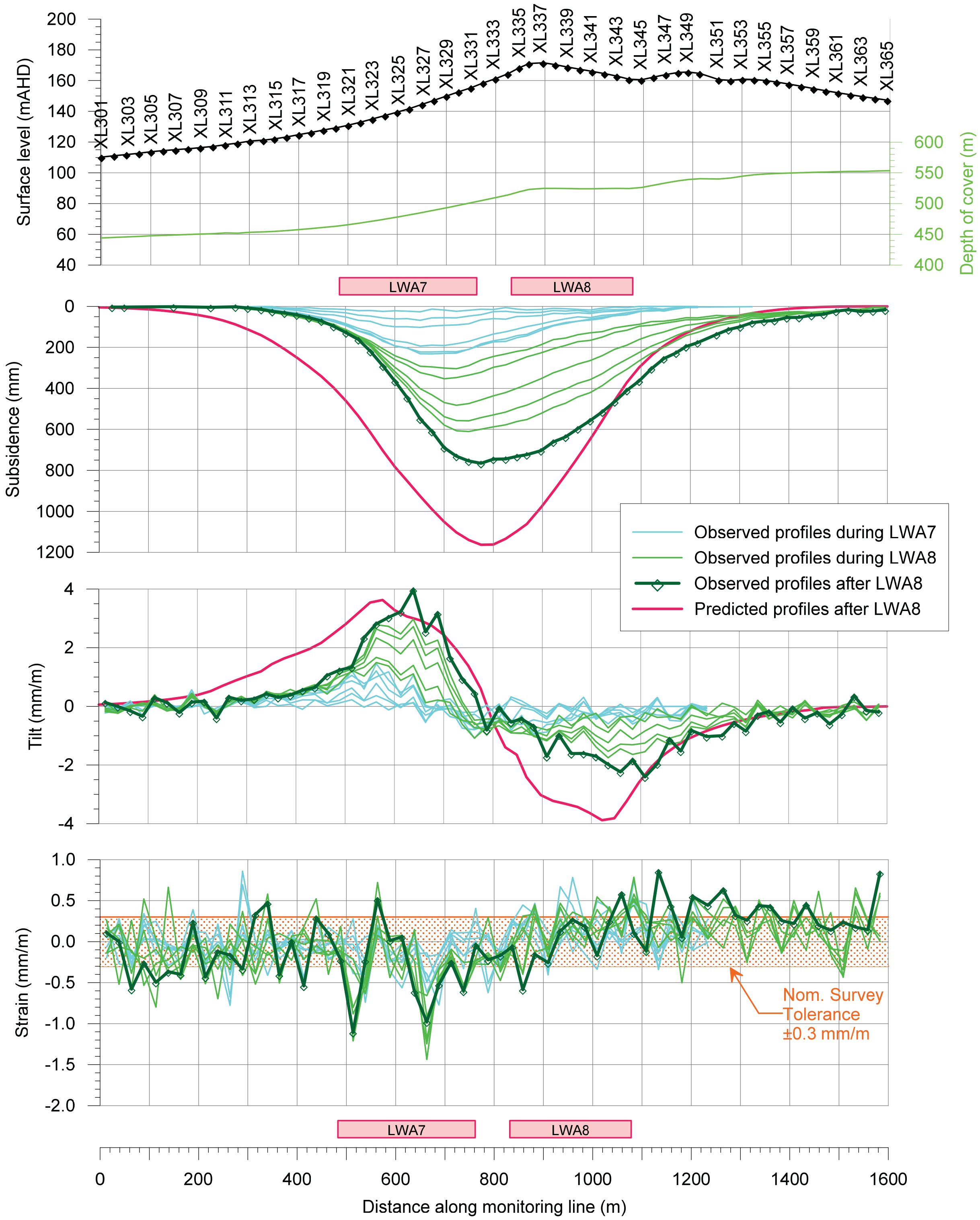


Fig. 3.4 Observed and predicted profiles of subsidence, tilt and strain along Line XL3 above Longwalls A7 and A8 in Stage 3

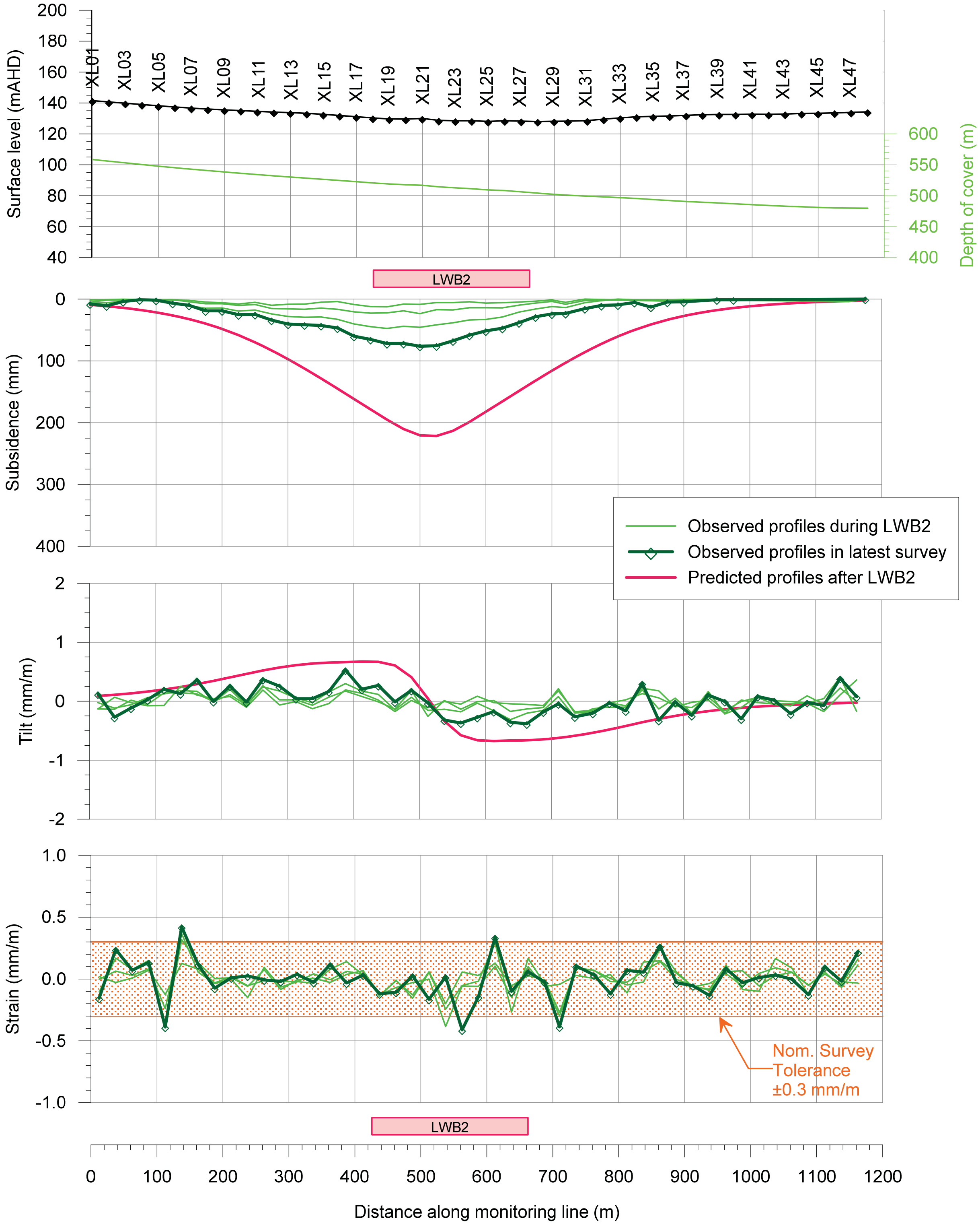


Fig. 3.5 Observed and predicted profiles of subsidence, tilt and strain along the Crossline above Longwall B2 in the Bellbird South Mining Area

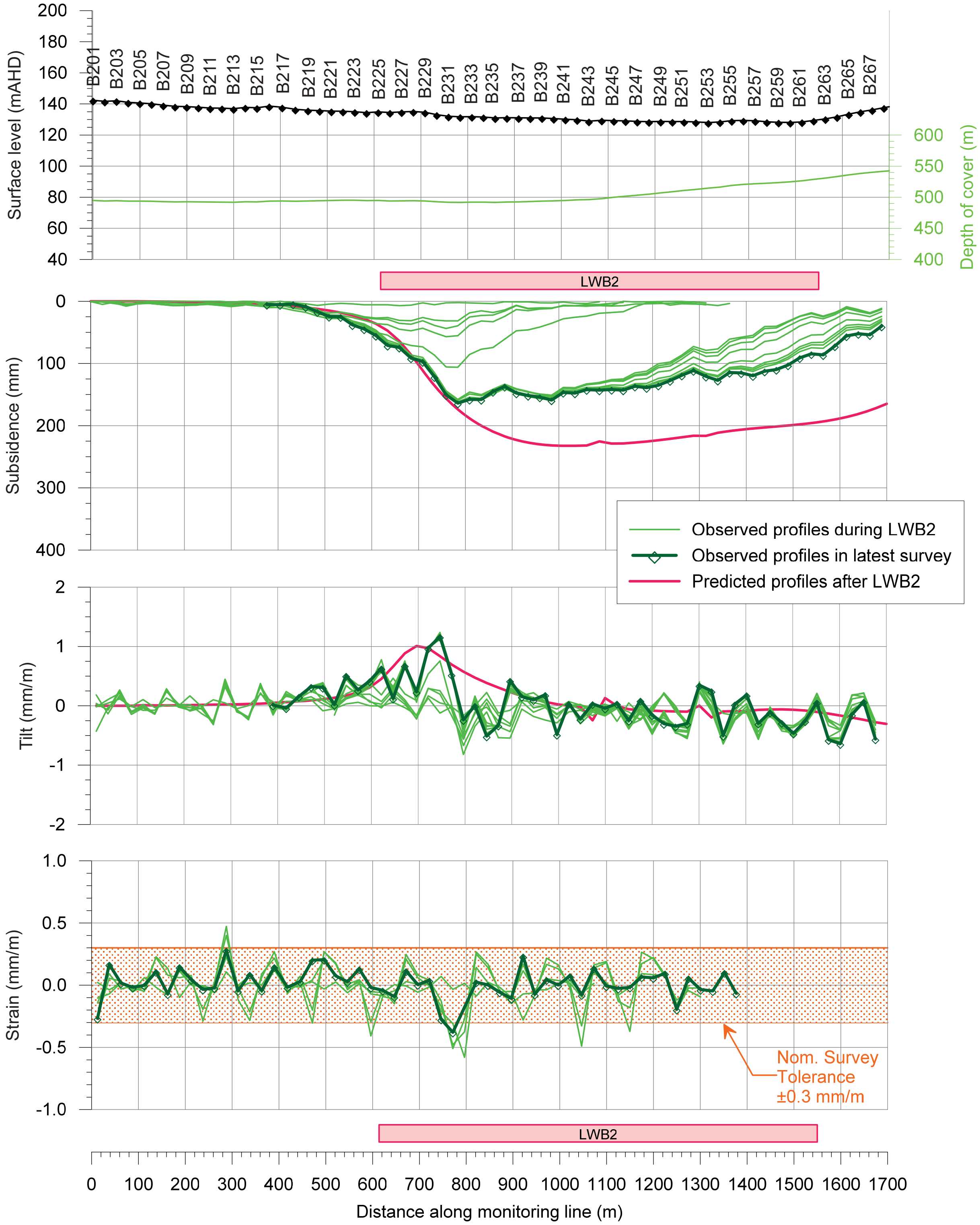


Fig. 3.6 Observed and predicted profiles of subsidence, tilt and strain along Line B2 above Longwall B2 in the Bellbird South Mining Area

It can be seen from Fig. 3.2 to Fig. 3.6, that the maximum observed vertical subsidence along these monitoring lines are less than the maxima predicted using the calibrated Incremental Profile Method. The percentages of the maximum observed to maximum predicted vertical subsidence are 75 % for Line 1B, 83 % for Line A3X, 66 % for Line XL3, 34 % for the Crossline and 70 % for Line B2. The IPM has provided conservative predictions of vertical subsidence as no subsidence reduction factor has been applied due to the presence of the massive Branxton Formation within the overburden.

The observed vertical subsidence slightly exceeds the predicted vertical subsidence outside the extents of the extracted longwalls adjacent to the tailgate of Longwall A1 (see Fig. 3.2), adjacent to the maingate of Longwall A8 (see Fig. 3.4) and adjacent to the commencing end of Longwall B2 (see Fig. 3.6). This low level vertical subsidence, however, is not associated with any significant observed tilts, curvatures or strains and impacts are not anticipated outside the extents of the extracted longwalls.

The shapes of the observed vertical subsidence profiles reasonably match the predicted profiles. The maximum observed tilts are generally less than the maxima predicted. However, the maximum observed tilt along Line A3X (see Fig. 3.3) of 7.6 mm/m is greater than the maximum predicted of 5.1 mm/m. It has been considered that the higher observed tilt is associated with the reduced subsidence above solid coal which may be the result of stronger strata cantilevering and reducing the subsidence over the tailgate of Longwall A3.

The maximum observed tilt along Line B2 (see Fig. 3.6) of 1.2 mm/m is slightly greater than the maximum predicted of 1.0 mm/m. This exceedance is very small and is within the order of accuracy of the prediction method and the survey tolerance. Localised and elevated tilts have also observed in other locations along the monitoring lines, which exceeded the predictions, however, it is likely that many of these have occurred as the result of disturbed survey marks, as they occurred outside of the extents of the longwalls.

The observed strains are typically less than those expected based on conventional ground movements, which are 1 mm/m tensile and 2 mm/m compressive. A localised tensile strain of 3.1 mm/m has occurred along Line 1B (see Fig. 3.2) which is considered to have been influenced by top of hill effects. Localised tensile strains between 1 mm/m and 2 mm/m have also occurred along Line A3X (see Fig. 3.3), which are likely the result of disturbed survey marks.

It is considered that the calibrated IPM has provided reasonable, if not, conservative predictions for the monitoring lines above the longwalls extracted in Stages 1 to 3 and in the Bellbird South mining area. It has not been considered necessary to undertake any further refinement of the subsidence prediction model based on the available results. It is expected that the calibrated IPM would provide reasonable, if not, slightly conservative predictions for the Longwalls B4 to B7.

4.1. Introduction

The following sections provide the maximum predicted conventional subsidence parameters resulting from the extraction of Longwalls B4 to B7. The predicted subsidence parameters and the impact assessments for the natural and built features are provided in Chapters 5 and 6.

The predicted subsidence, tilt and curvature have been obtained using the Incremental Profile Method, which has been calibrated and reviewed based on the local mining conditions, as described in Sections 3.5 and 3.6. The predicted strains have been determined by analysing the strains measured at the Mine.

The maximum predicted subsidence parameters and the predicted subsidence contours provided in this report describe and show the conventional movements and do not include the valley related upsidence and closure movements, nor the effects of faults and other geological structures. Such effects have been addressed separately in the impact assessments for each feature provided in Chapters 5 and 6.

4.2. Maximum predicted conventional subsidence, tilt and curvature

The predicted additional conventional subsidence contours, due to the extraction of the proposed Longwalls B4 to B7 only, are shown in Drawing No. MSEC869-10. These contours represent the additional movements after the completion of Longwall B3, but include the influence of the previous extracted Longwalls B1 to B3.

The predicted total conventional subsidence contours, due to the extraction of Longwalls B1 to B7, are shown in Drawing No. MSEC869-11. The predicted total subsidence contours including the adjacent existing and approved longwalls at Ellalong and Austar Mines are shown in Drawing No. MSEC869-12.

A summary of the maximum predicted values of incremental conventional vertical subsidence, tilt and curvature due to the extraction of each of the proposed longwalls is provided in Table 4.1. The incremental values are the additional movements due to each proposed longwall.

Table 4.1 Maximum predicted incremental conventional vertical subsidence, tilt and curvature due to the extraction of each of the longwalls

Longwall	Maximum predicted incremental vertical subsidence (mm)	Maximum predicted incremental tilt (mm/m)	Maximum predicted incremental hogging curvature (km^{-1})	Maximum predicted incremental sagging curvature (km^{-1})
LWB4	675	3.5	0.03	0.06
LWB5	625	3.5	0.03	0.05
LWB6	700	3.5	0.04	0.05
LWB7	725	4.0	0.05	0.06

A summary of the maximum predicted values of total conventional vertical subsidence, tilt and curvature after the extraction of each of the proposed longwalls is provided in Table 4.2. The total values are the maximum accumulated movements within the Study Area including the predicted movements due to the approved Longwalls B1 to B3.

Table 4.2 Maximum predicted total conventional vertical subsidence, tilt and curvature after the extraction of each of the proposed longwalls

Longwalls	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
LWB4	1,200	5.0	0.03	0.06
LWB5	1,250	5.5	0.04	0.06
LWB6	1,350	5.5	0.04	0.06
LWB7	1,350	5.5	0.05	0.06

The maximum predicted total vertical subsidence within Study Area is 1,350 mm, which represents 40 % of the proposed extraction height of 3.4 m. The maximum predicted subsidence occurs directly above the approved Longwall B3.

The maximum predicted total conventional tilt is 5.5 mm/m (i.e. 0.55 % or 1 in 180), which occurs adjacent to the maingate of Longwall B7. The maximum predicted total conventional curvatures are 0.05 km^{-1} hogging and 0.06 km^{-1} sagging, which represent minimum radii of curvatures of 20 km and 17 km, respectively.

The predicted conventional subsidence parameters vary across the Study Area as the result of, amongst other factors, variations in the depths of cover, seam thickness and overburden geology. To illustrate this variation, the predicted profiles of conventional subsidence, tilt and curvature have been determined along Prediction Line 1, the location of which is shown in Drawing Nos. MSEC869-10 to MSEC869-12.

The predicted profiles of conventional vertical subsidence, tilt and curvature along Prediction Line 1, resulting from the extraction of Longwalls B1 to B7, are shown in Fig. C.01, in Appendix C. The predicted total profiles after the extraction of each of the proposed longwalls are shown as the blue lines. The predicted total profiles after the completion of the approved Longwalls B1 to B3 are shown as cyan lines.

4.3. Comparisons of the maximum predicted subsidence parameters

The comparison of the maximum predicted subsidence parameters for the proposed Longwalls B4 to B7 with the maximum predicted for the approved Longwalls B1 to B3 is provided in Table 4.3. The total values are the maximum accumulated movements within the Study Area including the predicted movements due to the approved Longwalls B1 to B3.

Table 4.3 Comparison of the maximum predicted total conventional subsidence parameters within the Bellbird South mining area

Layout	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
LWB1 to LWB3	925	3.5	0.03	0.05
LWB1 to LWB7	1,350	5.5	0.05	0.06

The maximum predicted subsidence parameters after the extraction of the proposed Longwalls B4 to B7 are greater than the maximum predicted due to the approved Longwalls B1 to B3. The predicted parameters increase due to the accumulation of the movements from the four additional longwalls in the series.

The comparison of the maximum predicted subsidence parameters in the Bellbird South mining area with the maximum predicted in Stages 2 and 3 at the Mine is provided in Table 4.4. The total values are the maximum accumulated movements due to the extraction of each series of longwalls.

Table 4.4 Comparison of the maximum predicted total conventional subsidence parameters with the existing and approved longwalls in Stages 2 and 3 at the Mine

Layout	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
LWA3 to LWA5a (Stage 2 existing)	1,500	6.0	0.05	0.12
LWA8 to LWA19 (Stage 3 approved)	1,800	6.5	0.05	0.09
LWB1 to LWB7 (Bellbird South)	1,350	5.5	0.05	0.06

The maximum predicted subsidence parameters in the Bellbird South mining area are less than the maximum predicted due to the completed Longwalls A3 to A5a in Stage 2 and the approved Longwalls A7 to A19 in Stage 3 at the Mine. The predicted parameters for Stages 2 and 3 are greater, as these are based on longwall top coal caving mining techniques, whereas the longwalls in the Bellbird South mining area are extracted using conventional mining techniques.

4.4. Predicted strains

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including ground curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock and the depth of bedrock. Survey tolerance can also represent a substantial portion of the measured strain, in cases where the strains are of a low order of magnitude. The profiles of observed strain, therefore, can be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

In previous MSEC subsidence reports, predictions of conventional strain were provided based on the best estimate of the average relationship between curvature and strain. Similar relationships have been proposed by other authors. The reliability of the strain predictions was highlighted in these reports, where it was stated that measured strains can vary considerably from the predicted conventional values.

Adopting a linear relationship between curvature and strain provides a reasonable estimate for the conventional tensile and compressive strains. The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones.

In the Newcastle Coalfield a factor of 10 is generally used to predict the conventional strains from curvatures. It has been found, however, that a factor of 15 provides a better prediction of the conventional strains at Austar Coal Mine based on reviews of the available ground monitoring data. The maximum predicted conventional strains for Longwalls B4 to B7, adopting a factor of 15, are 1 mm/m tensile and compressive.

At a point, however, there can be considerable variation from the linear relationship, resulting from non-conventional movements or from the normal scatters which are observed in strain profiles. When expressed as a percentage, observed strains can be many times greater than the predicted conventional strain for low magnitudes of curvature. In this report, therefore, we have provided a statistical approach to account for the variability, instead of just providing a single predicted conventional strain.

The range of potential strains for the longwalls has been determined using monitoring data from the previously extracted longwalls at the Mine. Longwalls A1 and A2 in Stage 1, Longwalls A3 to A5A in Stage 2 and Longwalls A7 and A8 in Stage 3 were extracted using LTCC mining techniques. Longwall B2 in the Bellbird South mining area was extracted using conventional longwall mining techniques.

A summary of the overall void widths, depths of cover, width-to-depth ratios and seam thicknesses for these previously extracted longwalls is provided in Table 4.5.

Table 4.5 Mine geometry for previously extracted longwalls at the Austar Coal Mine

Stage	Longwall	Void width (m)	Depth of cover (m)	Width-to-depth ratio	Extraction thickness* (m)
Stage 1	LWA1	157	395 ~ 470	0.33 ~ 0.40	5.9 ~ 6.3
	LWA2	227	385 ~ 450	0.50 ~ 0.59	6.0 ~ 6.3
Stage 2	LWA3	227	485 ~ 535	0.42 ~ 0.47	4.7 ~ 6.2
	LWA4	237	500 ~ 535	0.44 ~ 0.47	4.7 ~ 6.1
	LWA5	237	510 ~ 535	0.44 ~ 0.46	5.0 ~ 6.0
	LWA5A	237	530 ~ 555	0.43 ~ 0.45	5.1 ~ 5.6
Stage 3	LWA7	237	455 ~ 520	0.46 ~ 0.52	5.6 ~ 6.0
	LWA8	237	490 ~ 555	0.43 ~ 0.48	3.4 ~ 6.0
Bellbird South	LWB2	237	485 ~ 545	0.43 ~ 0.49	3.4

Note: * denotes that the effective extraction thickness for Stages 1 to 3 (i.e. LTCC mining techniques) has been taken as 3 m bottom coal plus 85 % recovery of the top coal (i.e. remaining seam thickness).

The width-to-depth ratios for the previously extracted longwalls at the Mine typically vary between 0.4 and 0.5, with the ratios varying between 0.33 and 0.59 for the longwalls in Stage 1. The width-to-depth ratios for Longwalls B4 to B7 vary between 0.47 and 0.59 and, therefore, are within the range of those for the previously extracted longwalls.

The effective extraction thickness for the previously extracted longwalls in Stages 1 to 3 (i.e. longwall top coal caving mining techniques) varied between 3.4 and 6.3 m. A constant extraction thickness of 3.4 m was adopted for Longwall B2 in the Bellbird South mining area. It is proposed that Longwalls B4 to B7 will also extract a constant thickness of 3.4 m using conventional longwall mining techniques.

The range of strains measured during the extraction of the previous longwalls in Stages 1 to 3 and in the Bellbird South mining area should provide a good, if not, conservative indication of the range of potential strains for the proposed Longwalls B4 to B7. The mine subsidence movements were measured along 13 monitoring lines during the extraction of the previous longwalls at the Mine, which were: Line 1A, Line 1B and Line 2 in Stage 1; Line A3, Line A3X, Line A4 and Line A5A in Stage 2; Line XL3, Line A7, Line A8 and Quorrobolong Road in Stage 3; and the B2-Line and the BSX-Line in the Bellbird South mining area.

In order to improve the strain analysis, the monitoring lines above the previously extracted Longwalls SL1 to SL4 and Longwalls 1 to 13A at the adjacent Ellalong Colliery were also included. These longwalls were extracted using conventional longwall mining techniques, where the width-to-depth ratios typically varied between 0.4 and 0.5 and the seam thickness typically varied between 3.0 m and 3.5 m, which are similar to the ranges for the proposed Longwalls B4 to B7.

The data used in the analysis of observed strains included those resulting from both conventional and non-conventional anomalous movements, but did not include those resulting from valley related movements, which are addressed separately in this report. The strains resulting from damaged or disturbed survey marks have also been excluded.

4.4.1. Analysis of strains measured in survey bays

For features that are in discrete locations, such as building structures, farm dams and archaeological sites, it is appropriate to assess the frequency of the observed maximum strains for individual survey bays.

The monitoring lines have been analysed to extract the maximum tensile and compressive strains that have been measured at any time during mining, for survey bays that were located directly above the goaf or the chain pillars that are located between the extracted longwalls. A number of probability distribution functions were fitted to the empirical data and, it was found, that a *Generalised Pareto Distribution* (GPD) provided good fits to the raw strain data.

The histogram of the maximum observed tensile and compressive strains measured in survey bays located above goaf is provided in Fig. 4.1. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

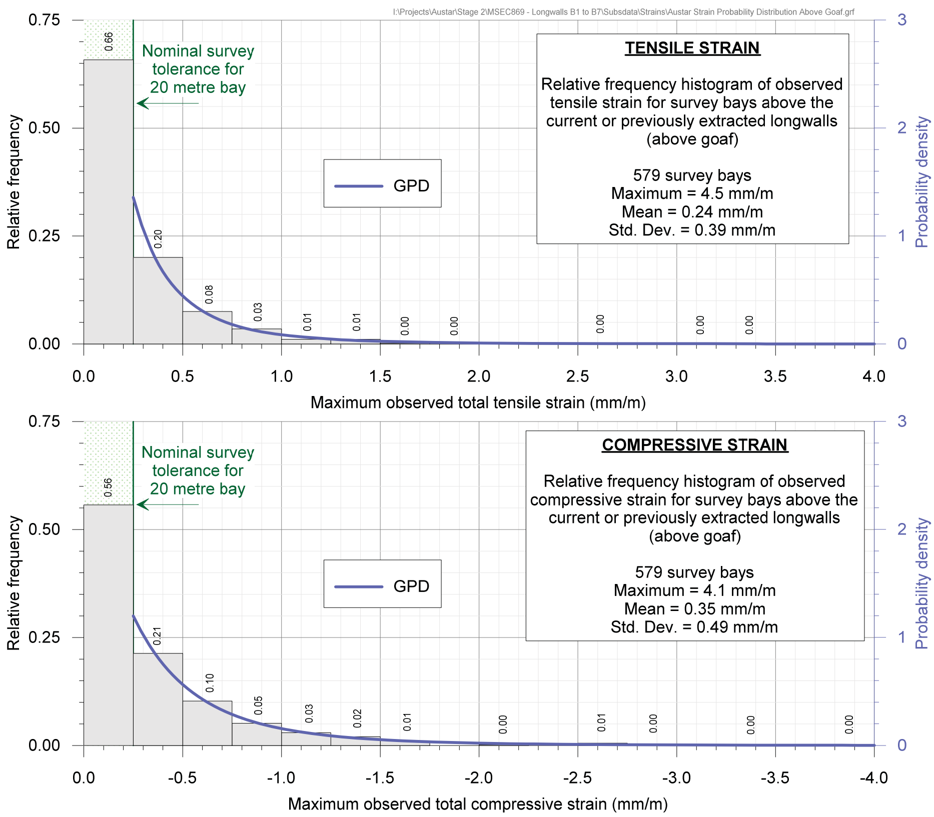


Fig. 4.1 Distributions of the measured maximum tensile and compressive strains during the extraction of previous longwalls for survey bays located above goaf

Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during the longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay). A summary of the predicted strains directly above Longwalls B4 to B7 (i.e. above goaf) is provided in Table 4.6.

Table 4.6 Predicted strains directly above Longwalls B4 to B7 (i.e. above goaf)

Location	Confidence level	Predicted tensile strain (mm/m)	Predicted compressive strain (mm/m)
Above goaf	95 %	0.9	1.2
	99 %	1.7	2.2

The survey database has also been analysed to extract the maximum tensile and compressive strains that have been measured at any time during mining, for survey bays that were located directly above solid coal and within 250 m of the nearest longwall goaf edge. Solid coal is defined as the surface area above where the coal has not been extracted by longwalls.

The histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal is provided in Fig. 4.2. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

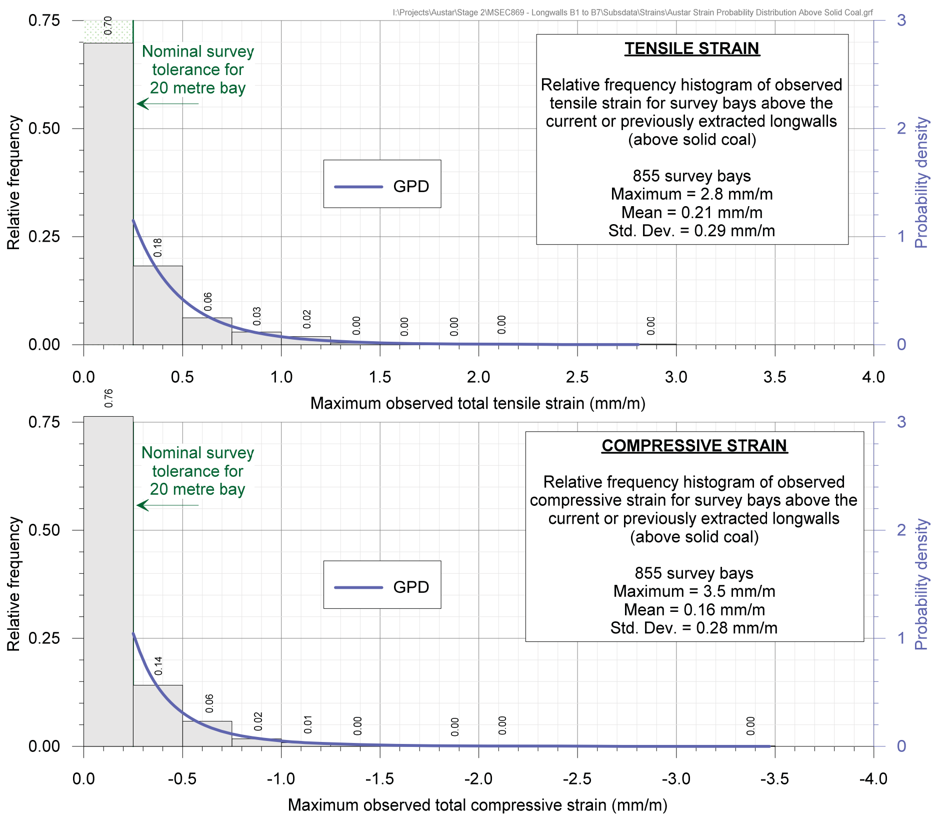


Fig. 4.2 Distributions of the measured maximum tensile and compressive strains during the extraction of previous longwalls for survey bays located above solid coal

Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during the longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay). A summary of the predicted strains outside but within 250 m of Longwalls B4 to B7 (i.e. above solid coal) is provided in Table 4.7.

Table 4.7 Predicted strains outside Longwalls B4 to B7 (i.e. above solid coal)

Location	Confidence level	Predicted tensile strain (mm/m)	Predicted compressive strain (mm/m)
Above solid coal	95 %	0.8	0.7
	99 %	1.3	1.3

4.4.2. Analysis of strains measured along whole monitoring lines

For linear features such as roads, cables and pipelines, it is more appropriate to assess the frequency of observed maximum strains along whole monitoring lines, rather than for individual survey bays. That is, an analysis of the maximum strains anywhere along the monitoring lines, regardless of where the strain actually occurs.

The histogram of maximum observed tensile and compressive strains measured anywhere along the monitoring lines is provided in Fig. 4.3.

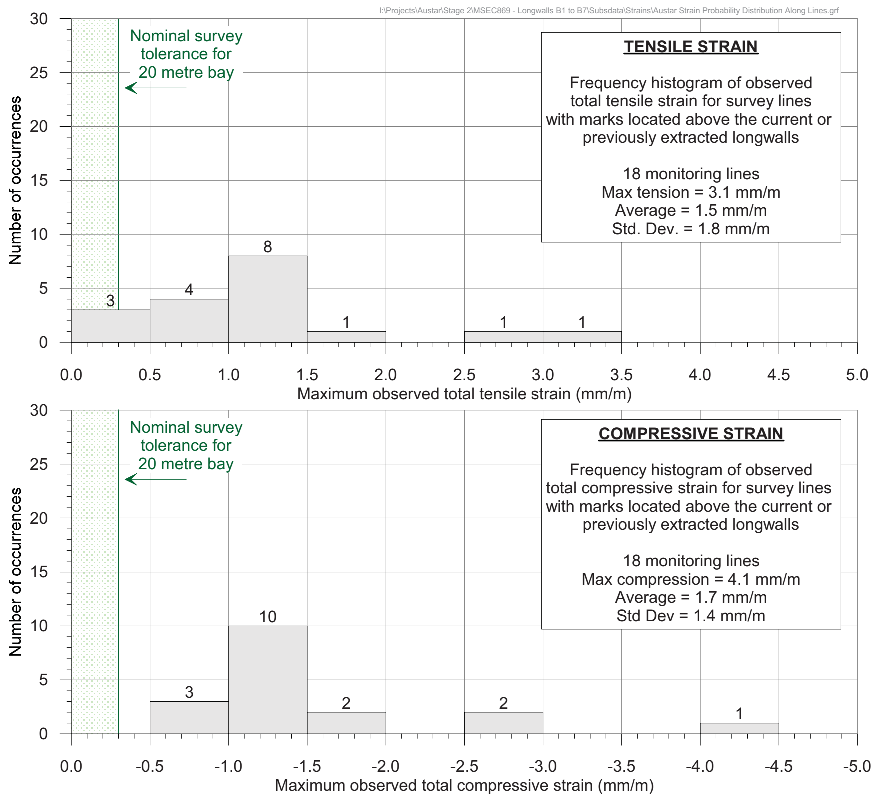


Fig. 4.3 Distributions of measured maximum tensile and compressive strains along the monitoring lines during the extraction of previous longwalls

It can be seen from Fig. 4.3, that 16 of the 18 monitoring lines (i.e. 89 % of the total) have recorded maximum total tensile strains of 2 mm/m or less. It can also be seen, that 15 of the 18 monitoring lines (i.e. 83 % of the total) also have recorded maximum compressive strains of 2 mm/m or less. The maximum observed strains along the monitoring lines, excluding the survey bays which appear to have been disturbed, were 3.1 mm/m tensile and 4.1 mm/m compressive.

4.5. Predicted conventional horizontal movements

The predicted conventional horizontal movements above Longwalls B4 to B7 are calculated by applying a factor to the predicted conventional tilt values. In the Newcastle Coalfield a factor of 10 is generally adopted, being the same factor as that used to determine the conventional strains from curvatures, and this has been found to give a reasonable correlation with measured data.

The comparisons between observed and back-predicted strains along the monitoring lines above the previously extracted longwalls at the Mine, as described in Sections 3.5 and 3.6, indicates that a factor of 15 provides a better correlation for the prediction of conventional horizontal movements at Austar Coal Mine.

This factor will in fact vary and will be higher at low tilt values and lower at high tilt values. The application of this factor will therefore lead to over-prediction of horizontal movements where the tilts are high and under-prediction of the movements where the tilts are low.

The maximum predicted conventional tilt within the Study Area, at any time during or after the extraction of Longwalls B4 to B7, is 5.5 mm/m, which occurs adjacent to the maingate of Longwall B7. This area will experience the greatest predicted conventional horizontal movement towards the centre of the overall goaf area resulting from the extraction of the longwalls. The maximum predicted conventional horizontal movement is, therefore, approximately 85 mm, i.e. 5.5 mm/m multiplied by a factor of 15.

Conventional horizontal movements do not directly impact on natural and built features, rather impacts occur as the result of differential horizontal movements. Strain is the rate of change of horizontal movement. The impacts of strain on the natural and built features are addressed in the impact assessments provided in Chapters 5 and 6.

4.6. Predicted far-field horizontal movements

In addition to the vertical subsidence movements that have been predicted above and adjacent to Longwalls B4 to B7, it is also likely that far-field horizontal movements will be experienced during the extraction of these longwalls.

An empirical database of observed incremental far-field horizontal movements has been compiled using monitoring data from the NSW Coalfields, but predominately from the Southern Coalfield. The far-field horizontal movements resulting from longwall mining were generally observed to be orientated towards the extracted longwall. At very low levels of far-field horizontal movements, however, there was a high scatter in the orientation of the observed movements.

The observed incremental far-field horizontal movements, resulting from the extraction of a single longwall, are provided in Fig. 4.4. The confidence levels, based on fitted *Generalised Pareto Distributions* (GPDs), have also been shown in this figure to illustrate the spread of the data.

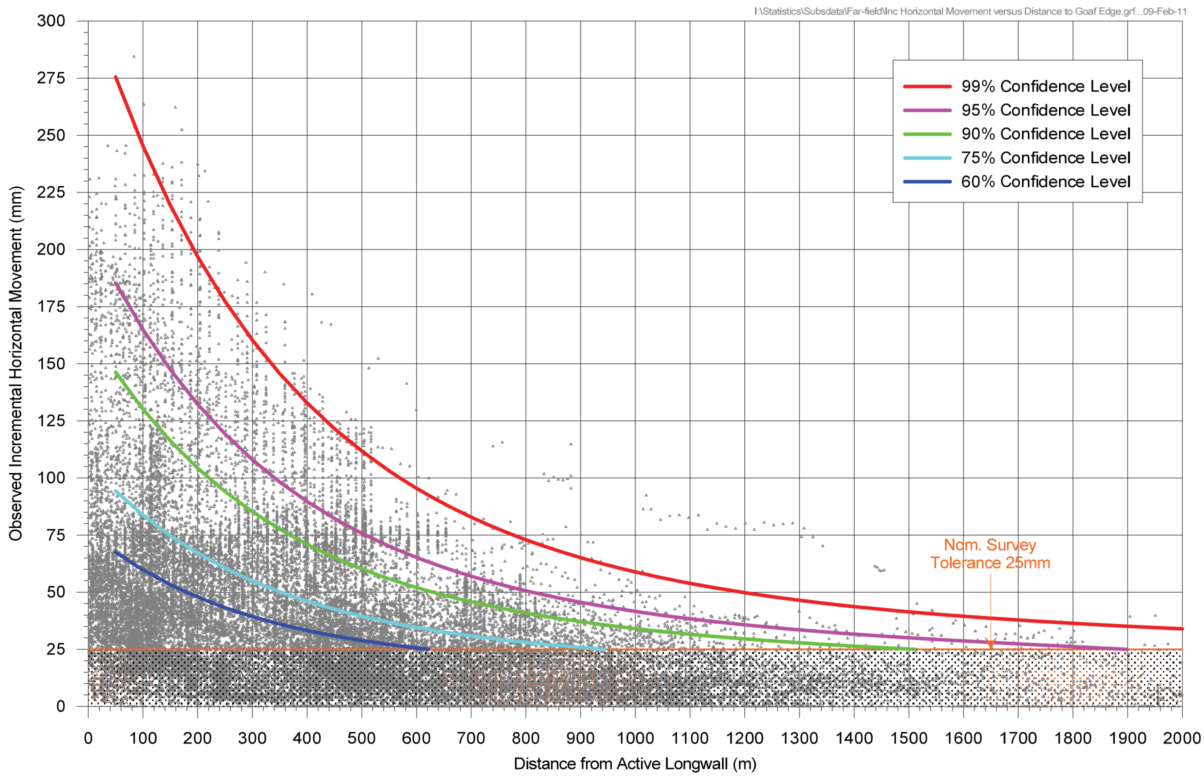


Fig. 4.4 Observed incremental far-field horizontal movements

As successive longwalls within a series of longwalls are mined, the magnitudes of the incremental far-field horizontal movements decrease. This is possibly due to the fact that once the in situ stresses within the strata have been redistributed around the collapsed zones above the first few extracted longwalls, the potential for further movement is reduced. The total far-field horizontal movement is not, therefore, the sum of the incremental far-field horizontal movements for the individual longwalls.

The predicted far-field horizontal movements resulting from the extraction of Longwalls B4 to B7 are very small and could only be detected by ground surveys. Such movements tend to be bodily movements towards the extracted goaf area, and are accompanied by very low levels of strain, which are generally less than the order of survey tolerance (i.e. less than 0.3 mm/m).

The potential impacts of far-field horizontal movements on the natural and built features within the vicinity of the proposed longwalls are not expected to be significant. It is not considered necessary, therefore, that monitoring be established to measure the far-field horizontal movements resulting from these longwalls.

4.7. General discussion on mining induced ground deformations

Longwall mining can result in surface cracking, heaving, buckling, humping and stepping at the surface. The extent and severity of these mining induced ground deformations are dependent on a number of factors, including the mine geometry, depth of cover, overburden geology, locations of natural jointing in the bedrock and the presence of near surface geological structures.

Faults and joints in bedrock develop during the formation of the strata and from subsequent distressing associated with movement of the strata. Longwall mining can result in additional fracturing in the bedrock, which tends to occur in the tensile zones, but fractures can also occur due to buckling of the surface beds in the compressive zones. The incidence of visible cracking at the surface is dependent on the pre-existing jointing patterns in the bedrock as well as the thickness and inherent plasticity of the soils that overlie the bedrock.

Surface cracking in soils as the result of conventional subsidence movements is not commonly observed where the depths of cover are greater than 400 m, such as is the case at Austar Coal Mine, and any cracking that has been observed has generally been isolated and of a minor nature.

Cracking is found more often in the bases of stream valleys due to the compressive strains associated with upsidence and closure movements. The likelihood and extent of cracking along the creeks within the Study Area are discussed in Section 5.2. Cracking can also occur at the tops of steep slopes as the result of downslope movements, which is discussed in Section 5.4.

Surface cracks are more readily observed in built infrastructure such as road pavements. In the majority of these cases no visible ground deformations can be seen in the natural ground adjacent to the cracks in the road pavements. In rare instances more noticeable ground deformations, such as humping or stepping of the ground can be observed at thrust faults.

There has been no significant or visible surface cracking above the previously extracted Longwalls A3 to A8 in Stages 2 and 3 and Longwall B2 in the Bellbird South mining area. The surface cracking, if any, resulting from the extraction of Longwalls B4 to B7 is expected to be of a minor nature, having widths generally less than 10 to 25 mm. It is expected that the surface cracking could be remedied by infilling with soil or other suitable materials, or by locally regrading and recompacting the surface.

Examples of surface tensile cracking and compression buckling from elsewhere in the NSW Coalfields are provided in the photographs in Fig. 4.5 and Fig. 4.6, respectively. These ground deformations were observed in the Southern Coalfield, where the depths of cover were similar to those within the Study Area.

Fig. 4.5 Example of surface tensile cracking in the natural ground surface (observed in the Southern Coalfield at a similar depth of cover as in the Study Area)

Fig. 4.6 Example of surface compression buckling observed in road pavement (observed in the southern coalfield at a similar depth of cover as the Study Area)

Localised ground buckling and shearing can occur wherever faults, dykes and abrupt changes in geology occur near the ground surface. The identified geological structures within the Study Area are discussed in Section 1.4.

4.8. Estimated height of the fractured zone

The extraction of longwalls results in deformation throughout the overburden strata. The terminology used by different authors to describe the strata deformation zones above extracted longwalls varies considerably and caution should be taken when comparing the recommendations from differing authors. Forster (1995) noted that most studies have recognised four separate zones, as shown in Fig. 4.7, with some variations in the definitions of each zone.

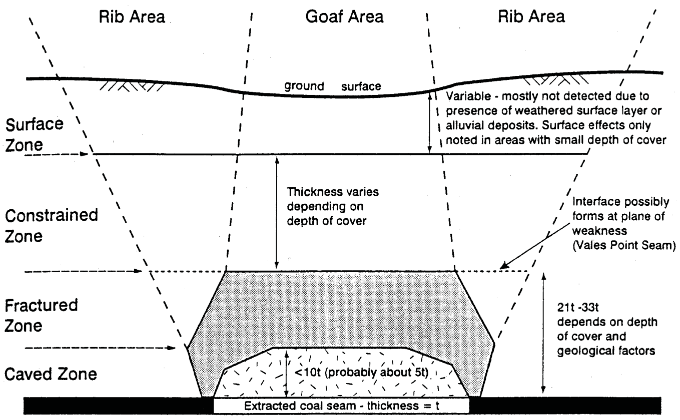


Fig. 4.7 Zones in the overburden according to Forster (1995)

Peng and Chiang (1984) recognised only three zones as reproduced in Fig. 4.8.

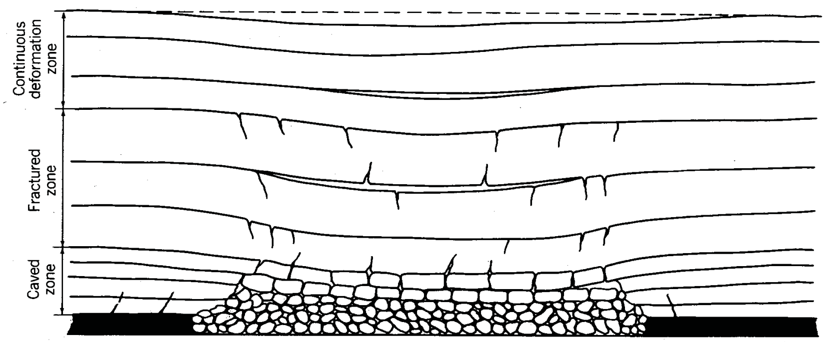


Fig. 4.8 Zones in the overburden according to Peng and Chiang (1984)

McNally et al (1996) also recognised three zones, which they referred to as the caved zone, the fractured zone and the elastic zone. Kratzsch (1983) identified four zones, but named them the immediate roof, the main roof, the intermediate zone and the surface zone.

For the purpose of these discussions, the following zones, as described by Singh and Kendorski (1981) and proposed by Forster (1995), as shown in Fig. 4.7, have been adopted:

- *Caved* or *Collapsed Zone* comprises loose blocks of rock detached from the roof and occupying the cavity formed by mining. This zone can contain large voids. It should be noted, that some authors note primary and secondary caving zones.
- *Disturbed* or *Fractured Zone* comprises in situ material lying immediately above the caved zone which have sagged downwards and consequently suffered significant bending, fracturing, joint opening and bed separation. It should be noted, that some authors include the secondary caving zone in this zone.
- *Constrained* or *Aquiclude Zone* comprises confined rock strata above the disturbed zone which have sagged slightly but, because they are constrained, have absorbed most of the strain energy without suffering significant fracturing or alteration to the original physical properties. Some bed separation or slippage can be present as well as some discontinuous vertical cracks, usually on the underside of thick strong beds, but not of a degree or nature which would result in connective cracking or significant increases in vertical permeability. Some increases in horizontal permeability can be found. Weak or soft beds in this zone may suffer plastic deformation.
- *Surface Zone* comprises unconfined strata at the ground surface in which mining induced tensile and compressive strains may result in the formation of surface cracking or ground heaving.

Just as the terminology differs between authors, the means of determining the extents of each of these zones also varies. Some of the difficulties in establishing the heights of the various zones of disturbance above extracted longwalls stem from the imprecise definitions of the fractured and constrained zones, the differing zone names, and the use of different testing methods and differing interpretations of monitoring data, such as extensometer readings.

Some authors interpret the collapsed and fractured zones to be the zone from which groundwater or water in boreholes would flow freely into the mine and, hence, look for the existence of aquiclude or aquitard layers above this height to confirm whether surface water would or would not be lost into the mine.

The heights of the collapsed and fractured zones above extracted longwalls are affected by a number of factors, which include the:

- widths of extraction;
- heights of extraction;
- depths of cover;
- types of previous workings, if any, above the current extractions;
- interburden thicknesses to previous workings;
- presence of pre-existing natural joints within each strata layer;
- thickness, geology, geomechanical properties and permeability of each strata layer;
- angle of break of each strata layer;
- spanning capacity of each strata layer, particularly those layers immediately above the collapsed and fractured zones;
- bulking ratios of each strata layer within the collapsed zone; and the
- presence of aquiclude or aquitard zones.

Some authors have suggested simple equations to estimate the heights of the collapsed and fractured zones based solely on the extracted seam height, others have suggested equations based solely on the widths of extraction, whilst others have suggested equations based on the width-to-depth ratios of the extractions. As this is a complex issue comprising the above factors, MSEC understand that no simple geometrical equation can properly estimate the heights of the collapsed and fractured zones and a more thorough analysis is required, which should include other properties, such as geology and permeability, of the overburden strata.

At the Austar Coal Mine, the massive sandstones in the Branxton Formation are capable of spanning the extracted voids with minimal sag subsidence, with the observed subsidence governed, to a large extent, by pillar compression. The combination of low width-to-depth ratios of the extracted longwalls and the properties of the overburden at the Mine limit the heights of vertical fracturing above the seam.

Two extensometers were installed above Longwalls A1 and A2 in Stage 1 at the Mine. The measured heights of vertical fracturing above the seam in these locations were: 86 m for Extensometer AQD1074 after Longwall A1; and 150 m for Extensometer AQD1085 after Longwall A2.

The height of the discontinuous fracturing (i.e. the Discontinuous Fracture Zone, or Zone B) can extend 1 to 1.5 times the longwall void width above the extracted seam. The overall void widths of the longwalls are 237 m and, therefore, the height of the discontinuous fracturing could extend 235 to 355 m above the seam.

The depth of cover above Longwalls B4 to B7 varies between 400 and 505 m. It is expected, therefore, that a constrained zone would develop in the upper section of the overburden, due to the high depths of cover, where vertical fracturing is generally discontinuous and unlikely, therefore, to result in significantly increased vertical hydraulic conductivity.

Further discussions on the effects of mining on the overburden and groundwater are provided by the specialist groundwater consultant in the report by Dundon Consulting (2017). Further details on sub-surface strata movements are provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at *www.minesubsidence.com*.

The following sections provide the descriptions, predictions and impact assessments for the natural features within the Study Area, as identified in Chapter 2. The impact assessments are based on the predicted movements due to the extraction of the proposed Longwalls B4 to B7, as well as the predicted movements due to the previously extracted longwalls at Ellalong Colliery and Austar Coal Mine (i.e. cumulative movements due to the existing and proposed longwalls).

All significant natural features located outside the Study Area, which may be subjected to valley related or far-field horizontal movements due to the proposed Longwalls B4 to B7 and may be sensitive to these movements, have also been included as part of these assessments.

5.1. Natural Features

As listed in Table 2.1, the following natural features were not identified within the Study Area nor in the immediate surrounds:

- drinking water catchment areas or declared special areas;
- known springs or groundwater seeps;
- seas or lakes;
- shorelines;
- natural dams;
- cliffs or pagodas;
- escarpments;
- lands declared as critical habitat under the *Threatened Species Conservation Act 1995*;
- National Parks or State Forests;
- State Recreation Areas or State Conservation Areas;
- areas of significant geological interest; and
- other significant natural features.

The following sections provide the descriptions, predictions and impact assessments for the natural features which have been identified within or in the vicinity of the Study Area.

5.2. Streams

The locations of the streams within the Study Area are shown in Drawing No. MSEC869-07. The descriptions, predictions and impact assessments for these streams are provided in the following sections.

5.2.1. Descriptions of the streams

Quorrobolong Creek crosses directly above the proposed Longwalls B6 and B7. The total length of the creek located above these longwalls is approximately 1.3 km. Quorrobolong Creek has been previously directly mined beneath by Longwalls SL1 and 1 to 5 at Ellalong Colliery and by Longwalls A3 to A5A at the Austar Coal Mine, with a total length of approximately 4 km located directly above these previously extracted longwalls.

Quorrobolong Creek flows in a westerly direction to where it drains to Ellalong Lagoon, which is located more than 5 km from the proposed longwalls. The creek is ephemeral, but localised areas of natural ponding occur along its alignment. The natural grade of the section of creek within the Study Area varies between approximately 1 mm/m and 3 mm/m, with an average grade of approximately 2 mm/m.

The creek is incised into the natural surface soils, with the heights of the banks ranging between 3 and 5 m. The bed of the creek comprises Quaternary alluvium. There are debris accumulations along some sections of the creek, including tree branches, other vegetation and loose rocks.

Photographs of Quorrobolong Creek within the Study Area are provided in Fig. 5.1.

Fig. 5.1 Quorrobolong Creek

There are also ephemeral drainage lines within the Study Area that have formed on and between the small ridgelines. The locations of these drainage lines are shown in Drawing No. MSEC869-07. The largest ephemeral drainage line within the Study Area has been referred to as Drainage Line 1, in this report, as shown in Drawing No. MSEC869-07.

The drainage lines within the Study Area all drain to Quorrobolong Creek. The upper reaches of the drainage lines have formed in the Branxton Formation and have steep natural gradients, but with localised areas of ponding and stepping in some locations. The lower reaches of the drainage lines have shallow incisions into the natural surface soils that are comprised of Quaternary alluvium.

Photographs of the typical drainage lines within the Study Area are provided in Fig. 5.2.

Fig. 5.2 Typical drainage lines within the Study Area

5.2.2. Predictions for the streams

The predicted profiles of conventional subsidence, tilt and curvature along the alignment of Quorrobolong Creek are shown in Fig. C.02, in Appendix C. The predicted total profiles along the creek, after the extraction of each of the proposed longwalls, are shown as blue lines. The predicted profiles after the completion of the existing and approved longwalls are shown as the cyan lines.

A summary of the maximum predicted values of total vertical subsidence, tilt and curvature for Quorrobolong Creek is provided in Table 5.1. The predictions are the maxima within the Study Area, i.e. do not include the sections of creek located above the previously extracted longwalls at Ellalong Colliery and Austar Coal Mine, but include the predicted movements resulting from these previous longwalls.

Table 5.1 Maximum predicted total vertical subsidence, tilt and curvature for Quorrobolong Creek

Location	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Quorrobolong Creek	After LWB1 to LWB3	60	0.5	0.01	< 0.01
	After LWB4	60	0.5	0.01	< 0.01
	After LWB5	90	0.5	0.01	< 0.01
	After LWB6	650	3.0	0.02	0.02
	After LWB7	1,100	5.0	0.04	0.04

The tilts provided in the above table are the maxima predicted along the alignment of Quorrobolong Creek after the completion of each of the longwalls. The curvatures are the maxima predicted in any direction at any time during or after the extraction of each of the longwalls.

The predicted profiles of conventional subsidence, tilt and curvature along the alignment of Drainage Line 1 are shown in Fig. C.03, in Appendix C. The predicted total profiles along the drainage line, after the extraction of each of the proposed longwalls, are shown as blue lines. The predicted profiles after the completion of the existing and approved longwalls are shown as the cyan lines.

A summary of the maximum predicted values of total vertical subsidence, tilt and curvature for Drainage Line 1 is provided in Table 5.2. The predictions are the maxima within the Study Area, but also include the predicted movements resulting from the adjacent previously extracted longwalls.

Table 5.2 Maximum predicted total vertical subsidence, tilt and curvature for Drainage Line 1

Location	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Drainage Line 1	After LWB1 to LWB3	925	2.5	0.02	0.05
	After LWB4	1,150	3.0	0.02	0.06
	After LWB5	1,250	3.5	0.04	0.06
	After LWB6	1,350	3.5	0.04	0.06
	After LWB7	1,350	3.5	0.04	0.06

The streams are linear features and, therefore, the most relevant distributions of strain are the maximum strains measured along whole monitoring lines. The analysis of strain along whole monitoring lines during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.2.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The remaining drainage lines are located across the Study Area and, therefore, could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence parameters within the Study Area is provided in Chapter 4.

Quorrobolong Creek and the drainage lines located within the Study Area have shallow incisions into the natural surface soils. It is unlikely, therefore, that these streams would experience any significant valley related movements resulting from the extraction of the proposed longwalls.

5.2.3. Impact assessments for the streams

The extraction of the proposed longwalls could potentially affect the surface water flows along the streams that are located directly above them. It is possible that locally increased ponding could occur if the mining induced tilts oppose and are greater than the natural gradients that exist before mining. The natural surface levels and grades and the predicted post mining surface levels and grades along Quorrobolong Creek and the Drainage Line 1 are illustrated in Fig. 5.3 and Fig. 5.4, respectively.

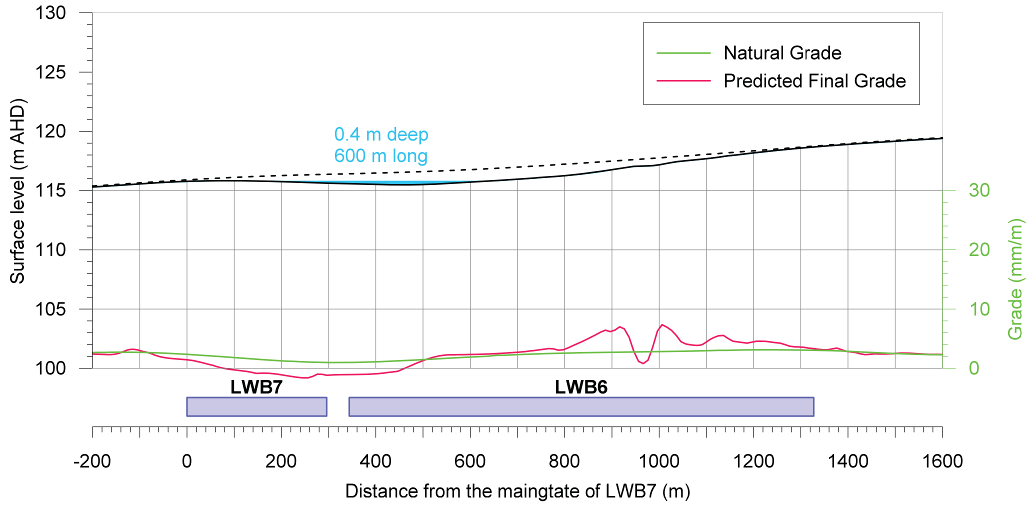


Fig. 5.3 Natural and predicted post-mining levels and grades along Quorrobolong Creek

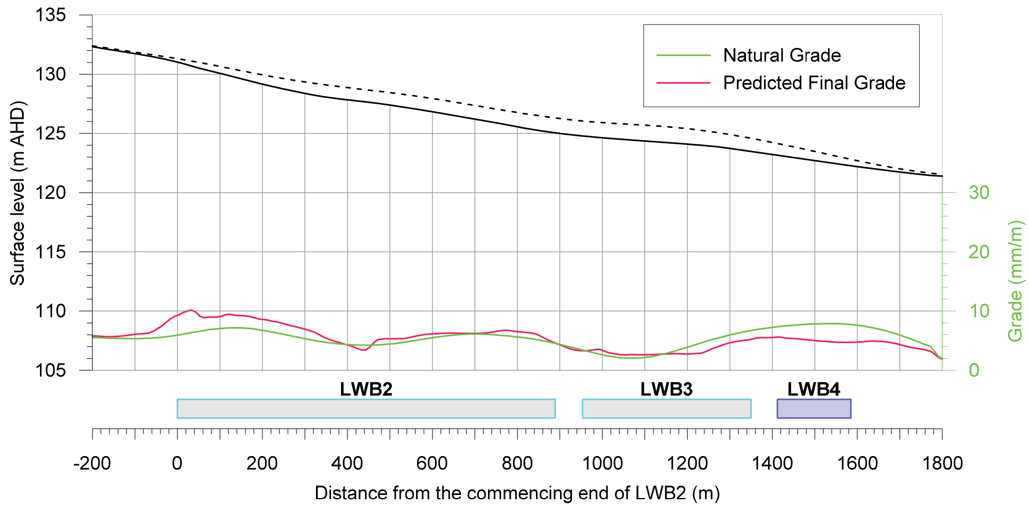


Fig. 5.4 Natural and predicted post-mining levels and grades along Drainage Line 1

Quorrobolong Creek has an average natural grade of approximately 2 mm/m within the Study Area. There is a predicted reversal in the creek grade above the chain pillar between the proposed Longwalls B6 and B7. It is possible, therefore, that there could be an increased potential for ponding to develop in this location. The mining-induced ponding is predicted to be up to 0.4 m deep and 600 m long along the alignment of the creek.

Drainage Line 1 has an average natural grade of approximately 6 mm/m within the Study Area. The post-mining grades along the drainage line are similar to the natural grades. There are no areas identified along Drainage Line 1 with the increased potential for ponding as a result of the proposed longwalls.

The other drainage lines within the Study Area have formed on the small ridgelines and have average natural grades greater than 10 mm/m. It is unlikely that increased ponding would develop along these other drainage lines as a result of the proposed longwalls.

A detailed flood model of the streams has been developed by Umwelt, using the predicted subsidence movements resulting from the extraction of the proposed longwalls, which have been provided by MSEC. The increased likelihoods of ponding and flooding along the streams have been assessed in the flood study and are provided in the report by Umwelt (2017b).

The maximum predicted curvature for Quorrobolong Creek is 0.04 km^{-1} both hogging and sagging, which represents a minimum radius of curvature of 25 km. The maximum predicted curvatures for the drainage lines within the Study Area are 0.05 km^{-1} hogging and 0.06 km^{-1} sagging, which represent minimum radii of curvature of 20 km and 17 km, respectively. The streams could also experience the full range of predicted ground strains which is discussed in Section 4.4.2.

It is likely that compressive buckling and dilation of the uppermost bedrock would occur beneath the natural surface soil beds along the streams that are located directly above the proposed longwalls. Surface cracking can potentially occur in the locations where the uppermost bedrock fractures or buckles and where the depths of cover to bedrock are shallow.

The Cessnock Sandstone forms the upper section of the overburden, which is relatively homogeneous and contains thick beds. A constrained zone is expected to develop in the upper section of the overburden, due to the high depths of cover, as described in Section 4.8. The vertical fracturing within the constrained zone is discontinuous and tortuous and, therefore, is unlikely to result in a significant increase in the vertical hydraulic conductivity.

The previous longwalls in Stages 2 and 3 at the Mine have been extracted beneath approximately 2.4 km of streams and no significant surface cracking or loss of surface water flows have been observed. It is considered unlikely, therefore, that there would be a net loss of water from the streams within the Study Area resulting from the extraction of the proposed longwalls.

The surface cracking above the proposed longwalls would tend to be naturally filled with the natural surface soils during subsequent flow events, especially during times of heavy rainfall. If the surface cracks were found not to fill naturally, remedial measures may be required at the completion of mining. Where necessary, the larger surface cracks in the stream beds could be remediated by infilling with the natural surface soils or other suitable materials, or by locally regrading and recompacting the surface.

Further discussion on the potential impacts on the changes in surface water flows are provided in the reports by Umwelt (2017a and 2017b).

5.2.4. Recommendations for the streams

It is recommended that the beds of the streams are periodically visually monitored during the extraction of the proposed longwalls, and that the major surface tensile cracking is remediated by infilling with the natural surface soils or other suitable materials, or by locally regrading and recompacting the surface, as required. With these management strategies in place, it is unlikely that there would be any significant long term impact on the streams resulting from the extraction of the proposed longwalls

5.3. Aquifers and known groundwater resources

The groundwater resources within the Study Area occur in the shallow alluvial aquifers associated with Quorrobolong Creek, the upper parts of the Branxton Formation and within the deeper Newcastle Coal Measures. Further descriptions of the aquifers within the Study Area are provided in the report by Dundon Consulting (2017).

5.4. Steep slopes

The definition of a steep slope provided in the NSW Department of Planning and Environment Standard and Model Conditions for Underground Mining (DP&E, 2012) is: *"An area of land having a gradient between 1 in 3 (33% or 18.3º) and 2 in 1 (200% or 63.4º)"*. The locations of any steep slopes were identified from the 1 m surface level contours, which were generated from the Light Detection and Ranging (LiDAR) survey of the area.

There are no broad areas that have been identified within the Study Area comprising steep slopes. That is, the natural grades within the Study Area are typically less than 1 in 3. The surface grades are locally greater than 1 in 3, in some isolated locations, such as along the banks of Quorrobolong Creek and the drainage lines. These areas could experience mining inducing cracking, as a result of the proposed longwalls, which is discussed in Section 5.2.

5.5. Land prone to flooding and inundation

The natural gradients along the alignments of Quorrobolong Creek and the lower reaches of the drainage lines are relatively flat and could be prone to flooding and inundation. A detailed flood study of the area has been undertaken and is described in the report by Umwelt (2017b).

5.6. Swamps, wetlands and water related ecosystems

There are no swamps or wetlands identified within the Study Area. There are water related ecosystems associated with the streams which are described in the report by Umwelt (2017c).

5.7. Natural vegetation

The land in the south-eastern part of the Study Area has been predominately cleared for agricultural and light residential uses. The land directly above the proposed longwalls contains large areas of native bushland, as shown in Fig. 1.1, predominately on the Crown and Austar-owned land. Threatened species and ecological communities have been identified within the Study Area and are described by the specialist ecology consultant (Umwelt, 2017c).

The potential for impacts on the natural vegetation are dependent on the surface cracking, changes in surface water and changes in groundwater. It is unlikely that significant surface cracking would occur as a result of the proposed longwalls, as none has been observed at Austar Coal Mine to date. Also, as described in Section 5.2, the streams within the Study Area are ephemeral and it is unlikely that the mining induced tilts would have a significant impact on the surface water flows. Further discussions on the potential impacts on the surface water are provided by Umwelt (2017b).

The following sections provide the descriptions, predictions and impact assessments for the built features which have been identified within or in the vicinity of the Study Area, as identified in Chapter 2. The impact assessments are based on the predicted movements due to the extraction of Longwalls B1 to B7, as well as the predicted movements due to the previously extracted longwalls at Ellalong Colliery and Austar Coal Mine (i.e. cumulative movements due to the existing and proposed longwalls).

6.1. Public roads

The locations of public roads within the Study Area are shown in Drawing No. MSEC869-08. The descriptions, predictions and impact assessments for the roads within the Study Area are provided in the following sections.

6.1.1. Descriptions of the roads

Sandy Creek Road crosses directly above the proposed Longwalls B4 and B5 as well as above the approved Longwalls B1 to B3. The total length of this road located directly above the Bellbird South mining area is approximately 1.8 km, of which approximately 0.9 km is located directly above the proposed longwalls. Sandy Creek Road has also been previously directly mined beneath by Longwalls 1 to 9 at Ellalong Colliery, to the west of the Study Area, with a total length of approximately 2 km located directly above these previously extracted longwalls.

Sandy Creek Road provides access between the township of Ellalong, which is located to the west of the Study Area, and Freemans Drive and Lake Road, which are located east of the Study Area. The section of road within the Study Area has a single carriageway with a bitumen seal and grass verges (i.e. no kerb and guttering), however, there are concrete v-channels adjacent to the road on the hill to the west of Barraba Lane. There is a small cutting above the south-western end of the proposed Longwall B5, which is less than 3 m in height. Drainage culverts are located where the road crosses the drainage lines, which are discussed in Section 6.3.

Barraba Lane is located in the south-eastern corner of the Study Area. The lane is located at a distance of 0.7 km east of Longwall B4, at its closest point to the proposed longwalls. Barraba Lane is an unsealed road that provides access to private properties located to the south of Sandy Creek Road.

Photographs of Sandy Creek Road (left side) and Barraba Lane (right side) are provided in Fig. 6.1.

Fig. 6.1 Sandy Creek Road (left side) and Barraba Lane (right side)

The roads are owned and maintained by the Cessnock City Council.

6.1.2. Predictions for the roads

The predicted profiles of conventional subsidence, tilt and curvature along the alignment of Sandy Creek Road are shown in Fig. C.04, in Appendix C. The predicted total profiles along the road, after the extraction of each of the proposed longwalls, are shown as blue lines. The predicted profiles after the completion of the existing and approved longwalls are shown as the cyan lines.

A summary of the maximum predicted values of total vertical subsidence, tilt and curvature for Sandy Creek Road is provided in Table 6.1. The predictions are the maxima within the Study Area, i.e. do not include the sections of road located above the previously extracted longwalls at Ellalong Colliery and Austar Coal Mine, but include the predicted movements resulting from these previous longwalls.

Table 6.1 **Maximum predicted total vertical subsidence, tilt and curvature for Sandy Creek Road**

Location	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Sandy Creek Road	After LWB1 to LWB3	850	2.5	0.02	0.05
	After LWB4	1,100	3.0	0.02	0.06
	After LWB5	1,250	3.5	0.03	0.06
	After LWB6	1,350	4.0	0.03	0.06
	After LWB7	1,350	4.0	0.03	0.06

The tilts provided in the above table are the maxima predicted along the alignment of Sandy Creek Road after the completion of each of the longwalls. The curvatures are the maxima predicted in any direction at any time during or after the extraction of each of the longwalls.

The roads are linear features and, therefore, the most relevant distributions of strain are the maximum strains measured along whole monitoring lines. The analysis of strain along whole monitoring lines during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.2.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The predicted additional vertical subsidence along Barraba Lane due to the extraction of the proposed Longwalls B4 to B7 is 30 mm. Whilst the lane could experience low levels of additional vertical subsidence due to the proposed longwalls, it is not expected to experience measurable tilts, curvatures or strains.

6.1.3. Impact Assessments for the roads

The maximum predicted conventional tilt for Sandy Creek Road is 4.0 mm/m (i.e. 0.4 %), which represents a change in grade of 1 in 250. The predicted tilts are less than 1 % and are unlikely, therefore, to result in adverse impacts on the serviceability or surface water drainage of this road. If additional ponding or adverse changes in surface water drainage were to occur as a result of the proposed longwalls, the road could be repaired using normal road maintenance techniques.

The maximum predicted conventional curvatures for Sandy Creek Road are 0.03 km^{-1} hogging and 0.06 km^{-1} sagging, which represent minimum radii of curvatures of 33 km and 17 km, respectively. The maximum predicted ground curvatures and the range of potential strains for this road are similar to or less than those predicted where: Longwalls A3 and A4 were extracted directly beneath Nash Lane (unsealed); and where Longwalls A7 and A8 were extracted beneath Quorrobolong Road (bitumen seal), Big Hill Road (unsealed) and a number of unsealed fire trails.

The previously extracted longwalls in Stages 2 and 3 at the Mine have extracted beneath approximately 1 km of public roads, which were maintained in safe and serviceable conditions at all times. Only isolated and minor impacts to the road surfaces have been observed, which were remediated using normal road maintenance techniques.

The predicted mine subsidence movements for Sandy Creek Road are also less than those typically experienced in the Southern Coalfield. The most extensive experience comes from Tahmoor Colliery, where Longwalls 22 to 27 have been extracted directly beneath approximately 24.5 km of local roads. A total of 46 impacts have been observed, to date, which equates to an average of one impact for every 533 m of pavement. The impacts were minor and did not present a public safety risk.

The predicted additional vertical subsidence along Barraba Lane due to the extraction of the proposed Longwalls B4 to B7 is 30 mm. It is unlikely, therefore, that this lane would experience adverse impacts as a result of the proposed longwalls.

It is expected that any impacts on the public roads within the Study Area could be repaired using normal road maintenance techniques. With the necessary remedial measures implemented, it is expected that the roads would be maintained in safe and serviceable conditions throughout the mining period.

6.1.4. Recommendations for the Roads

Management strategies have previously been developed for the public roads in the Bellbird South mining area for the approved Longwalls B1 to B3. It is recommended that the existing management strategies for the roads be reviewed in consultation with Cessnock City Council and, where required, are revised to include the effects of the proposed longwalls.

6.2. Road bridges

There are no road bridges within the Study Area. The *Quorrobolong Creek Forbes Bridge* (Ref. SCR-B1) is located outside the Study Area at a distance of approximately 0.9 km east of the proposed Longwall B4. The bridge is predicted to experience less than 20 mm vertical subsidence resulting from the extraction of Longwalls B4 to B7. Whilst the bridge could experience very low levels of vertical subsidence, it is not expected to experience measurable tilts, curvatures or strains. It is not anticipated that adverse impacts would occur to the bridge due to the extraction of Longwalls B4 to B7.

6.3. Road drainage culverts

The locations of the road drainage culverts within the Study Area are shown in Drawing No. MSEC869-08. The descriptions, predictions and impact assessments for the culverts within the Study Area are provided in the following sections.

6.3.1. Descriptions of the road drainage culverts

There are three concrete box culverts (Refs. SCR-C1 to SCR-C3) that are located directly above the approved Longwall B3. These double box culverts have overall widths of 5 m and heights between 0.6 and 1.2 m. There is also a double 600 mm diameter concrete culvert (Ref. SCR-C4) located above the maingate of the approved Longwall B3 and a single 1.5 m diameter concrete culvert (Ref. SCR-C5) located above the proposed Longwall B5. Photographs of these culverts are provided in Fig. 6.2 and Fig. 6.3.

Fig. 6.2 Box culverts SCR-C1 (left side) and SCR-C2 (Right)

Fig. 6.3 Box culvert SCR-C3 (left side) and concrete culvert SCR-C4 (right side)

Dual 300 mm diameter circular concrete culverts are also located on Barraba Lane (Ref. BL-C1), near the intersection with Sandy Creek Road, which are directly above the approved Longwall B1. There are also other concrete drainage culverts within the Study Area beneath the driveways to the properties along Sandy Creek Road and Barraba Lane.

6.3.2. Predictions for the road drainage culverts

A summary of the maximum predicted values of total vertical subsidence, tilt and curvature for the drainage culverts SCR-C1 to SCR-C5, after the completion of the approved and proposed longwalls, is provided in Table 6.2. The predictions are the maximum values within 20 m of the mapped locations of the culverts.

Table 6.2 Maximum predicted total vertical subsidence, tilt and curvature for the drainage culverts

Location	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
SCR-C1	After LWB1 to LWB3	600	2.5	0.01	0.01
	After LWB1 to LWB7	1350	1.5	0.02	0.04
SCR-C2	After LWB1 to LWB3	500	3.0	< 0.01	< 0.01
	After LWB1 to LWB7	1350	1.5	0.02	0.06
SCR-C3	After LWB1 to LWB3	350	3.0	0.02	< 0.01
	After LWB1 to LWB7	1300	1.5	0.02	0.02
SCR-C4	After LWB1 to LWB3	150	1.5	0.01	< 0.01
	After LWB1 to LWB7	1200	1.0	0.03	0.02
SCR-C5	After LWB1 to LWB3	< 20	< 0.5	< 0.01	< 0.01
	After LWB1 to LWB7	900	2.5	0.02	0.03

The maximum predicted subsidence parameters for the dual circular culverts BL-C1 are: 150 mm vertical subsidence, 2.0 mm/m tilt, 0.02 km^{-1} hogging curvature and less than 0.01 km^{-1} sagging curvature. The other culverts located outside the extents of the longwalls could also experience vertical subsidence up to around 100 mm.

The culverts are point features and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays. The analysis of strain measured in individual survey bays during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.1.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

6.3.3. Impact assessments for the road drainage culverts

The predicted curvatures and strains could be of sufficient magnitudes to result in cracking in the box culverts or the circular culverts that are located directly above the approved and proposed longwalls. It is unlikely, however, that these movements would adversely impact on the stability or structural integrity of these culverts. The potential impacts on the drainage culverts could be managed by visual inspection and, if required, any affected sections of the culvert repaired or replaced.

Previous experience of mining beneath culverts in the NSW Coalfields, at similar depths of cover, indicates that the incidence of impacts is very low. Impacts have generally been limited to cracking in the concrete headwalls which can be more readily remediated. In some cases, however, cracking in the culvert pipes occurred which required the culverts to be replaced.

6.3.4. Recommendations for the Road Drainage Culverts

Management strategies have previously been developed for the public roads, including the drainage culverts, in the Bellbird South mining area for the approved Longwalls B1 to B3. It is recommended that the existing management strategies for the roads and culverts be reviewed in consultation with Cessnock City Council and, where required, are revised to include the effects of the proposed longwalls.

6.4. Electrical infrastructure

The locations of the electrical infrastructure within the Study Area are shown in Drawing No. MSEC869-08. The descriptions, predictions and impact assessments for the electrical infrastructure are provided in the following sections.

6.4.1. Descriptions of the electrical infrastructure

The electrical services comprise above ground 11 kV powerlines supported by timber poles. There are also low voltage powerlines that supply power to the rural properties within the Study Area. The total length of the powerlines located directly above the Bellbird South mining area is approximately 4.3 km, of which 2.4 km is located directly above the proposed longwalls.

Photographs of the 11 kV powerlines within the Study Area are provided in Fig. 6.4.

Fig. 6.4 11 kV Powerlines

The powerlines are owned and maintained by Ausgrid.

6.4.2. Predictions for the electrical infrastructure

The powerlines will not be directly affected by the ground strains, as the cables are supported by poles above ground level. The cables, however, may be affected by changes in the bay lengths, i.e. the distances between the poles at the levels of the cables, resulting from differential subsidence, horizontal movements, and tilt at the pole locations. The stabilities of the poles may also be affected by the tilts and by changes in the catenary profiles of the cables.

The predicted profiles of conventional subsidence, tilt along and tilt across the alignments of the 11 kV Powerline Branch 1 (adjacent to Sandy Creek Road) and 11 kV Powerline Branch 2 (north of Sandy Creek Road) are shown in Figs. C.05 and C.06, respectively, in Appendix C. The predicted total profiles along the powerlines, after the extraction of each of the proposed longwalls, are shown as blue lines. The predicted profiles after the completion of the existing and approved longwalls are shown as the cyan lines.

A summary of the maximum predicted values of total vertical subsidence and tilt for the powerlines is provided in Table 6.3. The predictions are the maxima within the Study Area, i.e. do not include the sections of the powerlines located above the previously extracted longwalls at Ellalong Colliery and Austar Coal Mine, but include the predicted movements resulting from these adjacent previous longwalls. The values provided in this table are also the maxima anywhere along the powerlines, i.e. not just at the pole locations.

Table 6.3 Maximum predicted total vertical subsidence and tilt for the 11 kV powerlines

Location	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt along the alignment (mm/m)	Maximum predicted total tilt across the alignment (mm/m)
11 kV Powerline Branch 1	After LWB1 to LWB3	875	2.5	1.5
	After LWB4	1,150	3.0	1.5
	After LWB5	1,250	3.0	1.5
	After LWB6	1,350	3.0	1.5
	After LWB7	1,350	4.0	3.0
11 kV Powerline Branch 2	After LWB1 to LWB3	175	1.5	< 0.5
	After LWB4	175	1.5	< 0.5
	After LWB5	450	1.5	3.0
	After LWB6	1,000	4.0	2.0
	After LWB7	1,200	4.0	1.5

The maximum predicted tilt in any direction at the powerpole locations is 4.0 mm/m (i.e. 0.4 %, or 1 in 250). The maximum predicted horizontal movement at the tops of the powerpoles, based on a pole height of 15 m, is 120 mm.

6.4.3. Impact assessments for the electrical infrastructure

A rule of thumb used by some electrical engineers is that the tops of the poles may displace up to 2 pole diameters horizontally before remediation works are considered necessary. Based on pole heights of 15 m and pole diameters of 250 mm, the maximum tolerable tilt at the pole locations is in the order of 33 mm/m. It is unlikely, therefore, that the powerlines within the Study Area would experience adverse impacts as a result of the proposed longwalls, even if the predictions were exceeded by a factor of 2 times.

Longwalls at the Mine and elsewhere in the NSW Coalfields have successfully been mined directly beneath powerlines in the past, where the magnitudes of the predicted mine subsidence movements were similar to or greater than those predicted within the Study Area. This includes approximately 4 km of powerlines located above Longwalls 1 to 12A at Ellalong Colliery and approximately 4.5 km of powerlines located above the Longwalls A3 to A5A and Longwalls A7 and A8 at the Austar Coal Mine and no adverse impacts have been reported.

Whilst adverse impacts generally do not result, where the magnitudes of the predicted mine subsidence movements are similar to those predicted within the Study Area, there are some cases where tension adjustments have been required to some aerial connections to houses. This is understandable as the overhead cables are typically pulled tight between each house and the power pole.

The incidence of impacts on the powerlines within the Study Area, resulting from the extraction of the proposed longwalls, is expected to be low and it is anticipated that any impacts would be relatively very minor and easily repaired.

6.4.4. Recommendations for the Electrical Infrastructure

Management strategies have previously been developed for the 11 kV and consumer powerlines in the Bellbird South mining area for the approved Longwalls B1 to B3. It is recommended that the existing management strategies for the powerlines be reviewed in consultation with Ausgrid and, where required, are revised to include the effects of the proposed longwalls.

It is recommended that the powerlines should be inspected by a suitably qualified person prior to being mined beneath, to assess the existing conditions of the powerlines and to determine whether any preventive measures are required. The powerlines should be periodically visually monitored as each longwall is mined beneath them, so that any impacts can be identified and rectified immediately. With the implementation of the necessary management strategies, it is expected that the powerlines can be maintained in safe and serviceable conditions at all times.

6.5. Telecommunications infrastructure

The locations of the telecommunications infrastructure within the Study Area are shown in Drawing No. MSEC869-08. The descriptions, predictions and impact assessments for the telecommunications infrastructure are provided in the following sections.

6.5.1. Description of the telecommunications infrastructure

The telecommunication infrastructure within the Study Area are owned by Telstra and comprise underground copper cables with some aerial connections to the houses. The cables generally follow the alignments of Sandy Creek Road and Barraba Lane and service the rural properties within the Study Area. The total length of the copper telecommunications cables located directly above the Bellbird South mining area is approximately 3.3 km, of which 1.0 km is located directly above the proposed longwalls. There are no optical fibre cables located within the Study Area.

6.5.2. Predictions for the telecommunications infrastructure

The copper telecommunications cables within the Study Area generally follow the alignments of the public roads. The predicted profiles of subsidence, tilt and curvature for these copper cables, therefore, are similar to those predicted along Sandy Creek Road which are shown in Fig. C.03, in Appendix C.

A summary of the maximum predicted values of total vertical subsidence, tilt and curvature for the copper telecommunications cable, after the completion of each of the longwalls, is provided in, is provided in Table 6.4.

Table 6.4 Maximum predicted total vertical subsidence, tilt and curvature for the copper telecommunications cables

Location	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Copper telecommunications cables	After LWB1 to LWB3	850	3.5	0.02	0.05
	After LWB4	1,100	4.5	0.03	0.06
	After LWB5	1,250	5.0	0.03	0.06
	After LWB6	1,350	5.0	0.03	0.06
	After LWB7	1,350	5.0	0.03	0.06

The tilts and curvatures provided in the above table are the maxima predicted in any direction at any time during or after the extraction of each of the longwalls.

The cables are linear features and, therefore, the most relevant distributions of strain are the maximum strains measured along whole monitoring lines. The analysis of strain along whole monitoring lines during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.2.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

6.5.3. Impact assessments for the telecommunications infrastructure

The direct buried copper telecommunications cables are not directly affected by vertical subsidence or tilt. The maximum predicted curvatures for the cables are 0.03 km^{-1} hogging and 0.06 km^{-1} sagging, which represent minimum radii of curvatures of 33 km and 17 km, respectively. The copper cables are reasonably flexible and, therefore, are also unlikely to experience adverse impacts based on the magnitudes of the predicted conventional curvatures.

The direct buried copper cables, however, could be affected by the ground strains resulting from the extraction of the proposed longwalls. The copper cables are more likely to be impacted by the tensile strains rather than the compressive strains. It is possible, that the direct buried cables could experience higher tensile strains where they are anchored to the ground by associated infrastructure, or by tree roots.

Aerial copper telecommunications cables are generally not affected by ground strains, as they are supported by the poles above ground level. The aerial cables, however, could be affected by the changes in bay lengths, i.e. the distances between the poles at the levels of the cables, which result from mining induced differential subsidence, horizontal ground movements and lateral movements at the tops of the poles due to tilting of the poles. The stabilities of the poles can also be affected by mining induced tilts and by changes in the catenary profiles of the cables.

Longwalls at the Mine and elsewhere in the New South Wales Coalfields have successfully been mined directly beneath buried and aerial copper telecommunications cables in the past, where the magnitudes of the predicted mine subsidence movements were similar to or greater than those predicted within the Study Area. This includes approximately 0.8 km of cables located above Longwalls 1 to 12A at Ellalong Colliery and approximately 1.2 km of cables located above the Longwalls A3 to A5A and Longwalls A7 and A8 at the Austar Coal Mine and no adverse impacts have been reported.

It is also understood, that there have been no significant impacts on direct buried copper telecommunications cables elsewhere in the NSW Coalfields, where the depths of cover were greater than 400 m, such as is the case above the proposed longwalls. In some cases, there have been some minor impacts on aerial copper telecommunications cables, such as the aerial connections to houses. This is understandable as the overhead cables are typically pulled tight between each house and the power pole. The incidence of these impacts, however, was very low.

Based on this experience, it is unlikely that the extraction of the proposed longwalls would result in any adverse impacts on the direct buried or aerial copper telecommunications cables within the Study Area. Any minor impacts on these cables would be expected to be relatively infrequent and easily repaired.

6.5.4. Recommendations for Telecommunications Infrastructure

Management strategies have previously been developed for the copper telecommunications cables in the Bellbird South mining area for the approved Longwalls B1 to B3. It is recommended that the existing management strategies for the cables be reviewed in consultation with Telstra and, where required, are revised to include the effects of the proposed longwalls.

With the implementation of the necessary management strategies, it is expected that the copper telecommunications cables can be maintained in safe and serviceable conditions at all times.

6.6. Agricultural utilisation

The land in the south-eastern part of the Study Area has been predominately cleared for agricultural and light residential uses. The land directly above the proposed longwalls contains large areas of native bushland, as can be seen in Fig. 1.1, but also includes built features associated with agricultural and residential use. The descriptions, predictions and impact assessments for the built features on these rural properties are provided in the following sections.

The potential for impacts on the land use within the Study Area can occur from the mining-induced surface cracking, changes in surface water drainage and changes in ground water. It is unlikely that significant surface cracking would occur as a result of the proposed longwalls, as none has been observed at Austar Coal Mine to date. Also, as described in Section 5.2, the streams within the Study Area are ephemeral and it is unlikely that the mining induced tilts would have a significant impact on the surface water flows. Further discussions on the potential impacts on the surface water drainage are provided by Umwelt (2017b).

6.7. Rural structures

6.7.1. Descriptions of the rural structures

The rural structures (Structure Type R) are shown in Drawing No. MSEC869-09. The locations, sizes and details of the rural structures were determined from the aerial photograph of the area and from kerb side inspections.

There are 48 rural structures that have been identified within the Study Area, of which 20 are located directly above the proposed Longwalls B4 to B7 and 14 are located directly above the approved Longwalls B1 to B3. The rural structures within the Study Area are generally of lightweight construction and include farm sheds, garages, tanks and other non-residential structures.

6.7.2. Predictions for the rural structures

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at the vertices of each rural building structure, as well as at eight equally spaced points placed radially around the centroid and vertices at a distance of 20 m. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

The predicted total conventional subsidence, tilts and curvatures for the rural structures within the Study Area are provided in Table D.01, in Appendix D. A summary of the maximum predicted subsidence parameters for the rural structures on each of the properties within the Study Area is provided in Table 6.5. The values include the predicted movements resulting from the previous extraction of the adjacent longwalls at Ellalong Colliery and Austar Coal Mine (i.e. cumulative movements).

Table 6.5 Maximum predicted total vertical subsidence, tilt and curvature for the rural structures

Property	Number of rural structures	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
A01	2	200	1.5	0.02	< 0.01
A02	9	825	5.0	0.03	0.02
A06	3	225	2.0	0.02	< 0.01
A08	6	825	4.0	0.03	0.02
B03	7	950	2.5	0.01	0.04
C01	4	1,200	1.0	0.02	0.02
C02	10	1,200	1.0	0.03	0.03
C03	2	30	< 0.5	< 0.01	< 0.01
C05	5	100	1.0	< 0.01	< 0.01

The tilts provided in the above table are the maxima predicted in any directions at the completion of the longwalls. The curvatures are the maxima predicted in any direction at any time during or after the extraction of each of the longwalls.

The rural structures are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays. The analysis of strain in survey bays during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.1.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

6.7.3. Impact assessments for the rural structures

There are 20 rural structures that are located directly above the proposed Longwalls B4 to B7 and 14 structures located directly above the approved Longwalls B1 to B3. The maximum predicted movements for these structures are 1,200 mm vertical subsidence, 5.0 mm/m tilt, 0.03 km^{-1} hogging curvature and 0.04 km^{-1} sagging curvature.

The remaining 14 rural structures within the Study Area are located outside the extents of the proposed and approved longwalls. The maximum predicted movements for these structures are 225 mm vertical subsidence, 2.0 mm/m tilt, 0.02 km^{-1} hogging curvature and less than 0.01 km^{-1} sagging curvature.

It has been found from previous longwall mining experience, that tilts of the magnitudes predicted within the Study Area generally do not result in any significant impacts on rural structures. Some very minor serviceability impacts could occur at the rural structures located directly above the proposed longwalls, including door swings and minor issues with roof and pavement drainage, all of which can be repaired using normal building maintenance techniques.

The maximum predicted curvatures for the rural structures within the Study Area are similar to the maxima predicted for these types of structures that were located above the previously extracted longwalls at the Mine. There were 18 rural structures located directly above Longwalls A3 to A5A in Stage 2 and Longwalls A7 and A8 in Stage 3 and there were no reported mining related impacts.

There is also extensive experience of mining directly beneath rural structures in the Southern Coalfield, where the maximum predicted subsidence parameters are similar to or greater than the maxima predicted for the proposed longwalls. This incidence of impacts on these types of structures is very low, with adverse impacts generally reported for the larger industrial type sheds. This is not unexpected, as rural structures are generally small in size and of light-weight construction, they are less susceptible to impact than houses that are typically more rigid. In all cases, the rural structures remained in safe and serviceable conditions.

It is expected, therefore, that all the rural structures within the Study Area would remain safe and serviceable during the mining period, provided that they are in sound existing condition. The risk of impact is greater if the structures are in poor condition, though the chances of there being a public safety risk remains very low. A number of rural structures, which were in poor condition prior to mining, have been directly mined beneath and these structures have not experienced impacts during mining.

The impacts on the rural structures that occur as a result of the extraction of the proposed longwalls could be repaired using well established building techniques. With these remedial measures available, it is unlikely that there would be any significant long term impacts on rural structures resulting from the extraction of the proposed longwalls.

6.7.4. Recommendations for the rural structures

Built Features Management Plans have previously been developed for properties located above and adjacent to the approved Longwalls B1 to B3. It is recommended that similar management plans are developed for the additional properties within the Study Area.

It is recommended that the rural structures located above the proposed longwalls should be inspected, prior to being mined beneath, to assess the existing conditions and to determine whether any preventive measures may be required. It is also recommended that the rural structures located directly above the proposed longwalls are periodically visually monitored during active subsidence. With these management strategies in place, it is unlikely that there would be any significant long term impacts on the rural structures.

6.8. Gas and fuel storages

There are domestic gas and fuel storages on the rural properties within the Study Area and, therefore, could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the Study Area is provided in Chapter 4.

The storage tanks are generally elevated above ground level and, therefore, are not susceptible to mine subsidence movements. It is possible, however, that any buried gas pipelines associated with the storage tanks within the Study Area could be impacted by the ground strains, if they are anchored by the storage tanks, or by other structures in the ground. Any impacts would be expected to be of a minor nature, including minor gas leaks, which could be easily repaired. It is unlikely that there would be any significant impacts on the pipelines associated with the gas and fuel storage tanks.

6.9. Farm fences

There are a number of fences within the Study Area that are constructed in a variety of ways, generally using either timber or metal materials. Wire fences could be affected by tilting of the fence posts and changes of tension in the fence wires due to strain as mining occurs. Wire fences are generally flexible in construction and can usually tolerate tilts of up to 10 mm/m and strains of up to 5 mm/m without any significant impact.

The fences are located across the Study Area and, therefore, are expected to experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the Study Area is provided in Chapter 4.

The fences are linear features and, therefore, the most relevant distributions of strain are the maximum strains measured along whole monitoring lines. The analysis of strain along whole monitoring lines during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.2.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

It is possible that some of the wire fences within the Study Area would be impacted as a result of the extraction of the proposed longwalls. Any impacts on the wire fences are likely to be of a minor nature and relatively easy to remediate by re-tensioning the fencing wire, straightening the fence posts, and if necessary, replacing some sections of fencing.

Colorbond and timber paling fences are more rigid than wire fences and, therefore, are more susceptible to impacts resulting from mine subsidence movements. It is possible that these types of fences could be impacted as the result of the extraction of the proposed longwalls. Any impacts on Colorbond or timber paling fences are expected to be of a minor nature and relatively easy to remediate or, where necessary, to replace.

6.10. Farm dams

6.10.1. Descriptions of the farm dams

The farm dams (Structure Type D) are shown in Drawing No. MSEC869-09. The locations and sizes of the dams were determined from the aerial photograph of the area. There are 24 farm dams that have been identified within the Study Area, of which six are located directly above the proposed Longwalls B4 to B7 and 11 are located directly above the approved Longwalls B1 to B3.

The farm dams are typically of earthen construction and have been established by localised cut and fill operations along the natural drainage lines. The largest dam is Ref. C03d01, which is located on land owned by the Mine, above the finishing (i.e. north-eastern) end of the proposed Longwall B7. This dam has a surface area of 46,900 m^2 and a maximum dimension of 440 m. The remaining dams within the Study Area have surface areas ranging between 30 and 6,220 m^2 and maximum plan dimensions ranging between 8 and 160 m.

6.10.2. Predictions for the farm dams

The predicted total conventional subsidence, tilts and curvatures for the farm dams within the Study Area are provided in Table D.02, in Appendix D. A summary of the maximum predicted subsidence parameters for the farm dams on each of the properties within the Study Area is provided in Table 6.6. The values include the predicted movements resulting from the previous extraction of the adjacent longwalls at Ellalong Colliery and Austar Coal Mine (i.e. cumulative movements).

Table 6.6 **Maximum predicted total vertical subsidence, tilt and curvature for the farm dams**

Property	Number of farm dams	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
A01	1	300	3.0	0.02	< 0.01
A02	1	175	1.5	0.02	< 0.01
A04	1	375	3.5	0.04	< 0.01
A06	4	525	4.5	0.03	0.03
A07	1	675	4.5	0.04	< 0.01
A08	2	625	4.0	0.03	0.02
B01	3	1,300	2.5	0.02	0.06
B02	2	825	4.5	0.02	0.02
B03	3	700	4.0	0.02	0.02
C01	1	1,250	1.5	0.02	0.04
C03	2	625	4.5	0.04	0.03
C05	2	40	< 0.5	< 0.01	< 0.01
C06	1	60	< 0.5	0.01	< 0.01

The tilts provided in the above table are the maxima predicted in any directions at the completion of the longwalls. The curvatures are the maxima predicted in any direction at any time during or after the extraction of each of the longwalls.

The farm dams are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays. The analysis of strain in survey bays during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.1.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

6.10.3. Impact assessments for the farm dams

The maximum predicted tilt for the farm dams within the Study Area 4.5 mm/m (i.e. 0.45 %), which represents a change in grade of 1 in 225. Mining induced tilts can affect the water levels around the perimeters of farm dams, with the freeboard increasing on one side and decreasing on the other. Tilt can potentially reduce the storage capacity of farm dams, by causing them to overflow.

The predicted changes in freeboard at the farm dams within the Study Area have been determined by taking the difference between the maximum predicted subsidence and the minimum predicted subsidence anywhere around the perimeter of each farm dam. The predicted maximum changes in freeboard at the farm dams within the Study Area, after the completion of the proposed longwalls, are provided in Table D.02, in Appendix D.

The maximum predicted change in freeboard is 500 mm at Dam C03d01, which is located on land owned by the Mine, above the finishing (i.e. north-eastern) end of the proposed Longwall B7. This dam has formed in a natural depression of the land and there is no dam wall. The freeboard reduces (i.e. the stored water level increases) along the southern edge of this dam. There is an overflow channel in this location that drains to Quorrobolong Creek. It may be necessary to increase the height of the overflow channel, if required, to maintain the storage capacity of this dam.

The predicted maximum changes in freeboard at the remaining farm dams within the Study Area are 300 mm or less. It is unlikely, therefore, that the changes in freeboard to have a significant impact on the storage capacities.

The largest farm dam within the Study Area is Dam C03d01, which is located on land owned by the Mine, above the finishing (i.e. north-eastern) end of the proposed Longwall B7. The maximum predicted subsidence parameters for this dam are 625 mm vertical subsidence, 4.5 mm/m tilt, 0.04 km^{-1} hogging curvature and 0.03 km^{-1} sagging curvature.

The maximum predicted curvatures for the remaining farm dams are 0.04 km^{-1} hogging and 0.06 km^{-1} sagging, which equate to minimum radii of curvatures of 25 km and 17 km, respectively. These dams could experience the full range of the predicted strains, which is discussed in Section 4.4.

The dam walls are constructed with cohesive materials which would be expected to tolerate tensile strains of up to 3 mm/m without adverse impact, because of their inherent elasticity. The maximum predicted curvatures for the farm dams within the Study Area are similar to the maxima predicted for the farm dams which were located above the previously extracted longwalls at the Mine. There were 14 farm dams located directly above Longwalls A3 to A5A in Stage 2 and Longwalls A7 and A8 in Stage 3 and there were no reported mining related impacts.

There is also extensive experience of mining directly beneath farm dams in the Southern Coalfield, where the maximum predicted subsidence parameters are similar to or greater than the maxima predicted for the proposed longwalls. This incidence of impacts on farm dams is very low, being less than 0.5 %.

It is expected, therefore, that the incidence of impacts on the farm dams within the Study Area, resulting from the extraction of the proposed longwalls, will be extremely low. If cracking or leakage of water were to occur in the farm dam walls, it is expected that this could be easily identified and repaired as required. It is not expected that any significant loss of water will occur from the farm dams, and any loss that did occur would flow into the tributary in which the dam was formed.

6.10.4. Recommendations for the farm dams

Built Features Management Plans have previously been developed for properties located above and adjacent to the approved Longwalls B1 to B3. It is recommended that similar management plans are developed for the additional properties within the Study Area.

It is recommended that all water retaining structures located directly above the proposed longwalls be periodically visually monitored during active subsidence. With the necessary management strategies in place, it is unlikely that there would be any significant long term impacts on the farm dams.

6.11. Groundwater bores

The locations of the groundwater bores near the proposed longwalls are shown in Drawing No. MSEC869-09. The locations and details of the registered groundwater bores were obtained from the *Natural Resource Atlas* website (NRAtlas, 2017).

There are three registered groundwater bores that have been identified within the Study Area, which are shown in Drawing No. MSEC869-09. A summary of these bores is provided in Table 6.7. There are two other bores (Refs. GW080973 and GW054676) that have been decommissioned and, therefore, have not been shown in the drawing nor included in the table.

Table 6.7 Registered groundwater bores within the Study Area

Reference	Location	Authorised use	Owner
GW201408	Above the finishing end of the proposed Longwall B5	Monitoring	Austar Mine (Ref. NER1010)
GW080974	Located outside and adjacent to the finishing end of the proposed Longwall B4	Monitoring	DPI - Water
GW080975	Located outside and adjacent to the finishing end of the proposed Longwall B4	Monitoring	DPI - Water

It is possible that the groundwater bores could experience some impacts as a result of mining the proposed longwalls. Impacts could include temporary lowering of the piezometric surface, blockage of the bore due to differential horizontal displacements at different horizons within the strata and changes to groundwater quality.

Such impacts on the groundwater bores can be readily managed, by repairing or replacing the bores at the completion of mining. If required, temporary alternative supplies of water could be provided by the Mine during the mining period.

Further discussions on the potential impacts on the groundwater resources are provided in the report by Dundon Consulting (2017).

6.12. Archaeological sites

Archaeological sites have been identified within the Study Area than comprise artefact scatters and isolated finds (Umwelt, 2017d). The boundaries for the larger artefact scatter sites and the isolated finds are shown in Drawing No. MSEC869-09. The archaeological sites are generally located near Quorrobolong Creek and the associated tributaries.

A summary of the maximum predicted values of total vertical subsidence, tilt and curvature for the archaeological sites within the Study Area, after the completion of each of the longwalls, is provided in Table 6.8.

Table 6.8 Maximum predicted total vertical subsidence, tilt and curvature for the archaeological sites located within the Study Area

Location	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Archaeological sites	After LWB1 to LWB3	125	1.5	0.03	< 0.01
	After LWB4	125	1.5	0.03	< 0.01
	After LWB5	400	3.0	0.03	0.01
	After LWB6	1025	3.5	0.03	0.04
	After LWB7	1225	4.5	0.04	0.04

The archaeological sites are predicted to experience mine subsidence movements up to 1225 mm vertical subsidence, 4.5 mm/m tilt (i.e. 0.45 %), 0.04 km^{-1} hogging and sagging curvatures (25 km minimum radius of curvature).

The archaeological sites are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays. The analysis of strain in survey bays during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.1.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements

The archaeological sites could potentially be affected by cracking of the surface soils as a result of the proposed mining. It is expected that only isolated and minor cracking of the surface soils would develop, due to the extraction of the proposed Longwalls B4 to B7, which is discussed in Section 4.7. It is unlikely, however, that the scattered artefacts themselves would be impacted by any surface cracking.

Archaeological sites are located above the previously extracted Longwalls A3 to A5A in Stage 2 and Longwalls A7 and A8 in Stage 3 at the Mine. There has been no significant or visible surface cracking above these previously extracted longwalls. There have also been no reported adverse mining related impacts on the artefact scatters and isolated finds.

Management strategies should be developed to remediate any surface cracking, if required, in the vicinity of the archaeological sites. Further assessments of the potential impacts on the archaeological sites are provided in a report by Umwelt (2017d).

6.13. Survey control marks

The locations of the survey control marks near the proposed longwalls are shown in Drawing No. MSEC869-09. The locations and details of the state survey control marks were obtained from the *Land and Property Management Authority* using the *Six Viewer* (2017).

There are four survey control marks identified within the Study Area, located along the alignment of Sandy Creek Road. These marks are located directly above the approved and proposed longwalls and, therefore, could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the Study Area is provided in Chapter 4.

Additional survey control marks located further afield could be affected by far-field horizontal movements, up to 3 kilometres outside the extents of the proposed longwalls. Far-field horizontal movements and the methods used to predict such movements are described further in Section 4.6.

It will be necessary on the completion of the proposed longwalls, when the ground has stabilised, to re-establish any survey control marks that are required for future use. Consultation between Austar and the Department of Lands will be required to ensure that these survey control marks are reinstated at the appropriate time, as required.

6.14. Houses

6.14.1. Descriptions of the houses

There are six houses (Structure Type H) that have been identified within the Study Area, of which three are located directly above the proposed Longwalls B4 to B7 and one is located directly above the approved Longwalls B1 to B3. The locations of these houses are shown in Drawing No. MSEC869-09 and details provided in Table 6.9. The sizes of the houses were determined from the aerial photograph of the area. The types of construction of the houses were determined, where possible, from kerb side inspections.

Table 6.9 Descriptions of the houses

Structure ref.	Maximum planar dimension (m)	Number of Storeys	Wall construction	Footing construction	Roof construction
A02d	20	Single	Timber Frame	Piers	Metal
A06a	16	Single	Timber Frame	Slab on Ground	Metal
A08h01	24	Single	Timber Frame	Piers	Metal
C02h01	16	Double	Timber Frame	Piers	Metal
C04h01	23	Single	Steel Frame	Slab on Ground	Metal
C05h01	13	Single	Timber Frame	Piers	Tiles

House Ref. A02d is located above the approved Longwall B3. House Ref. A08h01 is located directly above the maingate of the proposed Longwall B5, near the finishing end of this longwall. House Ref. C02h01 is located above the middle of the proposed Longwall B5. House C04h01 is located above the commencing (i.e. south-western) end of the proposed Longwall B6. The remaining two houses are located outside the extents of the approved and proposed longwalls, at distances between 50 and 100 m.

6.14.2. Predictions for the houses

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at the vertices of each house, as well as at eight equally spaced points placed radially around the centroid and vertices at a distance of 20 m. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

The predicted total conventional subsidence, tilts and curvatures for the houses within the Study Area are provided in Table D.03, in Appendix D. A summary of the maximum predicted subsidence parameters for each of the houses within the Study Area is provided in Table 6.10. The values include the predicted movements resulting from the previous extraction of the adjacent longwalls at Ellalong Colliery and Austar Coal Mine (i.e. cumulative movements).

Table 6.10 Maximum predicted total vertical subsidence, tilt and curvature for the houses

Location	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted final total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Houses	A02d	725	5.0	0.03	< 0.01
	A06a	175	1.0	0.02	< 0.01
	A08h01	700	3.5	0.02	0.02
	C02h01	1200	1.0	0.03	0.03
	C04h01	450	3.5	0.03	0.02
	C05h01	90	1.0	< 0.01	< 0.01

The houses are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays. The analysis of strain in survey bays during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.1.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

6.14.3. Impact assessments for the houses

The following sections provide the impact assessments for the houses within the Study Area.

Potential impacts resulting from vertical subsidence

Vertical subsidence does not directly affect the stability or serviceability of houses. The potential impacts on houses are affected by differential subsidence, which includes tilt, curvature and strain, and the impact assessments based on these parameters are described in the following sections.

Vertical subsidence in this case, however, could affect the heights of the houses above the flood level. The potential impacts on the houses resulting from the changes in flood level from the proposed mining is assessed as part of the flood study, which is described in the report by Umwelt (2017b).

Potential impacts resulting from tilt

It has been found from past longwall mining experience that tilts of less than 7 mm/m generally do not result in significant impacts on houses. Some minor serviceability impacts can occur at these levels of tilt, including door swings and issues with roof gutter and wet area drainage, all of which can be remediated using normal building maintenance techniques. Tilts greater than 7 mm/m can result in greater serviceability impacts which may require more substantial remediation measures, including the relevelling of wet areas or, in some cases, the relevelling of the building structure.

The maximum predicted tilt for the houses is 5 mm/m (i.e. 0.5 %), which represents a change in grade of 1 in 200. It is expected, therefore, that only minor serviceability impacts would occur at the houses within the Study Area, as the result of tilt, which could be remediated using normal building techniques. It is expected that the houses within the Study Area will remain in safe conditions as the result of the mining induced tilts.

Potential impacts resulting from curvature and strain

There are three houses that are located directly above the proposed Longwalls B4 to B7 (i.e. Refs. C02h01, C04h01 and A08h01) and one house located directly above the approved Longwalls B1 to B3 (Ref. A02d). The maximum predicted curvature for these houses are 0.03 km^{-1} both hogging and sagging, which represent a minimum radius of curvature of 33 km. These houses could also experience strains of 0.9 mm/m tensile and 1.2 mm/m compressive, based on the 95 % confidence level.

The remaining two houses (i.e. Refs. A06a and C05h01) are located outside the extents of the proposed and approved longwalls, at distances of 50 to 100 m. The maximum predicted curvatures for these houses are 0.02 km^{-1} hogging and less than 0.01 km^{-1} sagging, which represent minimum radii of curvature of 50 km and greater than 100 km, respectively. These houses are expected to experience strains typically less than 0.5 mm/m, based on the 95 % confidence level.

The maximum predicted curvatures and strains for the houses within the Study Area are similar to the maxima predicted for the houses located above the previously extracted longwalls in Stages 2 at the Mine. Longwalls A3 to A5a were extracted directly beneath seven houses and no substantial impacts were reported.

It is unlikely, therefore, that the houses within the Study Area would experience substantial impacts as a result of the proposed mining. It is possible that some houses could experience some minor impacts, such as cracking in the internal plasterboard linings or cornices and cracking in the external brickwork. It would be expected that any such impacts could be remediated using normal building maintenance techniques. All houses within the Study Area are expected to remain safe, serviceable and repairable throughout the mining period.

6.14.4. Recommendations for the houses

Built Features Management Plans have previously been developed for properties located above and adjacent to the approved Longwalls B1 to B3. It is recommended that similar management plans are developed for the additional properties within the Study Area. It is recommended that the houses are periodically visually monitored during the extraction of the proposed longwalls.

6.15. Pools

There is one privately owned swimming pool (Ref. C02p01) identified within the Study Area, which is located above the proposed Longwall B5. This pool is located near House Ref. C02h01, which is shown in Drawing No. MSEC869-09.

The predicted subsidence parameters for the swimming pool are included in in Table D.01, in Appendix D. The maximum predicted parameters are: 1,200 mm vertical subsidence; 1.0 mm/m tilt (i.e. 0.1 %, or 1 in 1000); 0.03 km^{-1} hogging and sagging curvatures (33 km minimum radius).

Mining-induced tilts are more noticeable in pools than other structures due to the presence of the water line and small gaps to the edge coping, particularly when the pool lining has been tiled. Skimmer boxes are also susceptible to being lifted above the water line due to mining induced tilt. The Australian Standard AS2783-1992 (Use of reinforced concrete for small swimming pools) requires that pools be constructed level ± 15 mm from one end to the other. This represents a tilt of approximately 3 mm/m for pools that are 10 metres in length. Australian Standard AS/NZS 1839:1994 (Swimming pools – Pre-moulded fibre-reinforced plastics – Installation) also requires that pools be constructed with a tilt of 3 mm/m or less.

The maximum predicted tilt of the pool within the Study Area is 1 mm/m and, therefore, is less than the Australian Standard. The mining-induced tilt is very small and may not be noticeable.

Observations during the mining of Tahmoor Colliery Longwalls 22 to 27 have shown that pools, particularly in-ground pools, are more susceptible to severe impacts than houses and other structures. Pools cannot be easily repaired and some of the impacted pools may need to be replaced in order to restore them to pre-mining condition or better.

As of March 2014, a total of 155 pools have experienced mine subsidence movements during the mining of Tahmoor Colliery Longwalls 22 to 27, of which 142 were located directly above the extracted longwalls. A total of 32 pools have reported impacts, of which all except two pools were located directly above the extracted longwalls. This represents an impact rate of approximately 21 %. A higher proportion of impacts have been observed for in-ground pools, particularly fibreglass pools. The majority of the impacts related to tilt or cracking, though in a small number of cases the impacts were limited to damage to skimmer boxes or the edge coping

The maximum predicted curvatures and strains for the pool Ref. C02p01 are similar orders of magnitude to, but, less than the maxima predicted at Tahmoor Colliery. The potential for impacts on this pool, therefore, is expected to be similar to or less than that experienced at Tahmoor Colliery. The potential for major adverse impacts on pool Ref. C02p01 has been assessed as unlikely (i.e. less than 25 %).

6.16. On-site waste water systems

The residences on the rural properties within the Study Area have on-site waste water systems. The systems are located near the houses and, therefore, are expected to experience similar mine subsidence movements as the houses which are provided in Table D.03, in Appendix D.

The on-site waste water systems are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays. The analysis of strain in survey bays during the extraction of the previous longwalls at the Mine is discussed in Section 4.4.1.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The maximum predicted change in grade for the on-site waste water systems within the Study Area are less than 1 %. It is unlikely, therefore, that the maximum predicted tilts would result in any significant impacts on the systems. The maximum predicted conventional tilts, however, could be of sufficient magnitude to affect the serviceability of the buried pipes between the houses and the on-site waste water systems, if the existing grades of these pipes are very small, say less than 1 %.

The on-site waste water system tanks are generally small, typically less than 3 m in diameter, are constructed from reinforced concrete, and are usually bedded in sand and backfilled. It is unlikely, therefore, that the maximum predicted curvatures and ground strains would be fully transferred into the tank structures.

It is possible, however, that the buried pipelines associated with the on-site waste water tanks could be impacted by the ground strains if they are anchored by the tanks or other structures in the ground. Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be easily repaired. With the implementation of these remedial measures, it would be unlikely that there would be any significant impacts on the pipelines associated with the on-site waste water systems.

APPENDIX A. GLOSSARY OF TERMS AND DEFINITIONS

Glossary of Terms and Definitions

Some of the more common mining terms used in the report are defined below:

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Closure	The reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides. It should be noted that the observed closure movement across a valley is the total movement resulting from various mechanisms, including conventional mining induced movements, valley closure movements, far-field effects, downhill movements and other possible strata mechanisms.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections, i.e. curvature is the second derivative of subsidence. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (km-1)*, but the value of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*. Curvature can be either **hogging** (i.e. convex) or **sagging** (i.e. concave).
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel.
Face length	The width of the coalface measured across the longwall panel.
Far-field movements	The measured horizontal movements at pegs that are located beyond the longwall panel edges and over solid unmined coal areas. Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e. from rib to rib.

Shear deformations	The horizontal displacements that are measured across monitoring lines and these can be described by various parameters including; horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points, i.e. strain is the relative differential displacement of the ground along or across a subsidence monitoring line. Strain is dimensionless and can be expressed as a decimal, a percentage or in parts per notation. **Tensile Strains** are measured where the distance between two points or survey pegs increases and **Compressive Strains** where the distance between two points decreases. Whilst mining induced **strains** are measured **along** monitoring lines, ground **shearing** can occur both vertically, and horizontally **across** the directions of the monitoring lines.
Sub-critical area	An area of panel smaller than the critical area.
Subsidence	The vertical movement of a point on the surface of the ground as it settles above an extracted panel, but, 'subsidence of the ground' in some references can include both a vertical and horizontal movement component. The vertical component of subsidence is measured by determining the change in surface level of a peg that is fixed in the ground before mining commenced and this vertical subsidence is usually expressed in units of *millimetres (mm)*. Sometimes the horizontal component of a peg's movement is not measured, but in these cases, the horizontal distances between a particular peg and the adjacent pegs are measured.
Super-critical area	An area of panel greater than the critical area.
Tilt	The change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the horizontal distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.
Uplift	An increase in the level of a point relative to its original position.
Upsidence	Upsidence results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.

APPENDIX B. REFERENCES

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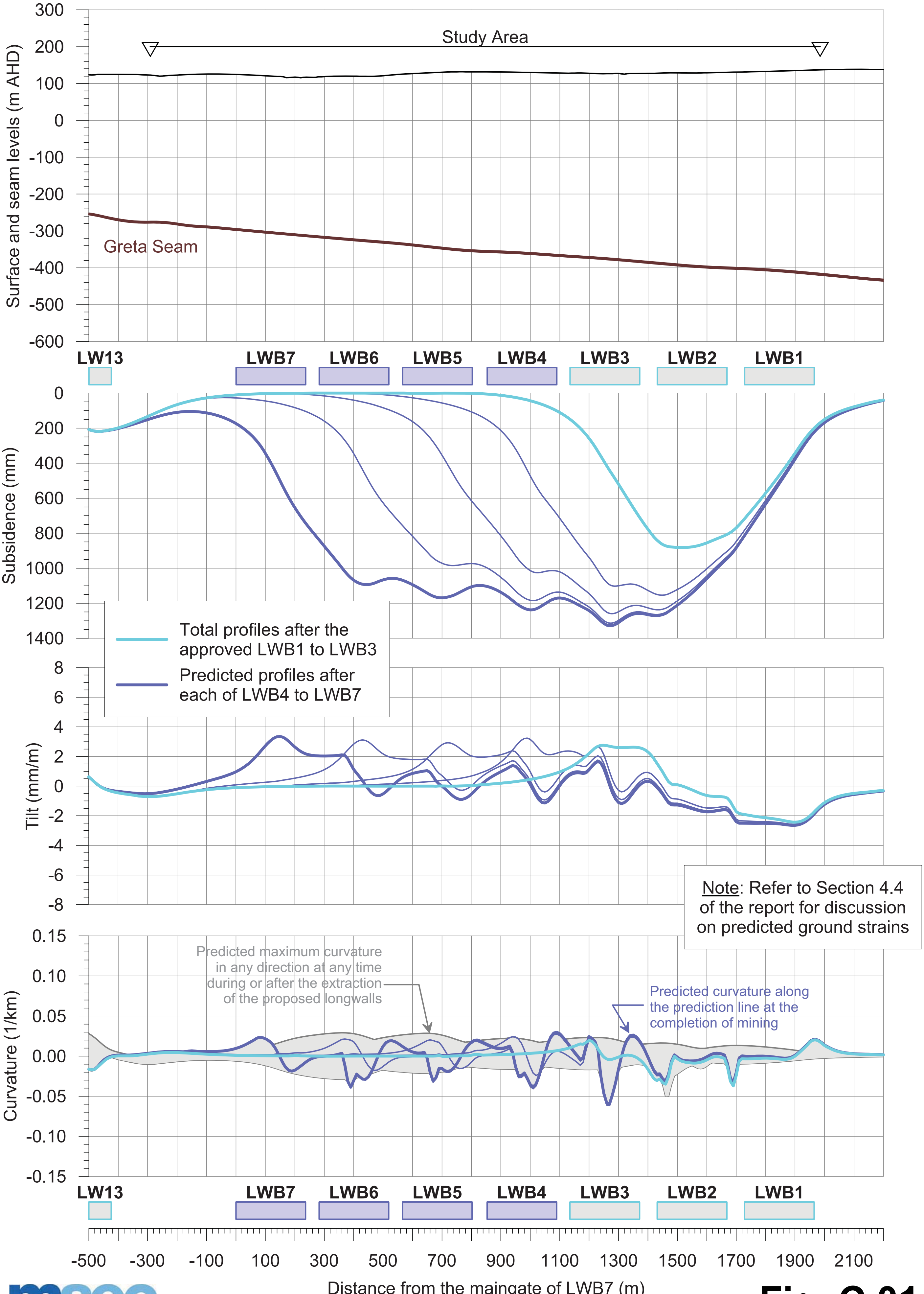
APPENDIX C. FIGURES

Predicted profiles of conventional subsidence, tilt and curvature along Prediction Line 1 resulting from the extraction of Longwalls B1 to B7



msec

Fig. C.01

Predicted profiles of conventional subsidence, tilt and curvature along Quorrobolong Creek resulting from the extraction of Longwalls B1 to B7

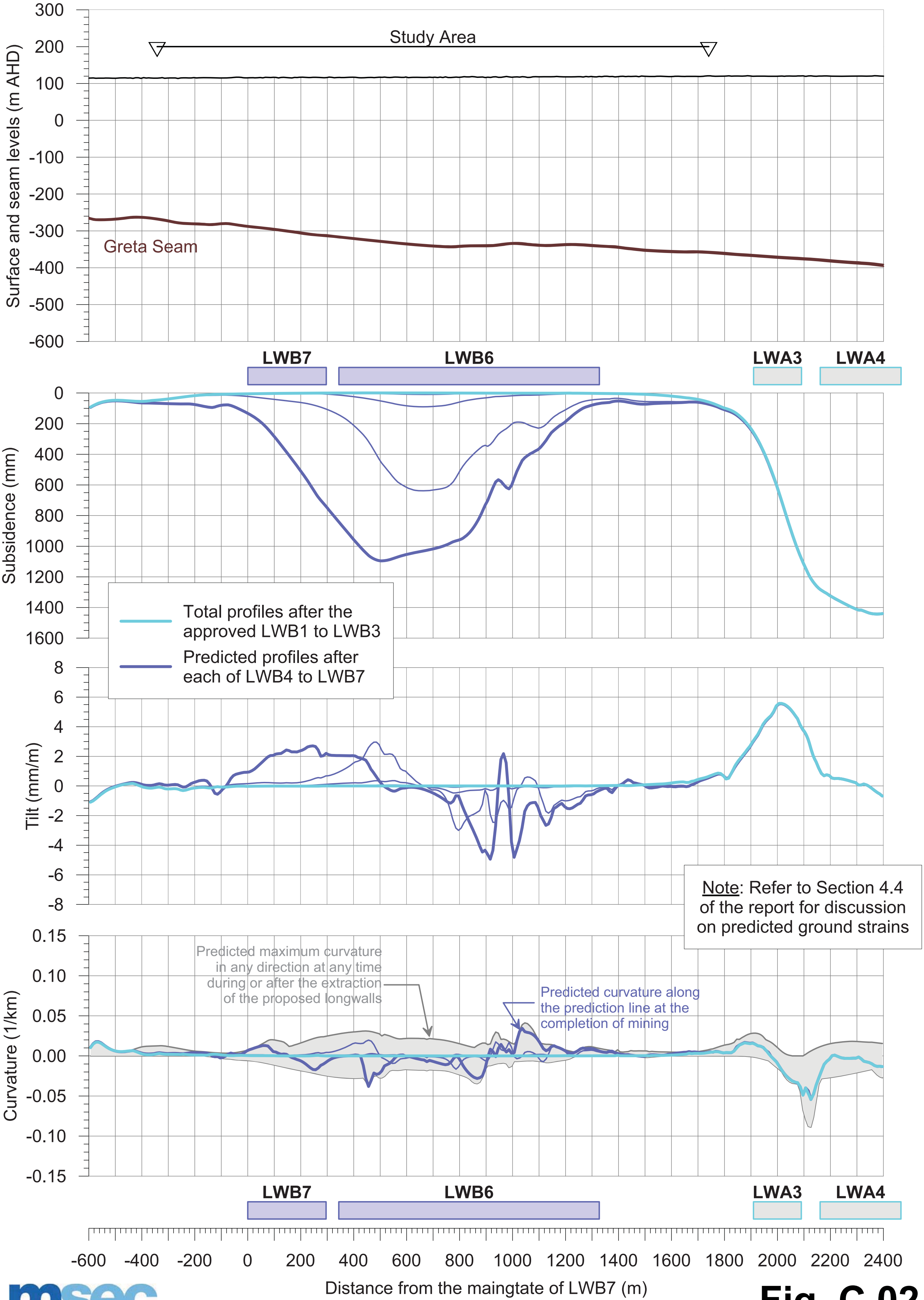


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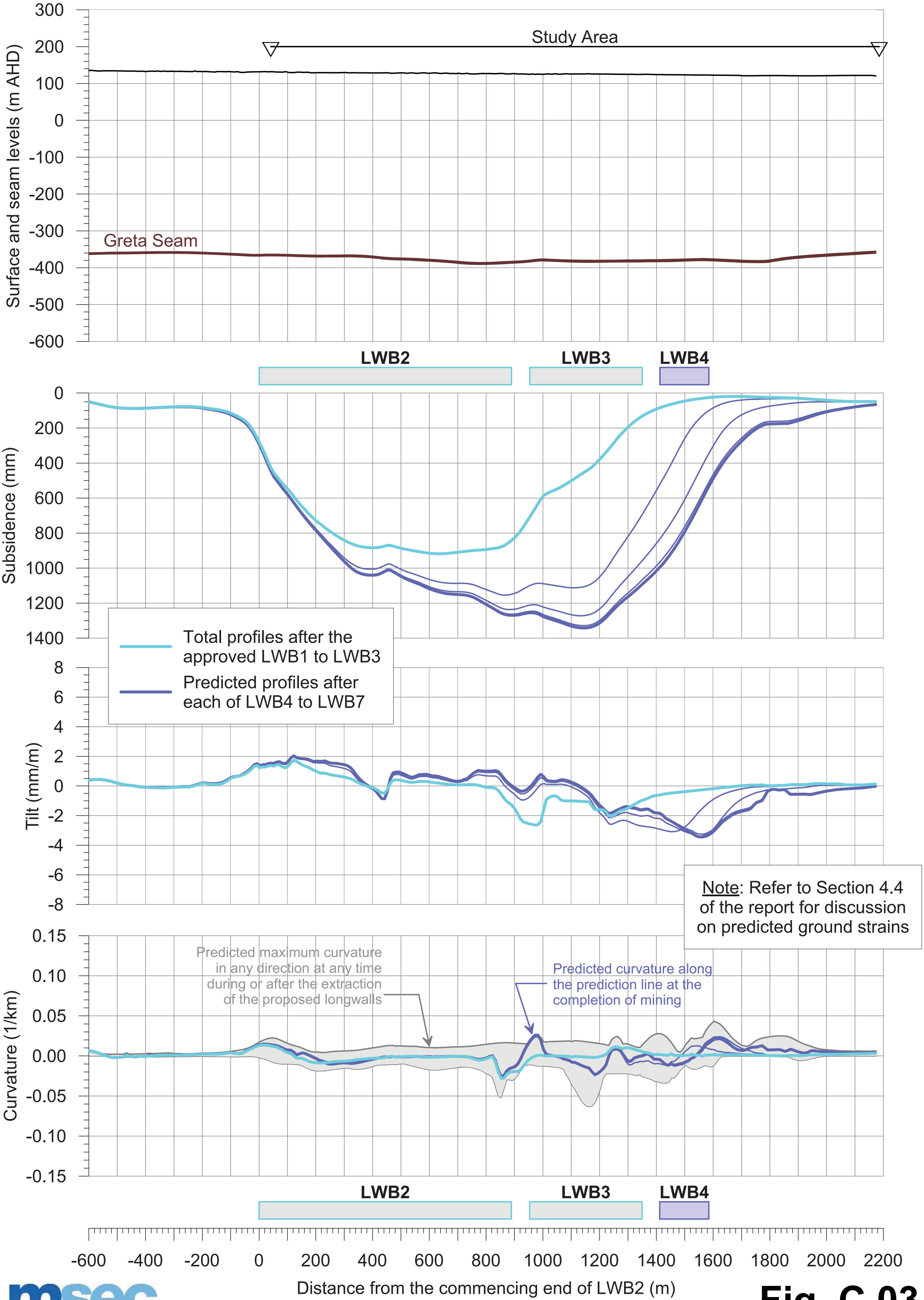
Fig. C.02

Predicted profiles of conventional subsidence, tilt and curvature along Drainage Line 1 resulting from the extraction of Longwalls B1 to B7



msec

Fig. C.03

Predicted profiles of conventional subsidence, tilt and curvature along Sandy Creek Road resulting from the extraction of Longwalls B1 to B7

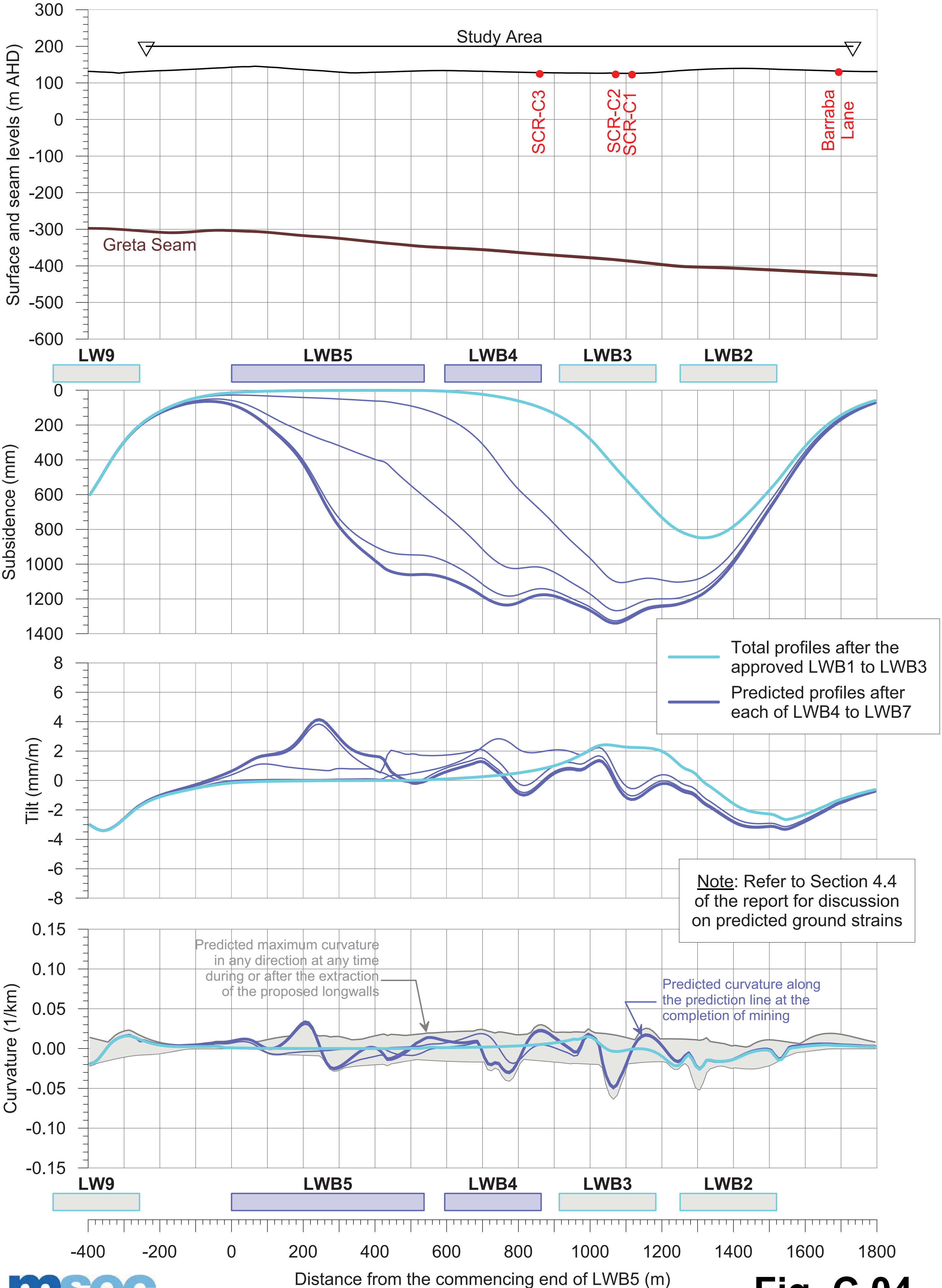


Fig. C.04

Predicted profiles of conventional subsidence, tilt along and tilt across the 11 kV Powerline Branch 1 resulting from the extraction of Longwalls B1 to B7

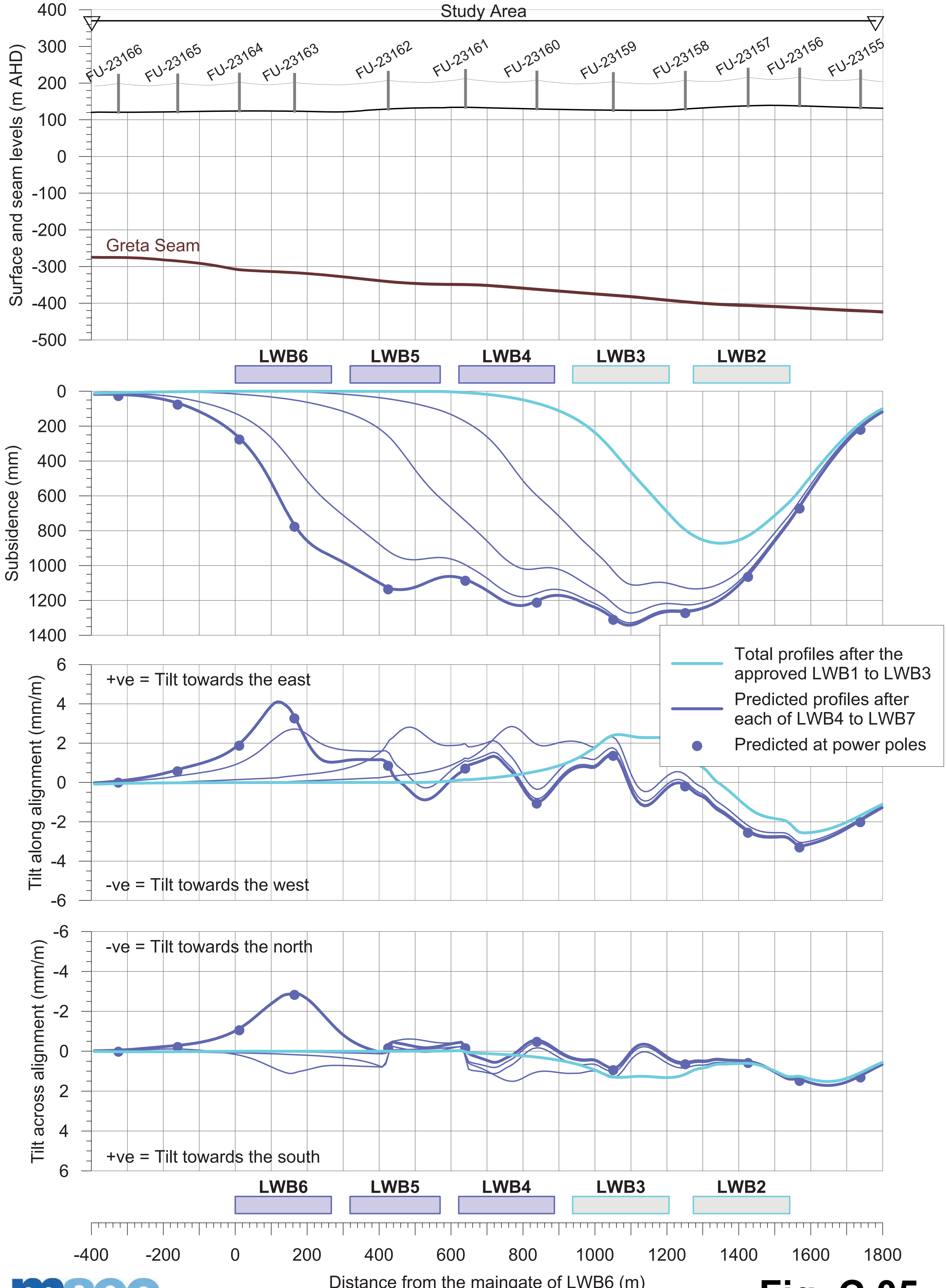


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Fig. C.05

Predicted Profiles of conventional subsidence, tilt along and tilt across the 11 kV Powerline Branch 2 resulting from the extraction of Longwalls B1 to B7

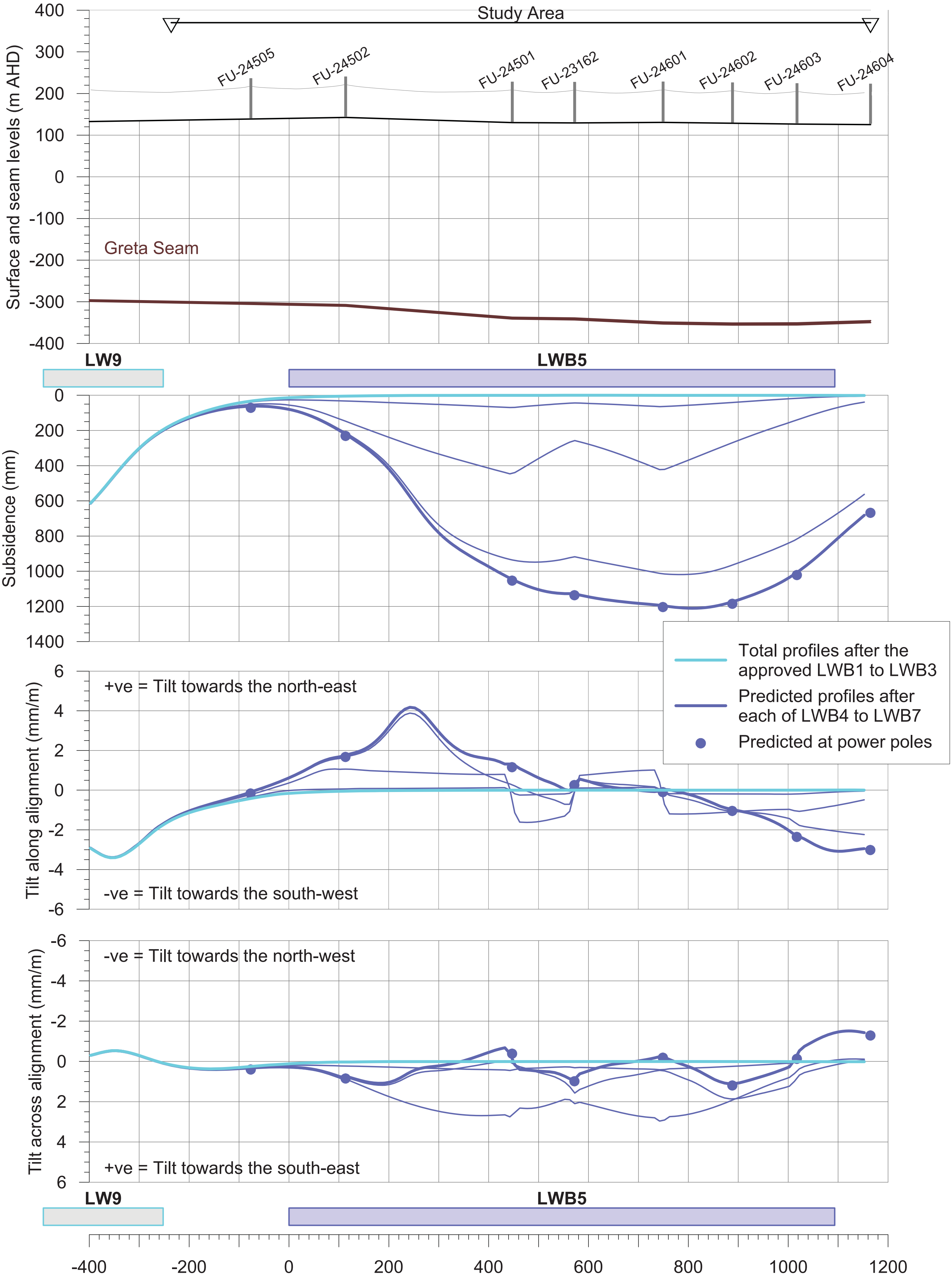

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Fig. C.06

APPENDIX D.   TABLES

Table D.01 - Maximum predicted subsidence parameters for the rural structures within the Study Area

Property Reference	Structure Reference (refer to Drawing No. MSEC869-09)	Type	Predicted Total Subsidence after LWB1 to LWB3 (mm)	Predicted Total Subsidence after LWB4 (mm)	Predicted Total Subsidence after LWB5 (mm)	Predicted Total Subsidence after LWB6 (mm)	Predicted Total Subsidence after LWB7 (mm)	Predicted Total Tilt after LWB1 to LWB7 (mm/m)	Predicted Total Hogging Curvature after LWB1 to LWB7 (1/km)	Predicted Total Sagging Curvature after LWB1 to LWB7 (1/km)
A01	A01j	Shed	150	175	175	175	175	1.5	0.02	< 0.01
	A01k	Tank	150	175	175	200	200	1.5	0.02	< 0.01
A02	A02a	Shed	80	90	100	125	125	< 0.5	0.01	< 0.01
	A02b	Shed	70	80	100	125	150	0.5	0.01	< 0.01
	A02c	Shed	175	475	675	775	775	5.0	0.03	0.01
	A02e	Shed	150	425	625	725	750	5.0	0.03	< 0.01
	A02f	Shed	200	525	725	800	825	5.0	0.03	0.02
	A02g	Shed	90	275	475	600	625	4.5	0.03	< 0.01
	A02h	Tank	125	375	575	675	675	5.0	0.03	< 0.01
	A02i	Tank	125	400	600	675	700	5.0	0.03	< 0.01
	A02j	Tank	150	425	600	700	725	5.0	0.03	< 0.01
A06	A06b	Shed	100	150	175	200	200	1.5	0.02	< 0.01
	A06c	Shed	100	150	175	200	225	1.5	0.02	< 0.01
	A06d	Shed	100	150	175	225	225	2.0	0.02	< 0.01
A08	A08r01	Shed	< 20	< 20	30	525	650	4.0	0.03	0.02
	A08r02	Shed	< 20	< 20	40	550	725	4.0	0.03	0.02
	A08r03	Shed	< 20	< 20	50	600	750	4.0	0.02	0.02
	A08r04	Shed	< 20	< 20	70	675	825	3.5	0.02	0.02
	A08t01	Tank	< 20	< 20	50	625	750	3.5	0.02	0.02
	A08t02	Tank	< 20	< 20	70	675	825	3.5	0.02	0.02
B03	B03r07	Shed	750	775	800	800	800	2.5	0.01	0.02
	B03r08	Shed	800	875	900	900	900	2.5	0.01	0.04
	B03r09	Shed	825	925	950	950	950	2.5	0.01	0.04
	B03r10	Tank	800	875	875	875	875	2.5	0.01	0.04
	B03r11	Tank	750	825	825	825	825	2.5	0.01	0.02
	B03r12	Tank	775	850	850	850	850	2.5	0.01	0.04
	B03r13	Shed	800	875	900	900	900	2.5	0.01	0.04
C01	C01r01	Shed	< 20	250	875	1100	1200	1.0	0.02	0.02
	C01r02	Tank	< 20	225	875	1100	1200	1.0	0.02	0.02
	C01r03	Shed	< 20	150	725	1050	1150	1.0	0.02	0.02
	C01r04	Shed	< 20	200	825	1100	1150	1.0	0.02	0.02
C02	C02p01	Pool	< 20	50	325	975	1200	1.0	0.03	0.03
	C02r01	Garage	< 20	50	300	975	1200	1.0	0.03	0.03
	C02r02	Shed	< 20	50	300	950	1150	1.0	0.03	0.03
	C02r03	Shed	< 20	50	275	950	1150	1.0	0.03	0.03
	C02r04	Shed	< 20	40	250	925	1150	1.0	0.03	0.02
	C02r05	Shed	< 20	40	225	900	1150	1.0	0.03	0.02
	C02r06	Shed	< 20	50	350	975	1200	1.0	0.03	0.03
	C02r07	Gazebo	< 20	70	425	1000	1200	< 0.5	0.03	0.03
	C02t01	Tank	< 20	50	325	975	1200	1.0	0.03	0.03
	C02t02	Tank	< 20	50	350	975	1200	1.0	0.03	0.03
C03	C03r01	Shed	< 20	< 20	< 20	20	30	< 0.5	< 0.01	< 0.01
	C03r02	Shed	< 20	< 20	< 20	20	30	< 0.5	< 0.01	< 0.01
C05	C05r01	Shed	< 20	< 20	40	70	80	1.0	< 0.01	< 0.01
	C05r02	Awning	< 20	< 20	40	80	90	1.0	< 0.01	< 0.01
	C05t01	Tank	< 20	< 20	30	60	70	0.5	< 0.01	< 0.01
	C05t02	Tank	< 20	< 20	30	70	80	1.0	< 0.01	< 0.01
	C05t03	Tank	< 20	< 20	50	90	100	1.0	< 0.01	< 0.01
		Maximum	**825**	**925**	**950**	**1100**	**1200**	**5.0**	**0.03**	**0.04**

Table D.02 - Maximum predicted subsidence parameters for the farm dams within the Study Area

Property Reference	Dam Reference (refer to Drawing No. MSEC869-09)	Maximum Planar Dimension (m)	Surface Area (m2)	Predicted Total Subsidence after LWB1 to LWB3 (mm)	Predicted Total Subsidence after LWB4 (mm)	Predicted Total Subsidence after LWB5 (mm)	Predicted Total Subsidence after LWB6 (mm)	Predicted Total Subsidence after LWB7 (mm)	Predicted Total Tilt after LWB1 to LWB7 (mm/m)	Predicted Total Hogging Curvature after LWB1 to LWB7 (1/km)	Predicted Total Sagging Curvature after LWB1 to LWB7 (1/km)	Predicted Total Change in Freeboard (mm)
A01	A01d06	71	1467	250	275	300	300	300	3.0	0.02	< 0.01	50
A02	A02d01	133	6223	70	70	80	150	175	1.5	0.02	< 0.01	< 50
A04	A04d06	83	1806	375	375	375	375	375	3.5	0.04	< 0.01	150
A06	A06d01	81	2968	200	325	400	475	475	4.0	0.03	< 0.01	200
	A06d02	28	480	125	150	175	175	175	1.0	0.02	< 0.01	< 50
	A06d03	60	968	425	475	500	525	525	4.5	0.03	0.03	100
	A06d04	9	52	60	90	125	175	175	1.5	0.02	< 0.01	< 50
A07	A07d01	80	2464	< 20	30	300	625	675	4.5	0.04	< 0.01	200
A08	A08d01	76	2549	< 20	< 20	40	550	625	4.0	0.03	0.02	200
	A08d02	40	417	< 20	< 20	< 20	< 20	< 20	< 0.5	< 0.01	< 0.01	< 50
B01	B01d01	40	956	800	900	925	950	950	2.5	0.01	0.04	100
	B01d02	47	879	425	1100	1250	1300	1300	1.5	0.02	0.06	< 50
	B01d03	35	1044	60	550	1000	1150	1200	1.5	0.02	0.04	< 50
B02	B02d01	63	1714	550	600	600	625	625	2.5	0.01	< 0.01	100
	B02d02	34	718	650	800	825	825	825	4.5	0.02	0.02	150
B03	B03d03	82	806	400	425	425	425	425	2.5	0.02	< 0.01	100
	B03d04	41	955	125	150	150	150	150	1.0	0.01	< 0.01	< 50
	B03d05	8	29	600	675	700	700	700	4.0	0.02	0.02	< 50
C01	C01d01	63	1695	80	625	1050	1200	1250	1.5	0.02	0.04	< 50
C03	C03d01	439	46886	70	70	70	150	625	4.5	0.04	0.03	500
	C03d02	159	3432	< 20	< 20	< 20	100	475	4.0	0.03	0.03	300
C05	C05d01	34	686	< 20	< 20	< 20	30	40	< 0.5	< 0.01	< 0.01	< 50
	C05d02	25	405	< 20	< 20	< 20	< 20	20	< 0.5	< 0.01	< 0.01	< 50
C06	C06d01	46	1006	50	50	50	60	60	< 0.5	0.01	< 0.01	< 50
			Maximum	**800**	**1100**	**1250**	**1300**	**1300**	**4.5**	**0.04**	**0.06**	**500**

Table D.03 - Maximum Predicted Subsidence Parameters for the Houses within the Study Area

Structure Reference (refer to Drawing No. MSEC869-09)	Predicted Total Subsidence after LWB1 to LWB3 (mm)	Predicted Total Subsidence after LWB4 (mm)	Predicted Total Subsidence after LWB5 (mm)	Predicted Total Subsidence after LWB6 (mm)	Predicted Total Subsidence after LWB7 (mm)	Predicted Total Tilt after LWB1 to LWB3 (mm/m)	Predicted Total Tilt after LWB4 (mm/m)	Predicted Total Tilt after LWB5 (mm/m)	Predicted Total Tilt after LWB6 (mm/m)	Predicted Total Tilt after LWB7 (mm/m)
A02d	200	475	625	725	725	2.0	4.0	5.0	5.0	5.0
A06a	100	150	150	175	175	< 0.5	0.5	1.0	1.0	1.0
A08h01	< 20	< 20	50	600	700	< 0.5	< 0.5	0.5	3.0	3.5
C02h01	< 20	60	375	1000	1200	< 0.5	< 0.5	3.0	2.0	1.0
C04h01	< 20	< 20	90	375	450	< 0.5	< 0.5	0.5	3.0	3.5
C05h01	< 20	< 20	40	80	90	< 0.5	< 0.5	< 0.5	1.0	1.0
Maximum	**200**	**475**	**625**	**1000**	**1200**	**2.0**	**4.0**	**5.0**	**5.0**	**5.0**

Table D.03 - Maximum Predicted Subsidence Parameters for the Houses within the Study Area

Structure Reference (refer to Drawing No. MSEC869-09)	Predicted Total Hogging Curvature after LWB1 to LWB3 (1/km)	Predicted Total Hogging Curvature after LWB4 (1/km)	Predicted Total Hogging Curvature after LWB5 (1/km)	Predicted Total Hogging Curvature after LWB6 (1/km)	Predicted Total Hogging Curvature after LWB7 (1/km)	Predicted Total Sagging Curvature after LWB1 to LWB3 (1/km)	Predicted Total Sagging Curvature after LWB4 (1/km)	Predicted Total Sagging Curvature after LWB5 (1/km)	Predicted Total Sagging Curvature after LWB6 (1/km)	Predicted Total Sagging Curvature after LWB7 (1/km)
A02d	0.02	0.03	0.03	0.03	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
A06a	< 0.01	0.01	0.01	0.02	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
A08h01	< 0.01	< 0.01	< 0.01	0.02	0.02	< 0.01	< 0.01	< 0.01	0.02	0.02
C02h01	< 0.01	< 0.01	0.02	0.03	0.03	< 0.01	< 0.01	< 0.01	0.03	0.03
C04h01	< 0.01	< 0.01	< 0.01	0.03	0.03	< 0.01	< 0.01	< 0.01	0.02	0.02
C05h01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Maximum	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**< 0.01**	**< 0.01**	**< 0.01**	**0.03**	**0.03**

APPENDIX E. DRAWINGS

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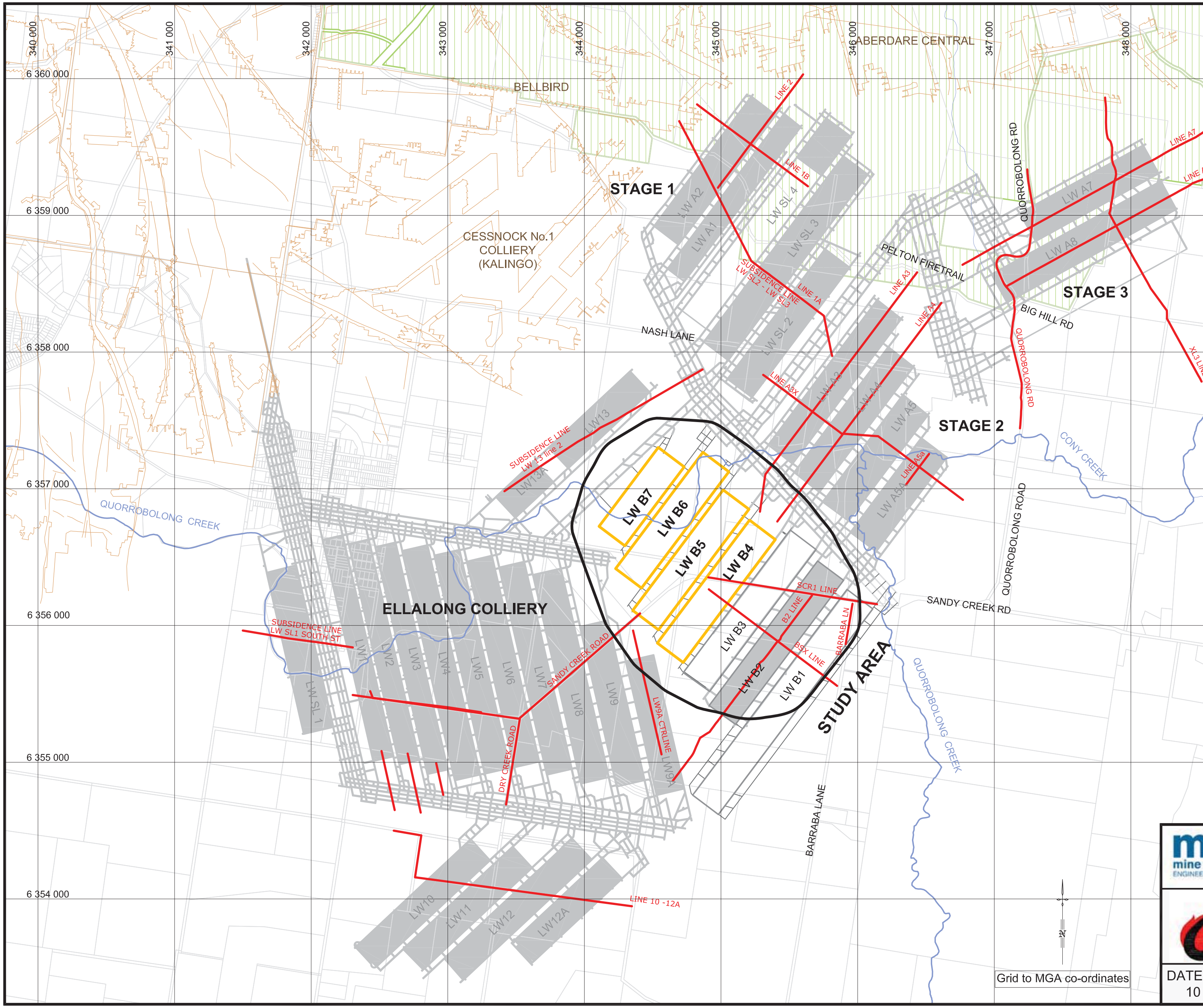

LEGEND

EXISTING MONITORING LINES

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AUSTAR COAL MINE

LONGWALLS B4 to B7
OVERALL LAYOUT & MONITORING

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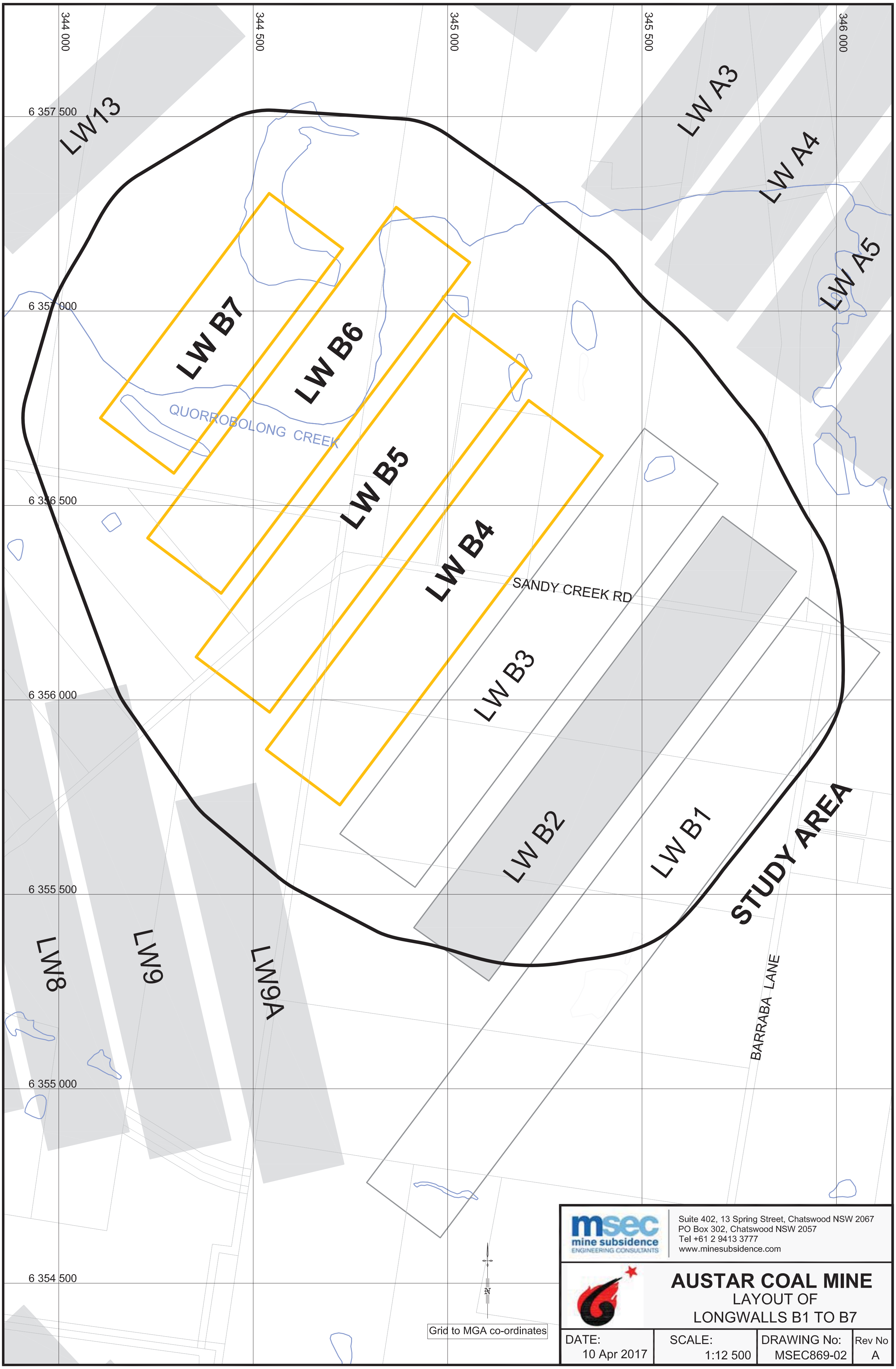

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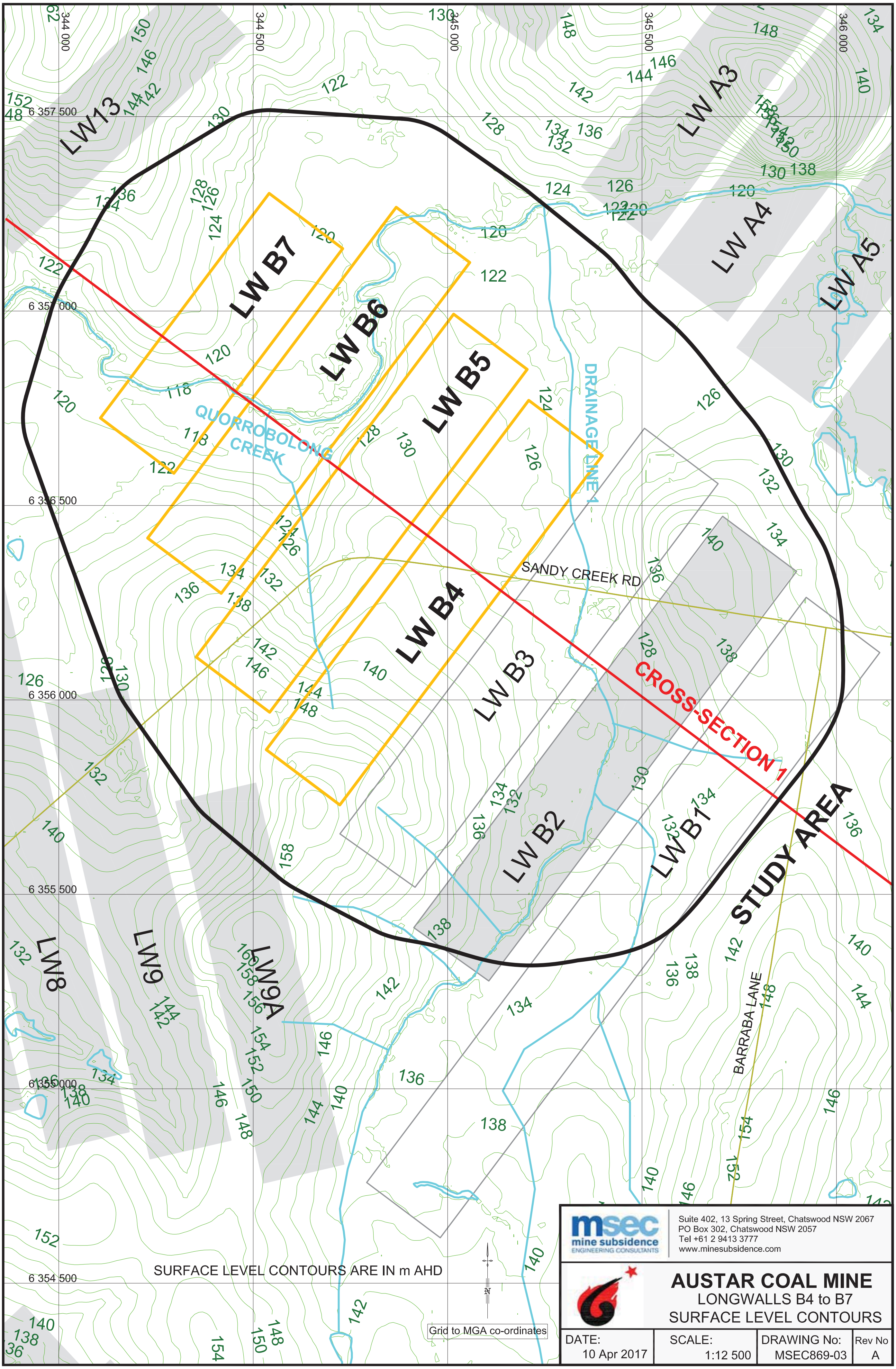

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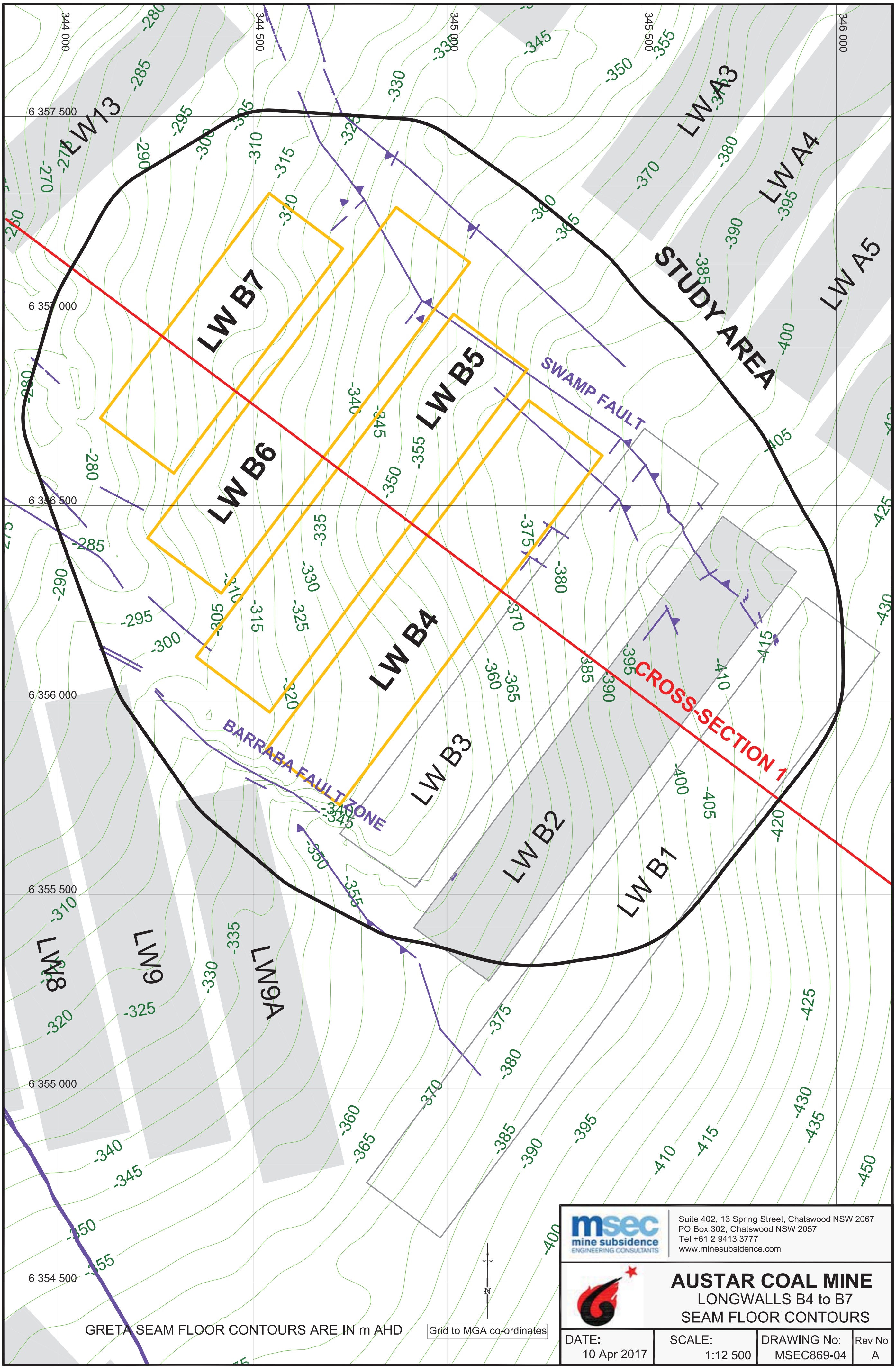

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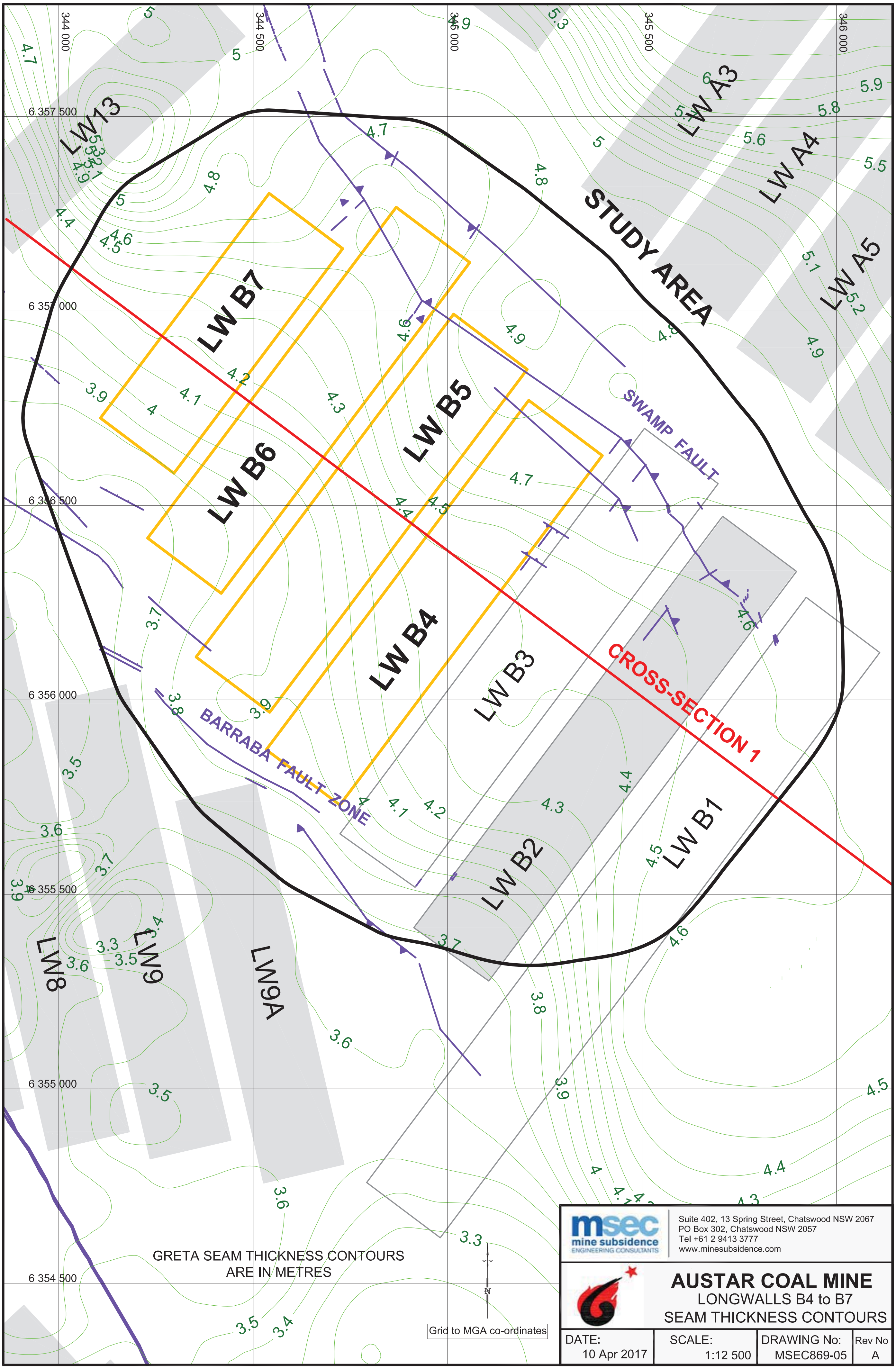

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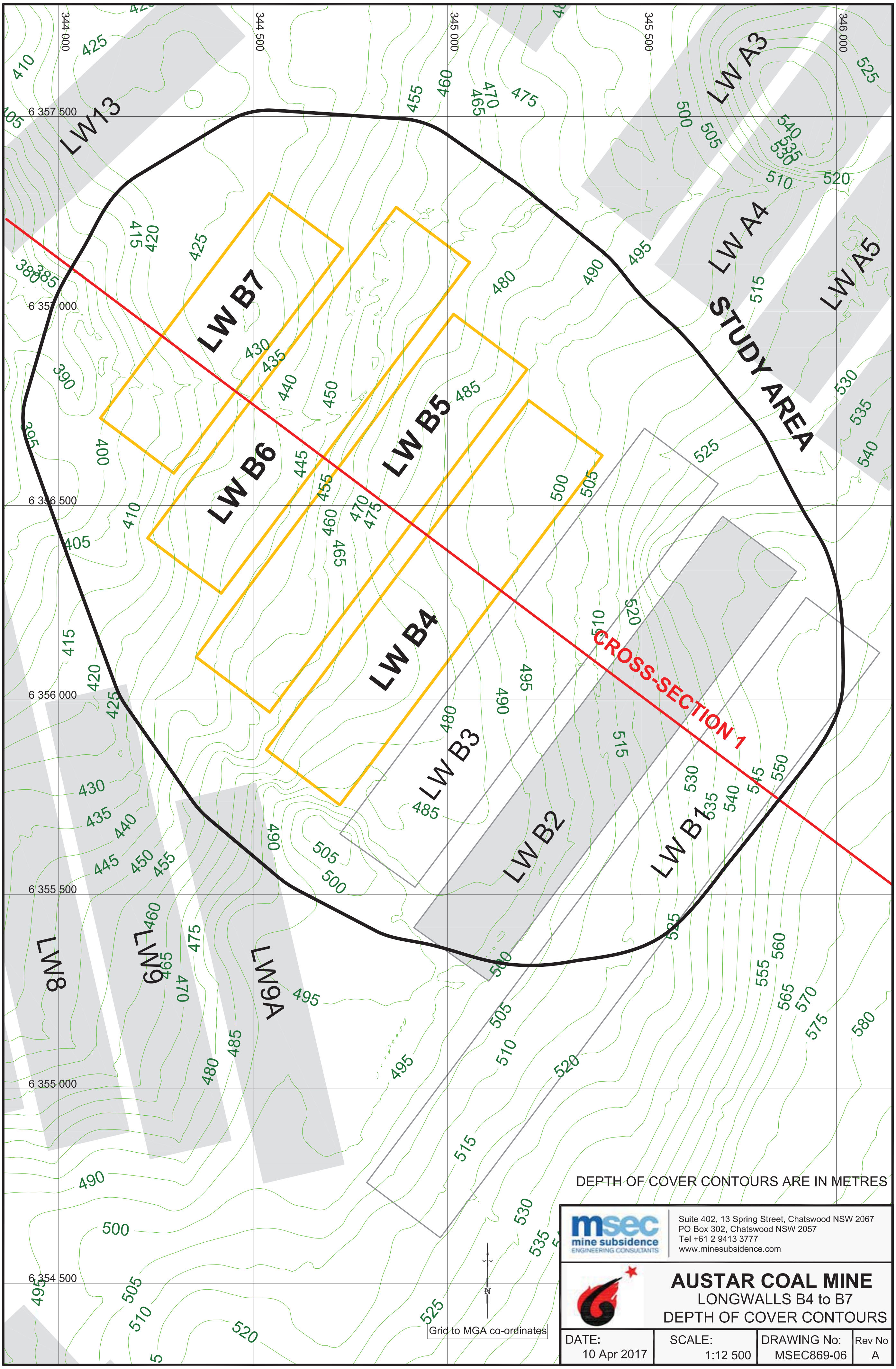

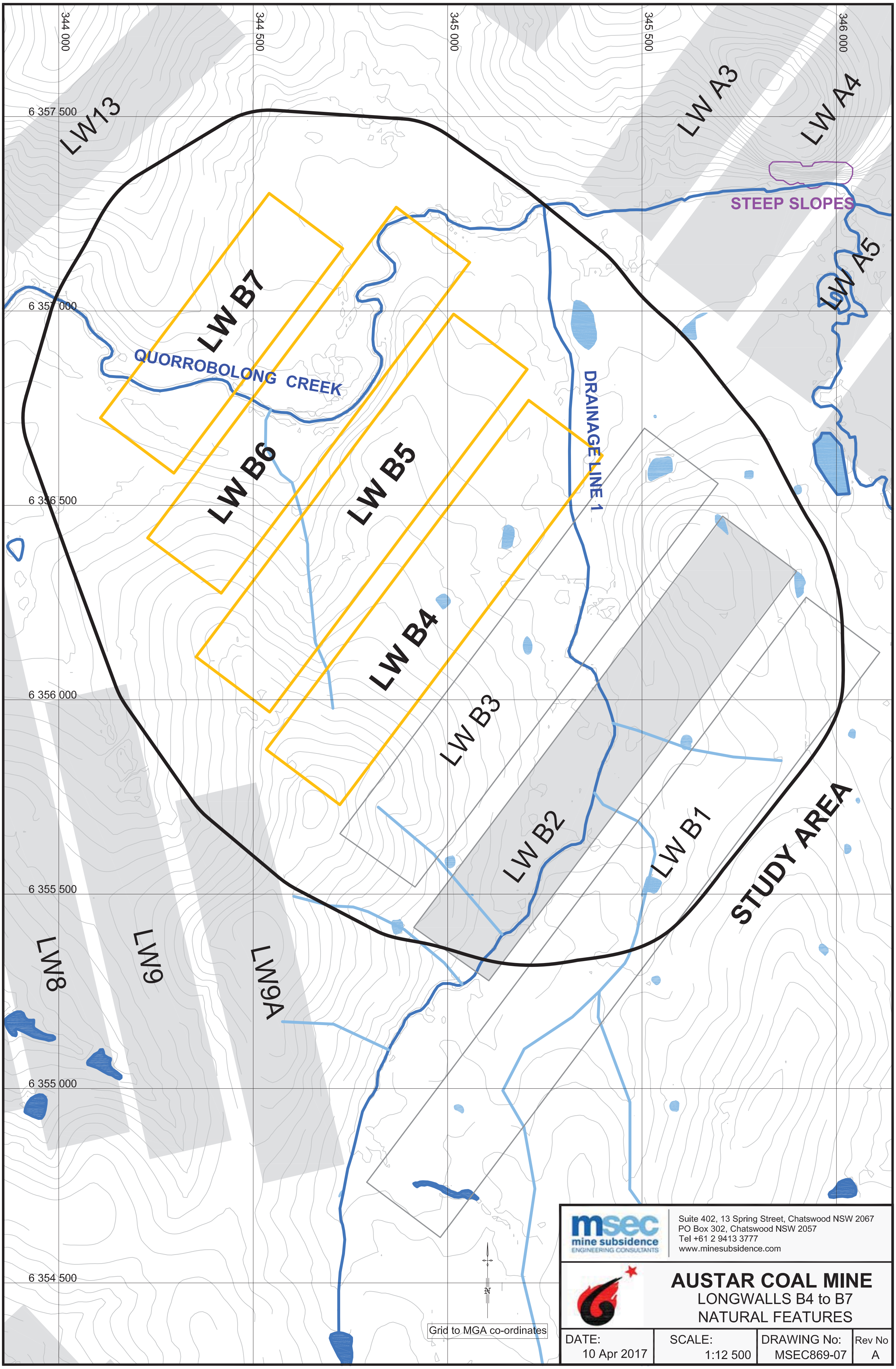

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AUSTAR COAL MINE
LONGWALLS B4 to B7
NATURAL FEATURES

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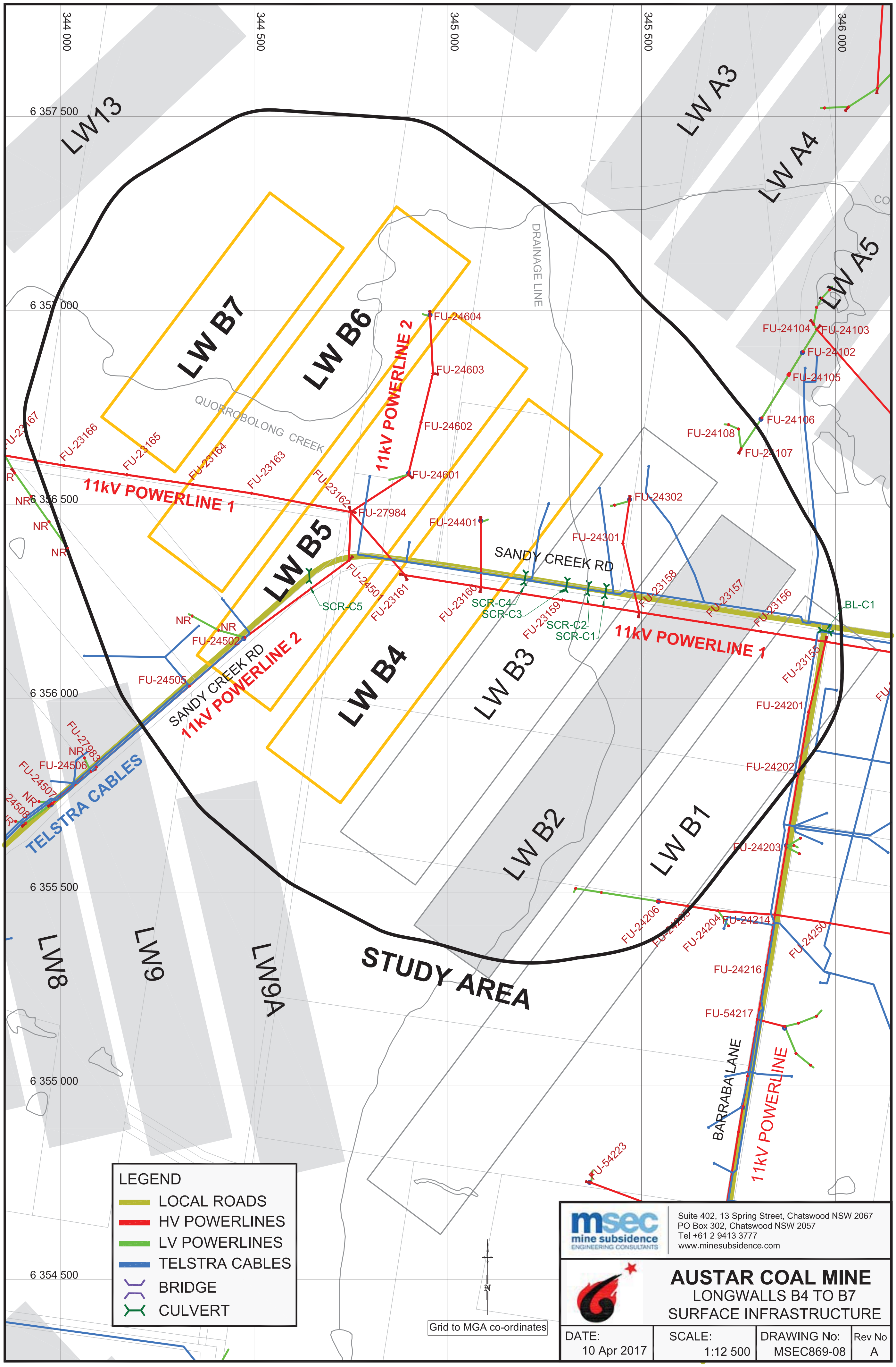

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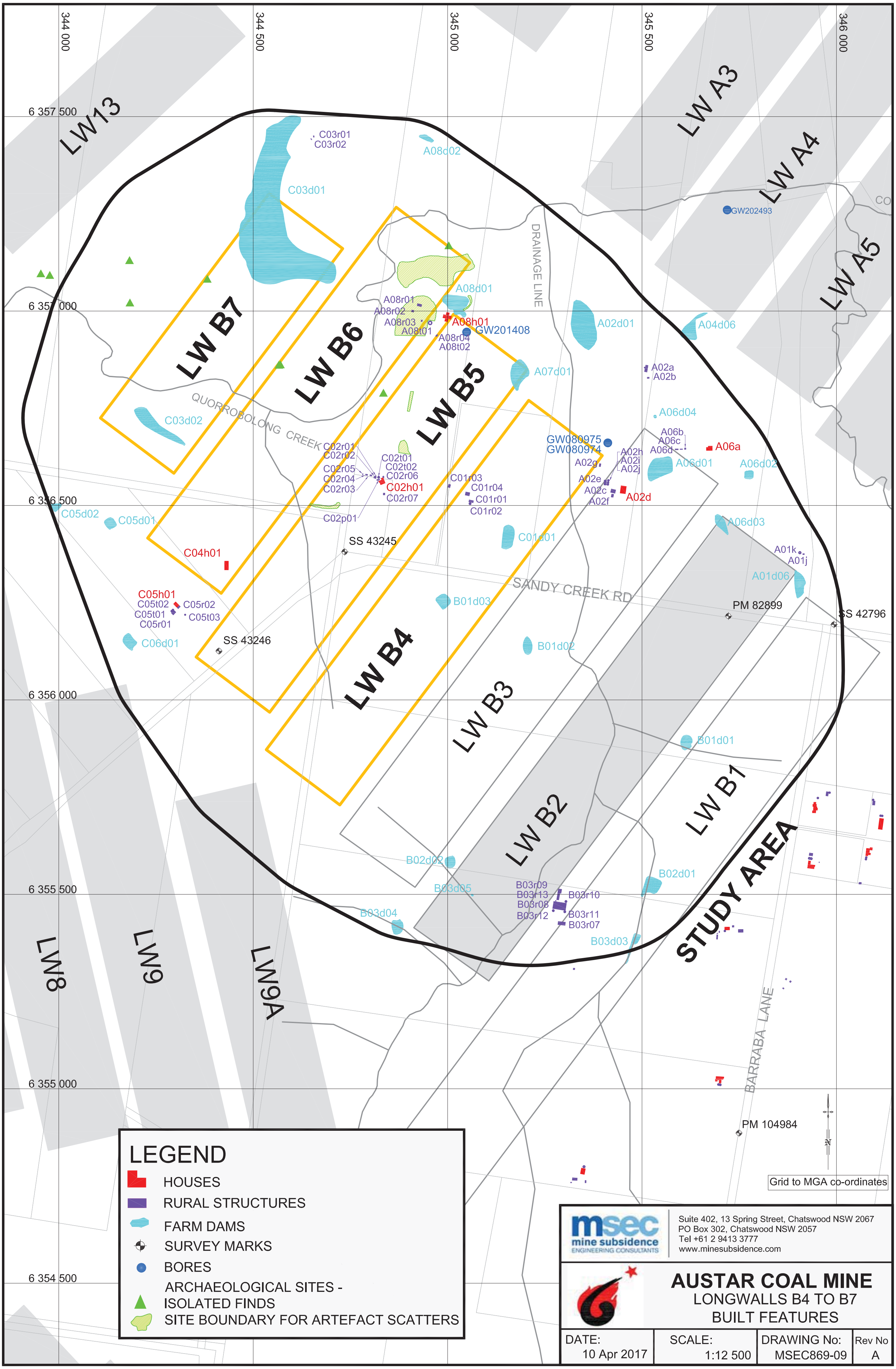

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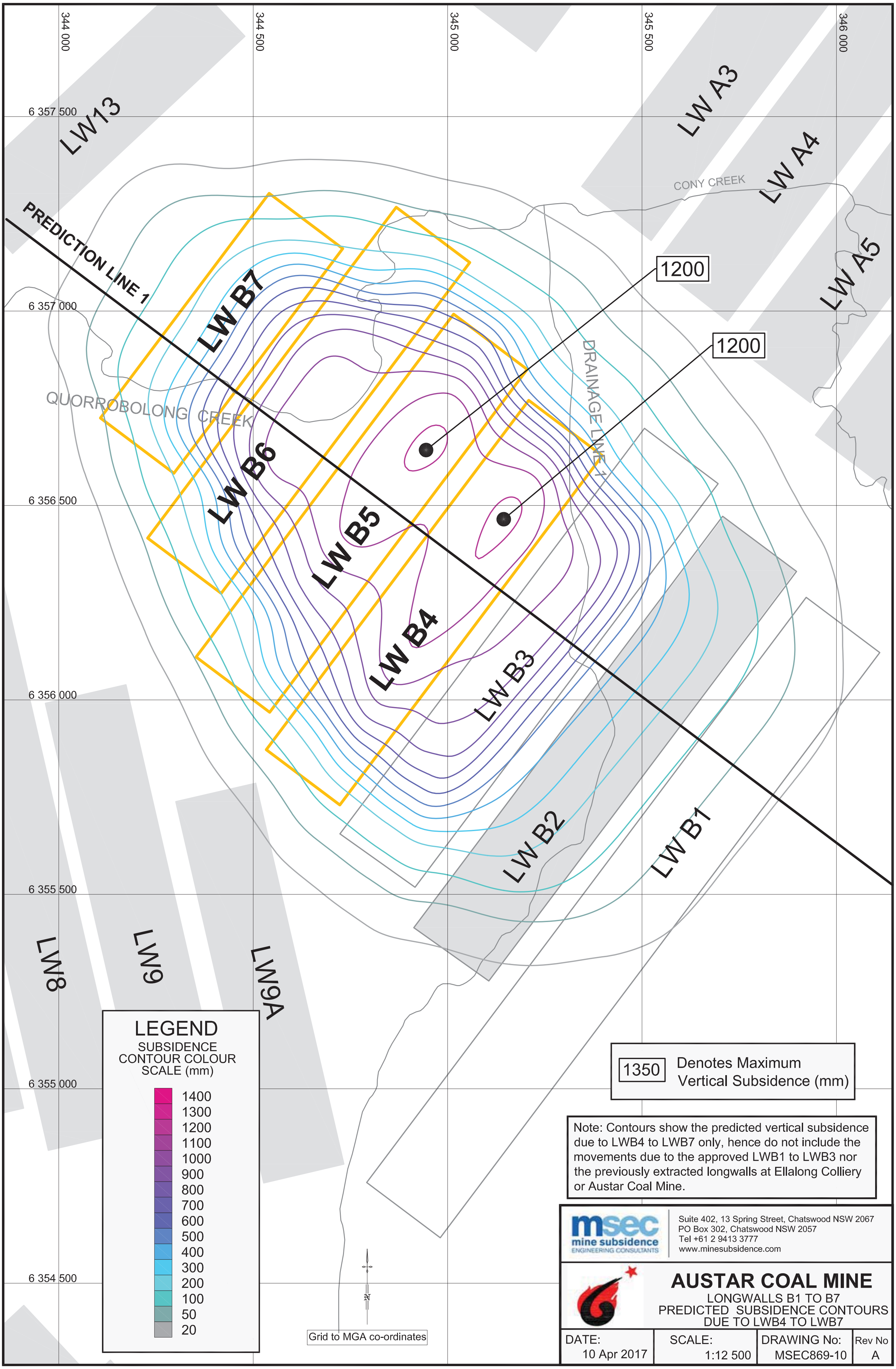

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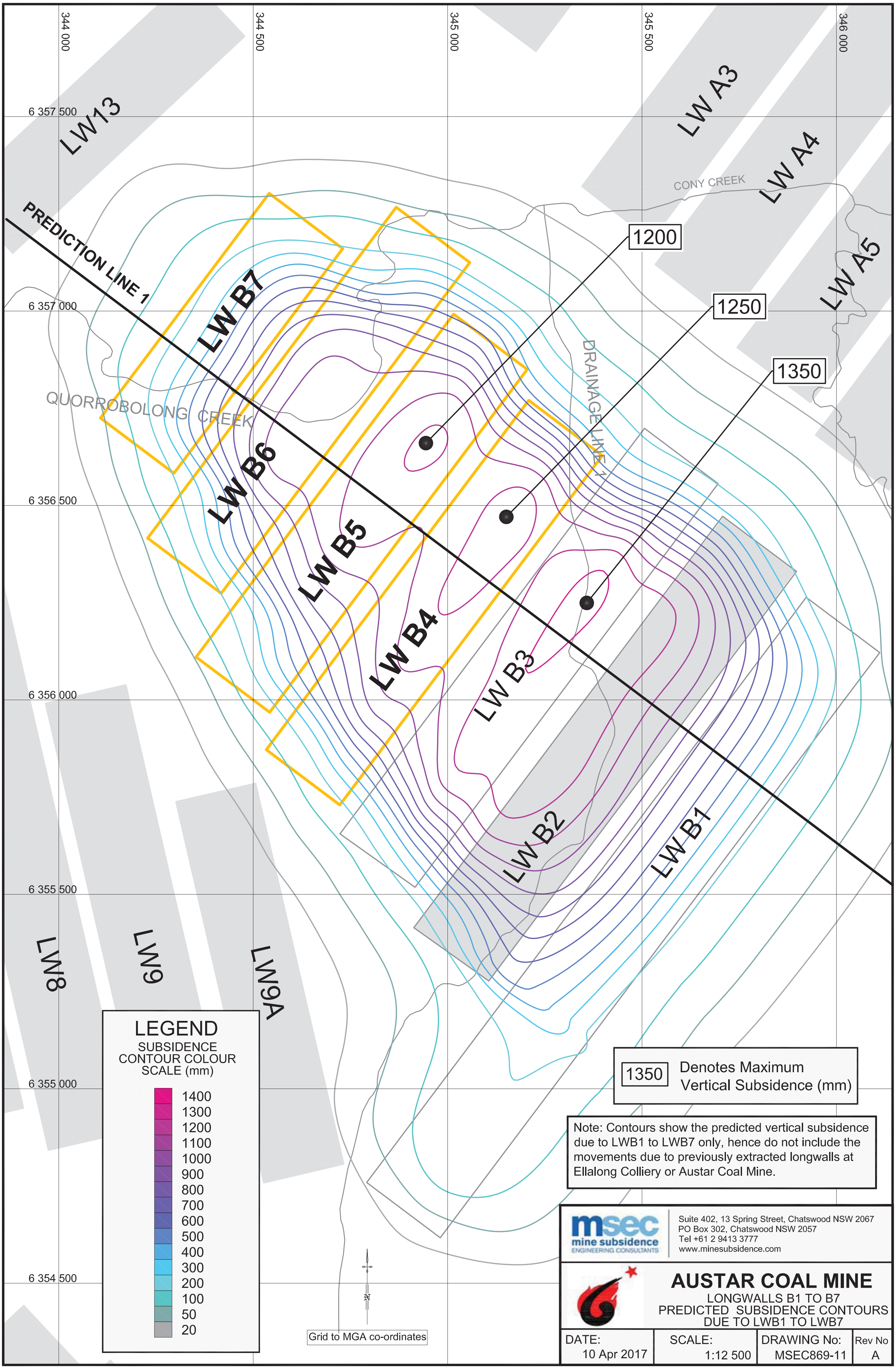

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AUSTAR COAL MINE
LONGWALLS B1 TO B7
PREDICTED SUBSIDENCE CONTOURS
DUE TO LWB1 TO LWB7

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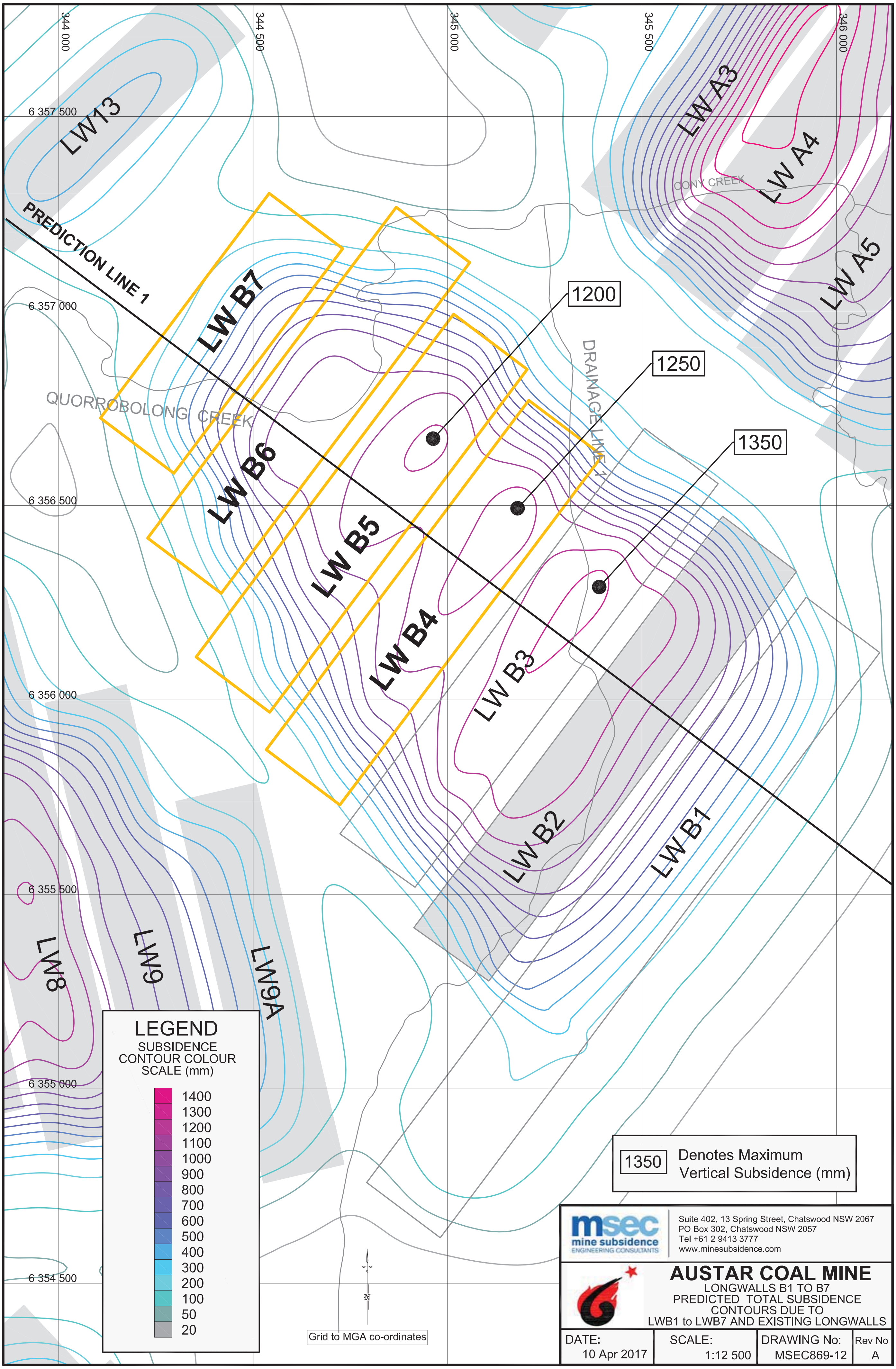

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AUSTAR COAL MINE

LONGWALLS B1 TO B7
PREDICTED TOTAL SUBSIDENCE CONTOURS DUE TO
LWB1 to LWB7 AND EXISTING LONGWALLS

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APPENDIX 3

Flooding and Drainage Assessment

Inspired people | Dedicated team
Quality outcomes

AUSTAR COAL MINE

LWB4-B7 MODIFICATION FLOODING AND DRAINAGE ASSESSMENT

Austar Coal Mine

FINAL

May 2017

AUSTAR COAL MINE

LWB4-B7 MODIFICATION FLOODING AND DRAINAGE ASSESSMENT

Austar Coal Mine

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Yancoal

Project Director:	Barbara Crossley
Project Manager:	Gabrielle Allan
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Report No.	R03/V2/Final
Date:	May 2017

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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	**Date**	**Name**	**Date**
V1	Gabrielle Allan	10/04/2017	Barbara Crossley	10/04/2017
V2	Gabrielle Allan	11/05/2017	Barbara Crossley	11/05/2017

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1.0 Introduction

1.1 Background

Austar Coal Mine Pty Ltd (Austar), a subsidiary of Yancoal Australia Limited (Yancoal) operates the Austar Coal Mine, an underground coal mine located approximately 10 kilometres south of Cessnock in the Lower Hunter Valley in NSW (refer to **Figure 1.1**). The Austar Coal Mine incorporates the former Pelton, Ellalong, Cessnock No. 1 (Kalingo) and Bellbird South Collieries and includes coal extraction, handling, processing and rail and road transport facilities (refer to **Figure 1.2**).

Extensive mining has been undertaken within the Austar Coal Mine since 1916. Historical mining was predominantly via bord and pillar mining and more recently via conventional longwall mining and Longwall Top Coal Caving (LTCC) methods. Mining within the Bellbird South areas (Southland, Stage 1 and Stage 2, refer to **Figure 1.2**) was approved by the Minister for Urban Affairs and Planning in 1996 under DA 29/95, while mining of Stage 3 was approved by the Minister for Planning in 2009 under Project Approval 08_0111. Mining is currently proceeding in the LWB1-B3 mining area in accordance with DA 29/95 (as modified).

A review of accessible coal resources within the Bellbird South/Ellalong Colliery areas has identified the potential for four additional longwall panels (LWB4-B7) adjacent to LWB3 that can be accessed from the Bellbird mains (refer to **Figure 1.3**). Austar proposes to modify DA 29/95 to permit the transfer and processing of coal from the four proposed longwall panels (LWB4-B7) via the existing Bellbird mains and to extend the development consent area to cover the four longwall panels (refer to **Figure 1.3**).

No other changes to the approved mining operations, associated surface facilities or production rates are proposed as part of the modification.

1.2 Scope of Assessment

The primary aim of this flood and drainage assessment is to determine the potential impacts of the proposed mining of LWB4 to LWB7 on the flood and drainage behaviour of the surrounding area, including cumulative impacts to the estimated flood behaviour in relation to the previously approved LWB1-B3, Stage 2 and Stage 3 mine plans.

This report has been prepared to accompany an Environmental Assessment (EA) that identifies and assesses the potential environmental impacts of LWB4-B7.

1.3 Catchment Context

The LWB4-B7 Modification Area (delineated by the predicted 20mm subsidence contour for LWB4-B7) is located within the Quorrobolong Creek catchment area (refer to **Figure 1.3**). Quorrobolong Creek drains in a westerly direction through the north of the LWB4-B7 Modification Area above proposed LWB6 and LWB7. The total length of Quorrobolong Creek above these longwalls is approximately 1.3 kilometres. Quorrobolong Creek is ephemeral with localised areas of natural ponding occurring along its alignment (refer to **Plates 1.1** and **1.2**). Quorrobolong Creek has been previously directly mined beneath within the Ellalong Colliery and Stage 2 mining area at the Austar Coal Mine, with a total length of approximately 4 kilometres located directly above these previously extracted longwalls. Monitoring of these previous extracted longwalls has shown no significant surface cracking or loss of surface water flows as a result of mining.

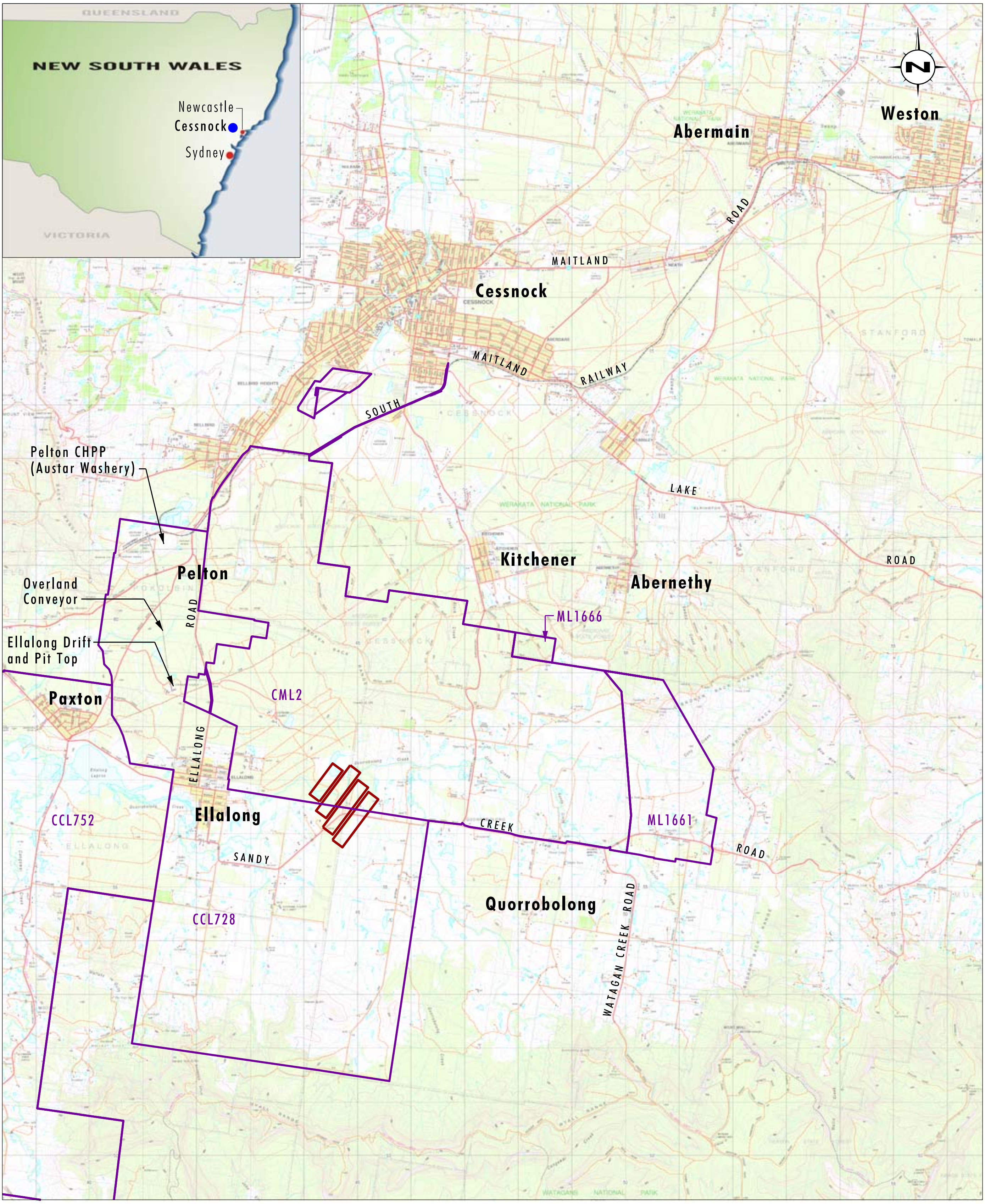

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

0 1.0 2.5 5.0km
1:100 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Mining Lease Boundary

FIGURE 1.1

Locality Plan

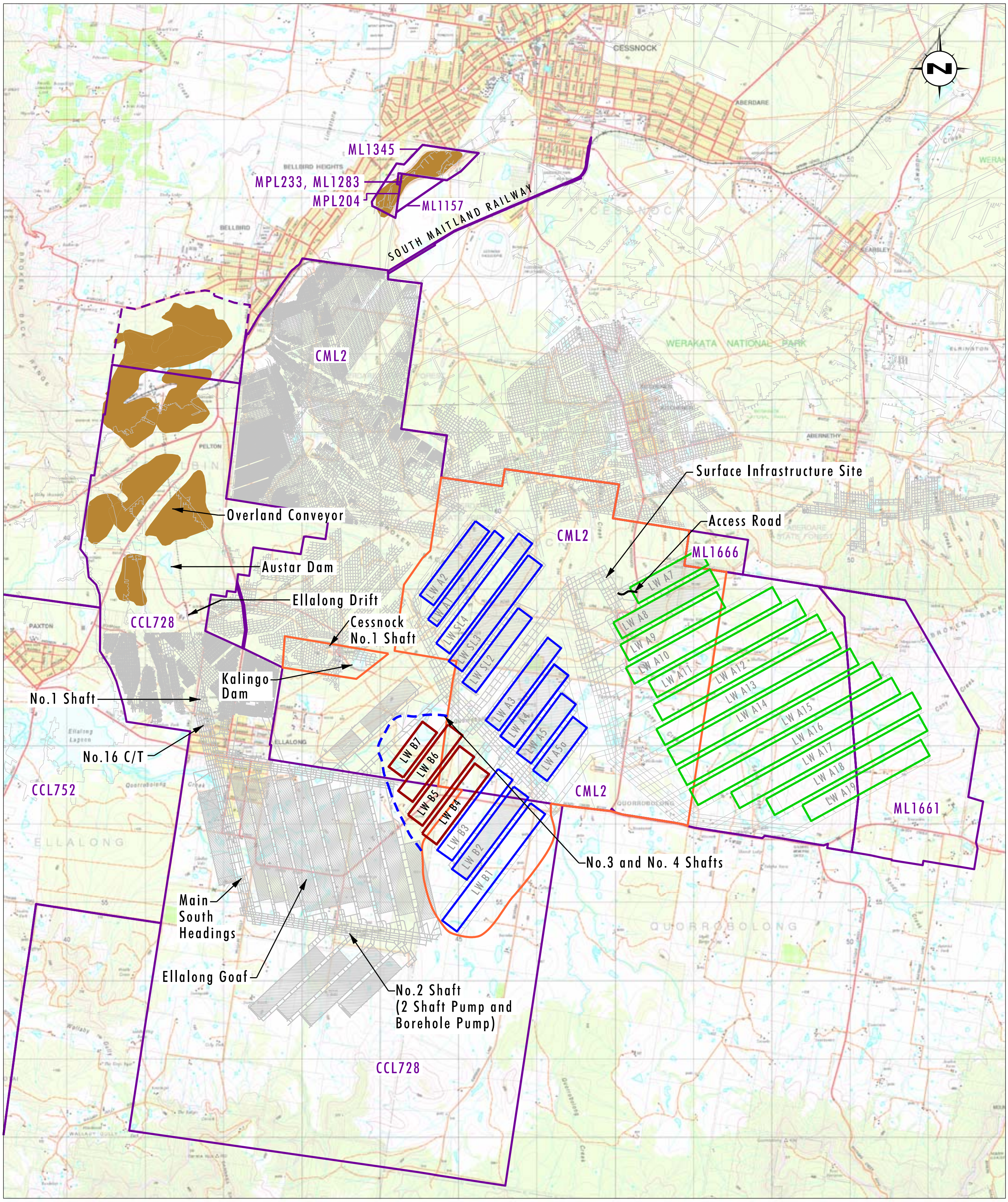

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

0 1 2 3km
1:70 000

Legend

- Bellbird South Stage 1, Stage 2, Southland and LWB1-B3 Longwall Panels (DA 29/95)
- Proposed LWB4-B7 Longwall Panels (DA 29/95)
- Stage 3 Longwall Panels (PA08_0111)
- DA 29/95 Bellbird South Consent Area (Subsurface) - As Approved
- DA 29/95 Bellbird South Consent Area (Subsurface) - Proposed Extension
- Approved Reject Emplacement Areas
- Completed Underground Workings
- Mining Lease Boundary
- Austar owned CHPP Land

FIGURE 1.2

Austar Coal Mine and Proposed LWB4-B7

File Name (A4): R03/3900_030.dgn
20170216 10.47

umwelt

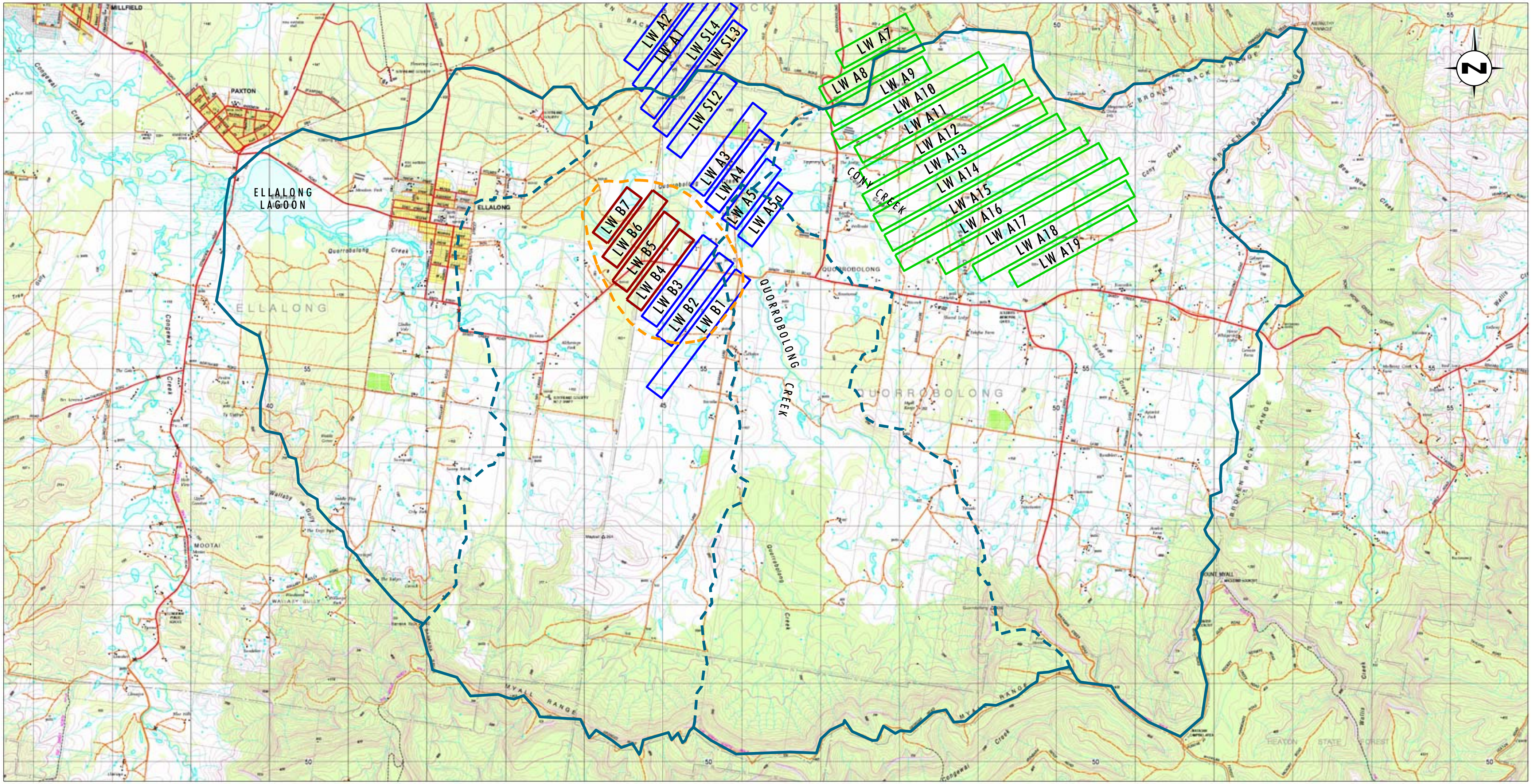

Image Source: LPI NSW 1:25 000 Topographic Map
Data Source: Austar Coal Mine

0 1 2 3km
1:70 000

Legend

Bellbird South Stage 1, Stage 2, Southland and LWB1-B3 Longwall Panels (DA 29/95)
Stage 3 Longwall Panels (PA08_0111)
Proposed LWB4-B7 Longwall Panels (DA 29/95)
LWB4-B7 Modification Area
Quorrobolong Creek Catchment Boundary
Quorrobolong Creek Sub-Catchment Boundary

FIGURE 1.3

Catchment Context

File Name (A4): R03/3900_035.dgn
20170216 10.54

An unnamed tributary (4th order) of Quorrobolong Creek that includes a number of secondary drainage channels drains in a northerly direction through the LWB4-B7 Modification Area above LWB1 to LWB4, converging with Quorrobolong Creek upstream of LWB5 (refer to **Plates 1.3** and **1.4**). A large farm dam water body is located to the north of the main channel of Quorrobolong Creek above LWB7 (refer to **Plate 1.5**), and is referred to in subsequent sections as the Northern farm dam water body. This feature is located within the floodplain of Quorrobolong Creek and overflows to the main channel. A 1st order drainage line also traverses above LWB6 and LWB7 and includes an ephemeral ponded area adjacent to Quorrobolong Creek above LWB7 (refer to **Plate 1.6**). This drainage line acts as an overland flow path for Quorrobolong Creek during high out of bank flows. Quorrobolong Creek, its unnamed tributary and the 1st order drainage line are ephemeral watercourses with flows only occurring as a result of prolonged or high rainfall periods.

Plate 1.1 Quorrobolong Creek main channel

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Plate 1.2 Quorrobolong Creek main channel

Plate 1.3 Unnamed tributary of Quorrobolong Creek at Sandy Creek Road culvert

Plate 1.4 Unnamed tributary of Quorrobolong Creek south of Sandy Creek Road

Plate 1.5 Northern farm dam water body located north of Quorrobolong Creek main channel, fed by surrounding paddock areas and a drainage line through the slopes of the treed hillslope in the background

Plate 1.6 Ephemeral ponded area associated with 1st order drainage line south of Quorrobolong Creek main channel

One soil landscape type is found within the LWB4-B7 Modification Area, being the Quorrobolong soil landscape (Kovac and Lawrie 1991). The main soils within this landscape are prairie soils which form in alluvium and occur in drainage depressions and on lower slopes. They are generally poorly drained, have moderate permeability and the upper horizon has moderate erodibility (Kovac and Lawrie 1991).

The dominant land use within and surrounding the LWB4-B7 Modification Area is grazing, however other land uses also include rural residential, vegetated land, underground mining, and surface mining infrastructure uses associated with the Austar Coal Mine. The villages of Kitchener, Abernethy, Ellalong and Paxton are located within four kilometres to the north and west of the LWB4-B7 Modification Area (refer to **Figure 1.2**). The Watagans National Park is located approximately four kilometres south of the LWB4-B7 Modification Area, the Werakata State Conservation Area is located approximately one kilometre to the north and Werakata National Park is located approximately five kilometres to the north-east.

1.4 Modelling and Assessment Approach

A two dimensional (2D) hydrodynamic model previously developed for Austar Coal Mine to describe the flood behaviour of Quorrobolong Creek and its tributaries was used to assess the potential impacts of the LWB4-B7 Modification. The development of the 2D hydrodynamic model is detailed fully in previous reports, being *Flooding Assessment: Longwalls A3, A4 and A5* (Umwelt, 2007), and *Flood and Drainage Assessment: Stage 3* (Umwelt, 2008). Further flood and drainage assessment of underground mining at the Austar Coal Mine using the 2D hydrodynamic model is documented in *Proposed Stage 2 Extension – Flood and Drainage Assessment for Longwall A5a (Umwelt, 2010), Flood and Drainage Assessment: Stage 3 Modification* (Umwelt, 2011), *Longwall A5a Extension Flood and Drainage Assessment* (Umwelt, 2012), *Austar Coal Mine LWA7-A10 Modification – Stage 3 Area Environmental Assessment* (Umwelt, 2013) and *Flood and Drainage Assessment LWB1-B3 Modification* (Umwelt, 2015).

The previously developed 2D hydrodynamic model was modified to incorporate the predicted subsidence expected as a consequence of the mining operations proposed in the LWB4-B7 Modification. This includes the cumulative impacts of subsidence from the earlier approved mining stages.

Inflows, boundary conditions, roughness categories and values, and the mesh structure adopted for the previous studies undertaken for the Austar Coal Mine (as listed above) were again used to model the likely changes to the flood and drainage responses due to the proposed mining operations. Consistent with previous studies (Umwelt, 2007), the 100% and 1% Annual Exceedance Probability (AEP) design storm events were assessed. In addition, in response to a request from the Office of Environment and Heritage for the LWB1-B3 Modification assessment, the scope of modelling has been expanded to include the 5% AEP storm event and the Probable Maximum Flood (PMF) event. This required modelling the 5% AEP storm event and PMF inflows to the model, re-running the flood model and subsequent lateral adjustments to the flood model mesh (where required) to assess the flood impacts for the PMF event.

Modelling was undertaken to assess the cumulative impact of the proposed modification on flooding and drainage, for the following scenarios:

1. Approved landform (incorporating mining within LWA3-19 and LWB1-B3); and

2. Proposed landform (incorporating all approved underground mining within the Stage 2 and 3 areas, being LWA3 to A19 and LWB1-B3 and the proposed mining of LWB4-B7 as shown on **Figure 1.3**).

The following terminology is subsequently used in this report to refer to the modelling results:

- Approved mining scenario – Approved longwalls A3 to A19 and B1 to B3 in the Bellbird South and Stage 3 area; and

- Proposed mining scenario – Approved longwalls A3 to A19 and B1 to B3 in the Bellbird South and Stage 3 area, plus proposed LWB4-B7.

After running the models, the output data was loaded into a database. From this database the peak flood depths, elevations and velocities were extracted and flood hazard categories generated according to Appendix G of the *Floodplain Development Manual* (NSW Government, 2005).

Flood depth, velocity and flood hazard category maps for the approved mining scenario were prepared for the 100%, 5% and 1% AEP storm events and the PMF event in order to demonstrate the impact of the proposed modification on the existing approved landform. Similar maps were produced for the proposed mining scenario in order to demonstrate the cumulative impacts of the proposed modification (refer to **Section 3.0**).

Based on the modelling outcomes, the following potential impacts of the proposed modification were assessed against approved impacts (refer to **Section 3.0**):

- changes to flood depths (in channel and out of channel)

- changes to freeboard at dwellings

- impacts on scouring and erosion due to changes in flow velocities

- flood hazard categories for dwellings and private property access routes and

- changes to flood regimes, including impacts on flood prone land, creek channels, flow paths and remnant ponding.

1.4.1 Design flood estimation

Australian Rainfall and Runoff (AR&R) is a national guideline document, accompanied by data and software, that can be used for the estimation of design flood characteristics in Australia. The most recent updates to the AR&R guidelines were published in 2016 (version 4). Historically, the AR&R 1987 guidelines (version 3) and terminology have been used to estimate the design inflows to the 2D model for Austar Coal Mine. To maintain consistency with previous reports and enable comparison to previous models the terminology and design flood estimation methodology as used in the AR&R 1987 guidelines have been used in this assessment to develop the 1%, 5% and 100% AEP design rainfall events. The intensity-frequency-duration (IFD) data was sourced from the Bureau of Meteorology (BOM) 2016 Rainfall IFD Data System for the 5% AEP event and from the 1987 Rainfall IFD Data System for the 1% and 100% AEP events. The 1987 data was used for the 1% and 100% AEP events to maintain consistency with previous reports. As the 5% AEP storm event has not previously been modelled the updated 2016 BOM IFD data was used for this storm event only.

The PMF event was modelled using the Probable Maximum Precipitation (PMP). The PMP can be estimated for any catchment in Australia using three generalised methods:

1. Generalised Short Duration Method (GSDM) – for durations up to 6 hours and areas up to 1,000 km^2.

2. Revised Generalised Tropical Storm Method (GTSMR) – for durations up to 120 hours and areas up to 150,000 km^2 in the regions of Australia where tropical storms are the source of the greatest depths of rainfall.

3. Generalised Southeast Australia Method (GSAM) – for durations up to 96 hours and areas up to 100,000 km^2 in the region of Australia where tropical storms are not the source of the greatest depths of rainfall.

All three methods apply to Austar Coal Mine due to the mine being located in the GSAM – GTSMR Coastal Transition Zone, and Quorrobolong Creek having a catchment area less than 1,000 km^2. Each method was applied to determine the maximum PMP. The resulting rainfall depths were 760 mm for GSDM; 880 mm for GSAM (36 hours); and 980 mm for GTSMR (48 hours). Both the GSAM and GTSMR events were modelled to determine which event type created the maximum flood depths. The modelling indicated that the GTSMR created the maximum flood depths and subsequently this PMP event was used for the modelling of and assessment of impacts for the PMF event.

2.0 Subsidence Predictions

In order to model the potential impacts that the proposed mining operations could have on the flood response of the Quorrobolong Valley, predictions of the likely subsidence are required. Subsidence predictions provided by MSEC (2017) for the proposed mining operations were used for this purpose. Subsidence monitoring completed within the previously extracted Stage 2, Stage 3 and LWB1-B3 mining areas indicates that predicted subsidence provides a reasonable, if not slightly conservative prediction for subsidence at the Austar Coal Mine. Therefore, flood modelling was conducted using maximum predicted subsidence only.

The subsidence predictions indicate that the landform after extraction of LWB1 to LWB7 is estimated to be subsided by up to 1.35 metres, and subsidence is predicted to occur as a broad, shallow bowl as shown in **Figure 2.1**.

Predicted subsidence impacts on the landform will occur within the vicinity of Quorrobolong Creek, the unnamed tributary of Quorrobolong Creek (refer to **Figure 2.1**) and its associated culvert under Sandy Creek Road, and the 1st order drainage line and ponded area adjacent to Quorrobolong Creek (refer to **Section 1.3**).

The predicted subsidence has the potential to change the flooding and drainage behaviour of the area. This report aims to quantify these changes and assess the potential impacts to the surrounding area, with regard to both natural and built features.

The predicted landform following subsidence is shown on **Figure 2.2**.

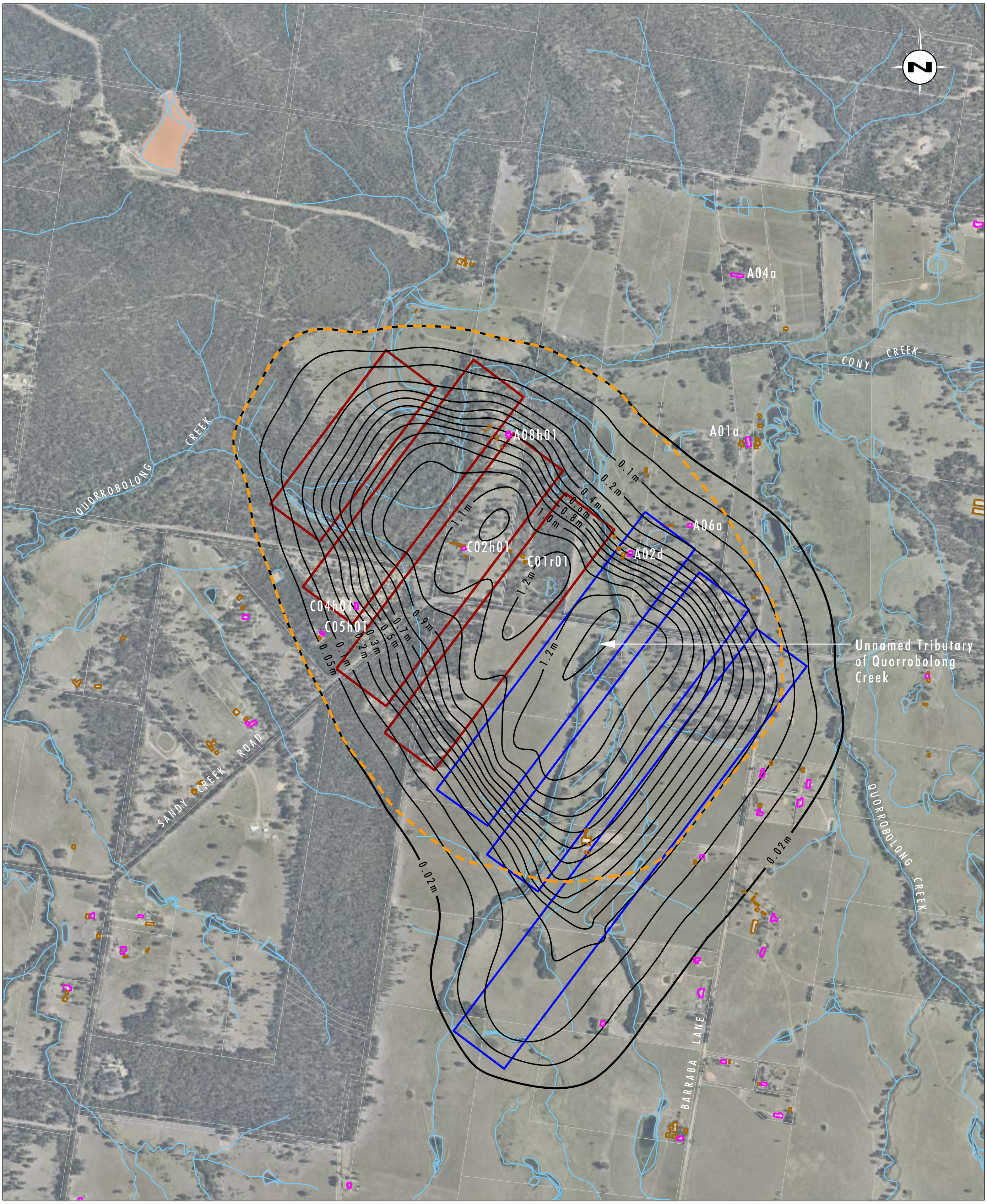


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017), MSEC (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Approved LWB1-B3 Longwall Panels
- Subsidence Contour
- Dwelling
- Other Structure

FIGURE 2.1

Predicted Cumulative Subsidence - LWB1-B7

File Name (A4): R03/3900_032.dgn
20170515 14.57

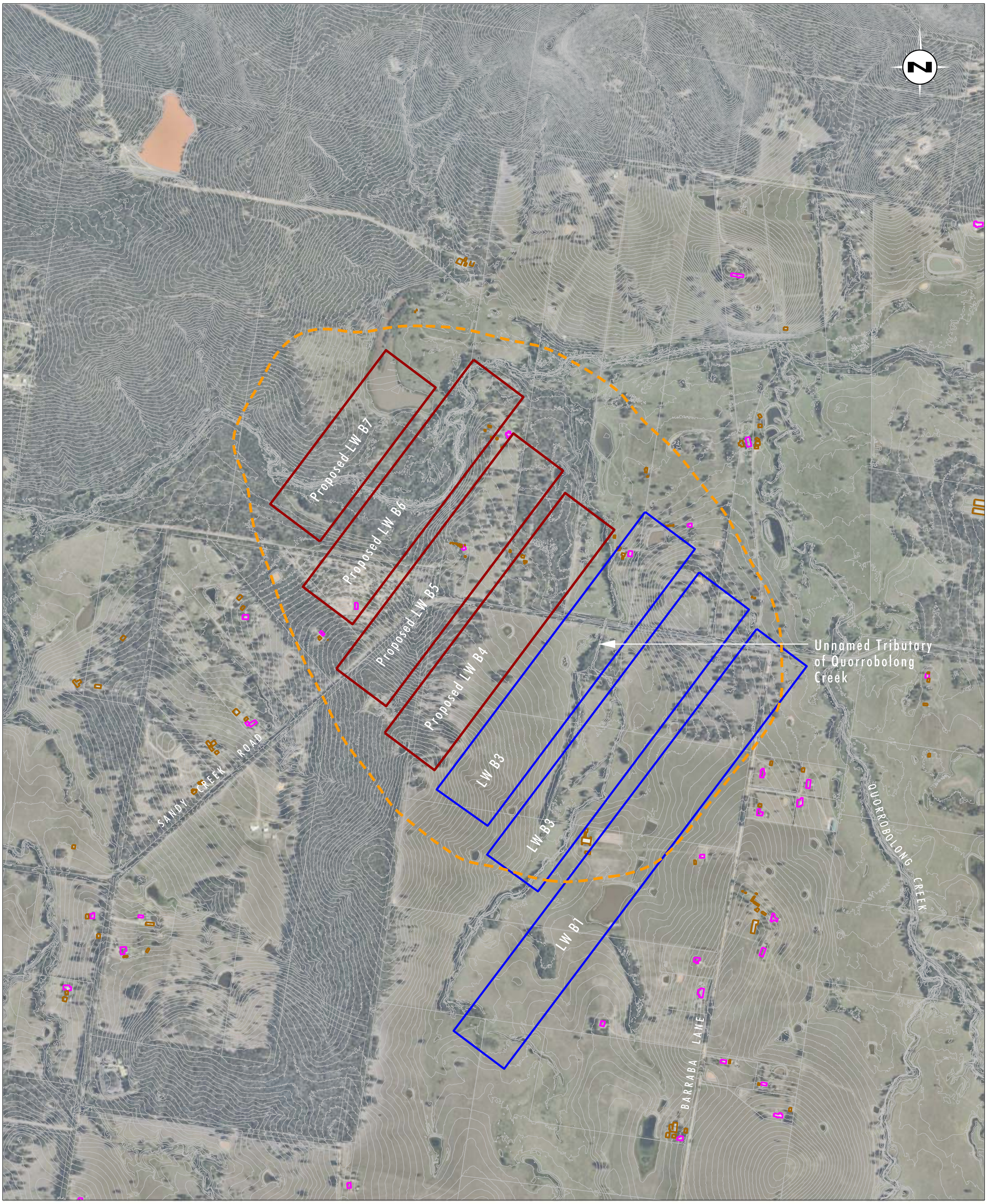


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2015), Cessnock LEP (2011), MSEC (2017)
Note: 1m Contours Interval

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Approved LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

FIGURE 2.2

Predicted Subsided Landform - LWB1-B7

3.0 Model Outcomes

3.1 Key Modelling Outcomes

The modelling indicates that the potential impacts on flooding and drainage associated with LWB4-B7 are generally limited in extent to the LWB4-B7 Modification Area. A detailed description of the outcomes of the flood and drainage assessment is included in **Sections 3.2** to **3.6**, with a summary of impacts described below.

Modelling indicates that mining of LWB4-B7 will result in increased flood depths and associated flow velocities where the longwalls intersect the central drainage channels of the unnamed tributary of Quorrobolong Creek and the main channel of Quorrobolong Creek downstream of the junction with Cony Creek. In addition, there are predicted increases and decreases in out of channel flood depths above the southern end of LWB6 and LWB7 in the catchment of Quorrobolong Creek and above the northern end of LWB4 in the catchment of the unnamed tributary.

Analysis of the flood modelling results indicate no changes will occur to the flood hazard category at Sandy Creek Road during the 1% AEP or PMF storm event with the road remaining impassable to vehicles during this event, however the analysis also indicates that the flood hazard category will decrease from the "vehicles unstable" category to "walking and vehicle access" for the 5% AEP storm event.

There are only minor predicted impacts on freeboards at dwellings and all dwellings remain flood free for all modelled storm events and there are no predicted impacts to private access routes.

There are only minor impacts predicted to remnant ponding with the analysis indicating ponding up to 0.5 metres deeper on the 1st order drainage line south of Quorrobolong Creek extending over an area of approximately 1.5 hectares, approximately 100 metres to 125 metres further upstream than in the approved scenario.

3.1.1 Detailed Model Results

Flood depth, velocity and flood hazard category maps for the current approved mining scenario for the 100%, 5%, 1% AEP storm events and the PMF event are provided in **Appendix A.**

Figures showing predicted flooding behaviour as a result of mining LWB4-B7 are provided in **Appendix B** which contains the following:

- Figures B1 to B4 describe the maximum modelled **flood depths** for the 100%, 5%, 1% AEP and PMF storm events with the maximum predicted subsidence for the four modelled scenarios.
- Figures B5 to B8 describe the maximum modelled **velocities** for the 100%, 5%, 1% AEP and PMF storm events with the maximum predicted subsidence for the four modelled scenarios.
- Figures B9 to B12 describe the maximum modelled **flood hazard categories** for the 100%, 5%, 1% AEP and PMF storm events with the maximum predicted subsidence for the four modelled scenarios.
- Figures B13 and B14 shows **flow hydrographs** extracted from the modelling for the 100%, 5%, 1% AEP and PMF storm events on Quorrobolong Creek downstream of the proposed LWB4 to B7 Modification Area.

- Figures B15 and B16 show the locations of and the profiles of Quorrobolong Creek and the Unnamed Tributary of Quorrobolong Creek.

3.2 Flood Depths

3.2.1 Within Channel

As shown on Figures B1 to B4, predicted impacts on flood depths are mostly limited to within the LWB4-B7 Modification Area. Modelling predicts increases to flood depths within the channel of Quorrobolong Creek, in particular downstream of the Cony Creek junction for all modelled storm events (100%, 5%, 1% AEP and PMF). Along the unnamed tributary, the modelling predicts increases in channel flood depths within the LWB4-B7 Modification Area in areas both upstream and downstream of Sandy Creek Road in all modelled storm events (100%, 5%, 1% AEP and PMF).

The maximum and average modelled increase in flood depths for Quorrobolong Creek and its unnamed tributary are summarised in **Table 3.1** and described in further detail below.

Table 3.1 Maximum and Average Modelled Increase in Flood Depth within Channel

Watercourse	Maximum Modelled Increase in Flood Depth (m)				Average Modelled Increase in Flood Depth (m)			
	100% AEP Storm Event	5% AEP Storm Event	1% AEP Storm Event	PMF Storm Event	100% AEP Storm Event	5% AEP Storm Event	1% AEP Storm Event	PMF Storm Event
Quorrobolong Creek upstream of Cony Creek junction	0.01	0.008	0.006	0.007	0.003	0.002	0.002	0.003
Quorrobolong Creek downstream of Cony Creek junction	0.50	0.78	0.82	0.90	0.21	0.35	0.36	0.40
Unnamed tributary of Quorrobolong Creek	0.17	0.33	0.34	0.35	0.08	0.10	0.09	0.11

There are minimal changes in peak flood depths predicted within the channel of Quorrobolong Creek upstream of the Cony Creek junction, with the maximum modelled increase in peak flood depths being 0.01 metres for the 100% AEP storm event (as shown in **Table 3.1**).

The modelled flood response indicates that the proposed modification will increase peak flood depths in Quorrobolong Creek downstream of the Cony Creek junction for all modelled storm events as outlined below:

- Increases in peak flood depths extend approximately 1000 metres downstream of the southern end of the Northern farm dam water body during the 100% AEP storm event. The maximum modelled increase for the 100% AEP storm event is approximately 0.50 metres and occurs at the point where the Quorrobolong Creek channel crosses the centreline of LWB6 in an area where existing modelled peak flood depths are in the order of 4 metres. The average modelled increase in flood depths during the 100% AEP storm event within the channel is approximately 0.21 metres.

- Increases in peak flood depths extend approximately 1020 metres downstream of the southern end of the Northern farm dam water body during the 5% AEP storm event. The maximum modelled increase for the 5% AEP storm event is approximately 0.78 metres and occurs at the point where the Quorrobolong Creek channel crosses the centreline of LWB6 in an area where existing modelled peak flood depths are in the order of 4.5 metres. The average modelled increase in flood depths during the 5% AEP storm event within the channel is approximately 0.35 metres.

- Increases in peak flood depths extend approximately 1050 metres downstream of the southern end of the Northern farm dam water body during the 1% AEP storm event. The maximum modelled increase for the 1% AEP storm event is approximately 0.82 metres and occurs at the point where the Quorrobolong Creek channel crosses the centreline of LWB6 in an area where existing modelled peak flood depths are in the order of 5 metres. The average modelled increase in flood depths during the 1% AEP storm event within the channel is approximately 0.36 metres.

- Increases in peak flood depths extend approximately 1100 metres downstream of the southern end of the Northern farm dam water body during the PMF event. The maximum modelled increase for the PMF event is approximately 0.90 metres and occurs at the point where the Quorrobolong Creek channel crosses the centreline of LWB6 in an area where existing modelled peak flood depths are in the order of 6 metres. The average modelled increase in flood depths during the PMF event within the channel is approximately 0.4 metres.

The modelled flood response indicates that the proposed modification will increase peak flood depths in the unnamed tributary of Quorrobolong Creek for all modelled storm events as outlined below:

- Increases in peak flood depths extend from the junction with Quorrobolong Creek to approximately 120 metres upstream of Sandy Creek Road during the 100% AEP storm event. The maximum modelled increase for the 100% AEP storm event is approximately 0.17 metres and occurs 360 metres upstream of junction with Quorrobolong Creek in an area where existing modelled peak flood depths are in the order of 1.4 metres. The average modelled increase in flood depths during the 100% AEP storm event within the channel is approximately 0.08 metres.

- Increases in peak flood depths from the junction with Quorrobolong Creek to approximately 50 metres upstream of Sandy Creek Road for the 5% AEP storm event. The maximum modelled increase for the 5% AEP storm event is approximately 0.33 metres and occurs 360 metres upstream of junction with Quorrobolong Creek in an area where existing modelled peak flood depths are in the order of 1.8 metres. The average modelled increase in flood depths during the 5% AEP storm event within the channel is approximately 0.10 metres.

- Increases in peak flood depths extend from the junction with Quorrobolong Creek to approximately the middle of LWB3 for the 1% AEP storm event. The maximum modelled increase for the 1% AEP storm event is approximately 0.34 metres and occurs 360 metres upstream of junction with Quorrobolong Creek in an area where existing modelled peak flood depths are in the order of 2 metres. The average modelled increase in flood depths during the 1% AEP storm event within the channel is approximately 0.09 metres.

- Increases in peak flood depths extend from the junction with Quorrobolong Creek to approximately the middle of LWB3 for the PMF event. The maximum modelled increase for the PMF event is approximately 0.35 metres and occurs 360 metres upstream of junction with Quorrobolong Creek in an area where existing modelled peak flood depths are in the order of 2.7 metres. The average modelled increase in flood depths during the PMF event within the channel is approximately 0.11 metres.

3.2.2 Out of Channel

The maximum and average modelled increase to out of channel flood depths adjacent to Quorrobolong Creek and its unnamed tributary are summarised in **Table 3.2** and described in further detail below.

Table 3.2 Maximum and Average Modelled Increase in Out of Channel Flood Depths

Watercourse	Maximum Modelled Increase in Flood Depth (m)				Average Modelled Increase in Flood Depth (m)			
	100% AEP Storm Event	5% AEP Storm Event	1% AEP Storm Event	PMF Storm Event	100% AEP Storm Event	5% AEP Storm Event	1% AEP Storm Event	PMF Storm Event
Quorrobolong Creek upstream of Cony Creek junction	0.04	0.03	0.03	0.09	0.005	0.004	0.004	0.004
Quorrobolong Creek downstream of Cony Creek junction	0.97	0.89	0.89	0.94	0.28	0.32	0.34	0.38
Unnamed tributary of Quorrobolong Creek	0.25	0.38	0.42	0.71	0.07	0.09	0.09	0.11

As shown in **Table 3.2**, modelling indicates that there will be minimal changes in the peak and average flood depths in Quorrobolong Creek upstream of the Cony Creek junction for all modelled storm events for the proposed modification when compared to the approved mine plan.

The modelled flood response indicates that the proposed modification will increase peak out of channel flood depths in Quorrobolong Creek for all modelled storm events as outlined below:

- Out of channel flooding for Quorrobolong Creek downstream of the Cony Creek junction within the LWB4-B7 Modification Area will increase on average by 0.28 metres in depth for an extent of approximately 1000 metres parallel to the main creek channel in the 100% AEP storm event where the channel passes over LWB6 and LWB7. This increase in out of channel flooding in this portion of the creek is associated with an average decrease (in the order of 0.26 metres) in out of channel flooding encompassing the Northern farm dam water body to the north of LWB6 and LWB7.

- Out of channel flooding for Quorrobolong Creek downstream of the Cony Creek junction within the LWB4-B7 Modification Area will typically on average by0.32 metres in depth for an extent of approximately 1020 metres parallel to the main creek channel in the 5% AEP storm event where the channel passes over LW6 and LW7. This increase in out of channel flooding in this portion of the creek is associated with an average decrease (in the order of 0.24 metres) in out of channel flooding encompassing the Northern farm dam water body to the north of LW 6 and LW7.

- In the 1% AEP storm event modelling indicates out of channel flooding for Quorrobolong Creek downstream of the Cony Creek junction within the LWB4-B7 Modification Area will increase on average by 0.34 metres in depth where the channel passes over LW6 and LW7 for an extent of approximately 1050 metres parallel to the creek. This increase in out of channel flooding in this portion of the creek is associated with an average decrease (in the order of 0.23 metres) in out of channel flooding encompassing the Northern farm dam water body to the north of LW 6 and LW7.

- In the PMF storm event modelling indicates out of channel flooding for Quorrobolong Creek downstream of the Cony Creek junction within the LWB4-B7 Modification Area will increase on average by 0.38 metres in depth for an extent of approximately 1100 metres parallel to the main creek channel where the channel passes over LW6 and LW7. This increase in out of channel flooding in this portion of the creek is associated with an average decrease (in the order of 0.19 metres) in out of channel flooding encompassing the Northern farm dam water body to the north of LW6 and LW7.

The modelled flood response indicates that the proposed modification will increase peak out of channel flood depths in the unnamed tributary of Quorrobolong Creek for all modelled storm events as outlined below:

- Adjacent to the unnamed tributary of Quorrobolong Creek, modelling indicates that out of channel flooding during the 100% AEP storm event for the approved mining scenario is typically in the order of 0.30 metres. With the proposed modification, out of channel flooding is predicted to increase on average 0.07 metres (extending approximately 850 metres downstream of the central section of LWB3) adjacent to the unnamed tributary of Quorrobolong Creek, and to decrease on average by approximately 0.05 metres (extending approximately 500 metres upstream of the central section of LWB3). The modelled changes to out of channel flooding are typically predicted to occur over LWB2 to LWB4. A minor change to out of channel flooding is also predicted over the southern extent of LWB1.

- During the 5% AEP storm event for the approved mining scenario, modelling indicates that out of channel flooding adjacent to the unnamed tributary of Quorrobolong Creek is typically in the order of 0.50 metres. With the proposed modification, out of channel flooding is predicted to increase on average 0.09 metres (extending approximately 850 metres downstream of the central section of LWB3) adjacent to the unnamed tributary of Quorrobolong Creek, and to decrease on average by approximately 0.07 metres (extending approximately 900 metres upstream of the central section of LWB3). The modelled changes to out of channel flooding are typically predicted to occur over LWB2 to LWB4. A minor increase to out of channel flooding is also predicted over the southern extent of LWB1.

- During the 1% AEP storm event for the approved mining scenario, modelling indicates that out of channel flooding adjacent to the unnamed tributary of Quorrobolong Creek is typically in the order of 0.55 metres. With the proposed modification, out of channel flooding is predicted to increase on average 0.09 metres (extending approximately 850 metres downstream of the central section of LWB3) adjacent to the unnamed tributary of Quorrobolong Creek, and to decrease on average by approximately 0.07 metres (extending approximately 950 metres upstream of the central section of LWB3). The modelled changes to out of channel flooding are typically predicted to occur over LWB2 to LWB4. A minor increase to out of channel flooding is also predicted over the southern extent of LWB1.

- During the PMF storm event for the approved mining scenario, modelling indicates that out of channel flooding adjacent to the unnamed tributary of Quorrobolong Creek is typically in the order of 0.75 metres. With the proposed modification, out of channel flooding is predicted to increase on average 0.11 metres (extending approximately 850 metres downstream of the central section of LWB3) adjacent to the unnamed tributary of Quorrobolong Creek, and to decrease on average by approximately 0.07 metres (extending approximately 950 metres upstream of the central section of LWB3). The modelled changes to out of channel flooding are typically predicted to occur over LWB2 to LWB4. An increase (in the order of 0.06 metres) to out of channel flooding is also predicted for an area extending approximately 400 m downstream of the southern end of LWB1.

3.2.3 At Dwellings

The modelling indicates that the maximum predicted flood extent for the 1% AEP flood event and the PMF event does not result in flooding of any dwellings within the LWB4-B7 Modification Area for the approved mining scenario. The flood planning level (FPL) is defined as the 1% AEP flood event plus 500 millimetres freeboard. The PMF flood event is typically used for emergency planning. As such, the modelled impacts of the 1% AEP flood event and the PMF event on the freeboard levels for the dwellings lying within and adjacent to the LWB4-B7 Modification Area are listed in **Table 3.3**. A further discussion of flood hazard categories at dwellings and access routes is provided in **Section 3.4.**

In summary, the modelling of the impacts of subsidence on flooding during the 1% AEP flood event and PMF event presented in **Table 3.3** indicates that for the proposed scenario no dwellings will be flooded above floor level.

For the 1% AEP flood event, no dwelling has a freeboard reduced to less than 500 millimetres, therefore all dwellings have sufficient freeboard to meet flood planning level requirements.

The PMF event results are provided in **Table 3.3** for the context of emergency management as a flood refuge. As the floor level of all dwellings will remain free from flooding, the proposed modification will not impact the ongoing suitability of these dwellings as a flood refuge for occupants. It is noted that in the PMF event, the freeboard for dwelling A08h01 is likely to be reduced below 500 millimetres under the proposed scenario, however the dwelling will remain flood free during the PMF event and has sufficient freeboard to meet the flood planning level requirements (1% AEP plus 500 millimetres freeboard).

Table 3.3 Predicted Freeboard, 1% AEP flood event and PMF event

Dwelling ID	Structure	Freeboard 1% AEP Flood Event (m)		Freeboard PMF Event (m)	
		Approved mining scenario	Proposed mining scenario	Approved mining scenario	Proposed mining scenario
A06a	Residence	5.811	5.882	4.955	4.988
B12h01	Residence	9.414	9.400	9.096	9.090
B11h01	Residence	2.872	2.873	2.636	2.636
B09h01	Residence	6.108	6.099	5.883	5.875
A02c	Residence	1.951	2.210	1.959	1.629
B10h01	Residence	1.893	1.893	1.747	1.746
B04h03	Residence	2.483	2.482	1.890	1.889
A08h01	Residence	1.342	1.239	0.642	0.162
C01r01	Residence	4.199	2.815	3.814	2.667
C02h01	Residence	9.092	8.162	8.013	6.997

Legend	
1	Not flooded pre-mining, predicted to flood
2	Flooded pre-mining, predicted higher flooding
3	Flooded pre-mining, predicted lower flooding
4	Not flooded pre-mining, predicted more freeboard (i.e. a lower flood water height at residence)
5	Not flooded pre-mining, predicted less freeboard (i.e. a higher flood water height at residence)
6	No change

3.3 Flow Velocities

3.3.1 Within Channel

The maximum and average modelled increases in flow velocities for the 100%, 5% and 1% AEP storm events and PMF event within the main channel of Quorrobolong Creek and the unnamed tributary of Quorrobolong Creek are presented in **Table 3.4.** The range (minimum and maximum) of modelled flow velocities for the 100%, 5% and 1% AEP storm events and PMF event within channel are presented in **Table 3.5**.

Table 3.4 Maximum and Average Modelled Increase in Flow Velocity within Channel

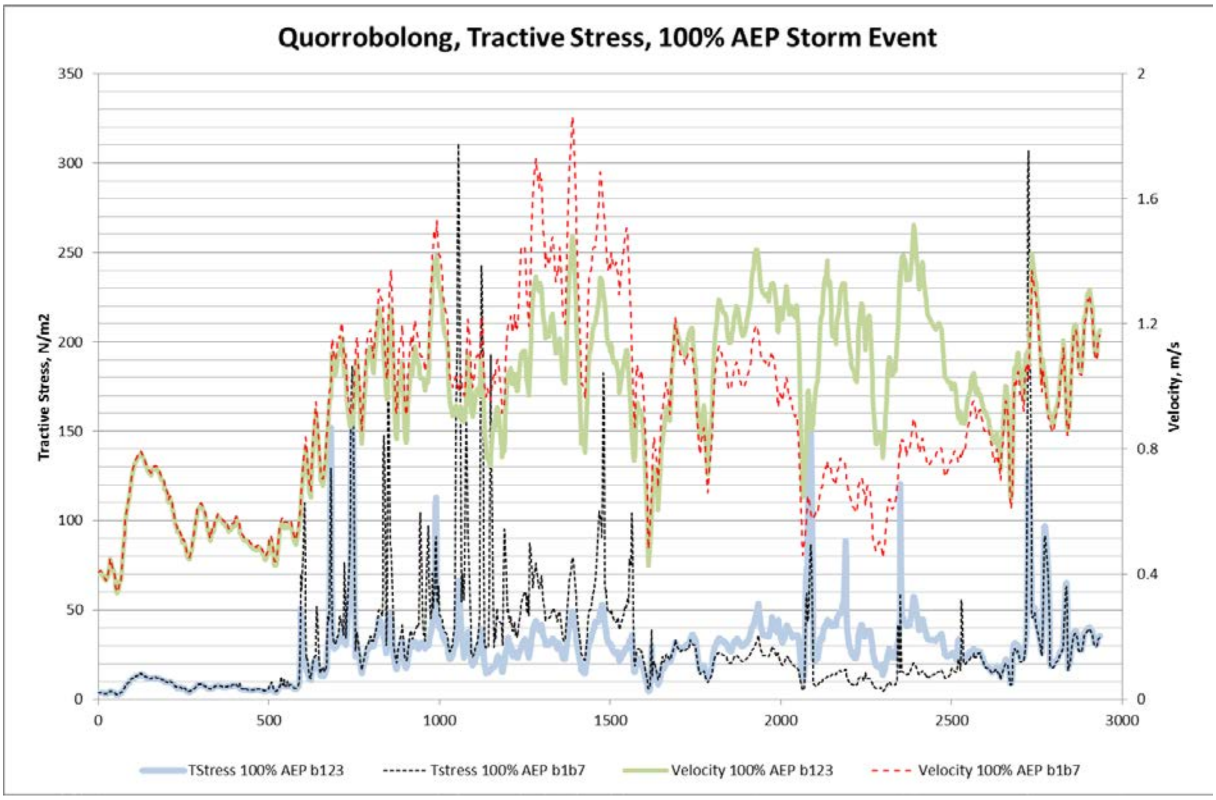
Watercourse	Maximum Modelled Velocity Increase (m/s)				Average Modelled Velocity Increase (m/s)				Average Modelled Velocity Decrease (m/s)			
	100% AEP	5% AEP	1% AEP	PMF	100% AEP	5% AEP	1% AEP	PMF	100% AEP	5% AEP	1% AEP	PMF
Quorrobolong Creek upstream of Cony Creek junction	0.01	0.01	0.01	0.02	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.009
Quorrobolong Creek downstream of Cony Creek junction	0.44	0.61	0.65	0.68	0.08	0.10	0.11	0.11	0.18	0.19	0.19	0.16
Unnamed tributary of Quorrobolong Creek	0.35	0.36	0.36	0.42	0.05	0.08	0.08	0.09	0.06	0.08	0.09	0.11

Table 3.5 Ranges in Flow Velocity within Channel

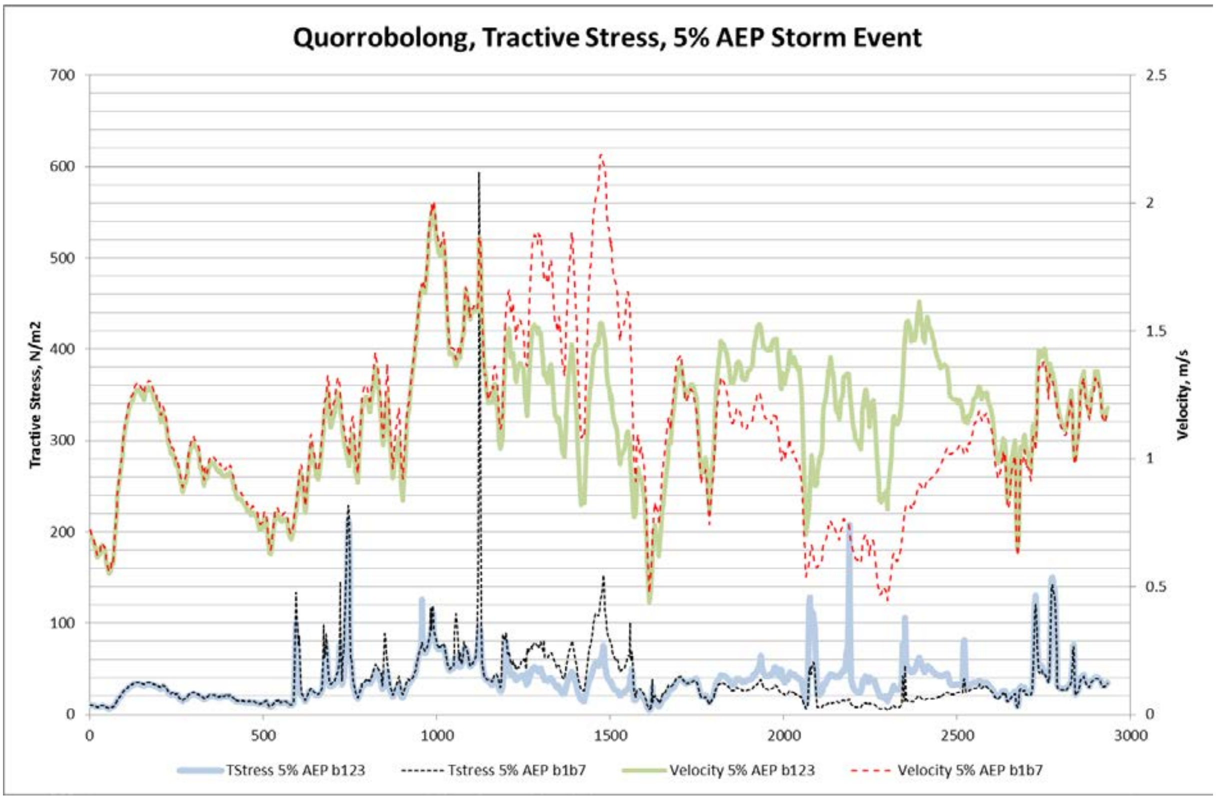
Watercourse	Velocity Ranges (m/s), Approved				Velocity Ranges (m/s), Proposed			
	100% AEP	5% AEP	1% AEP	PMF	100% AEP	5% AEP	1% AEP	PMF
Quorrobolong Creek upstream of Cony Creek junction	0.14 - 1.28	0.18 - 1.86	0.19 - 1.91	0.27 - 2.07	0.15 - 1.29	0.19 - 1.86	0.19 - 1.91	0.27 - 2.07
Quorrobolong Creek downstream of Cony Creek junction	0.32 - 1.41	0.47 - 1.73	0.49 - 1.79	0.58 - 2.02	0.30 - 1.56	0.41 - 1.91	0.41 - 1.99	0.51 - 2.17
Unnamed tributary of Quorrobolong Creek	0.12 - 1.62	0.19 - 2.05	0.22 - 2.19	0.33 - 2.44	0.11 - 1.69	0.19 - 2.13	0.22 - 2.17	0.34 - 2.42

3.3.1.1 Channel Stability

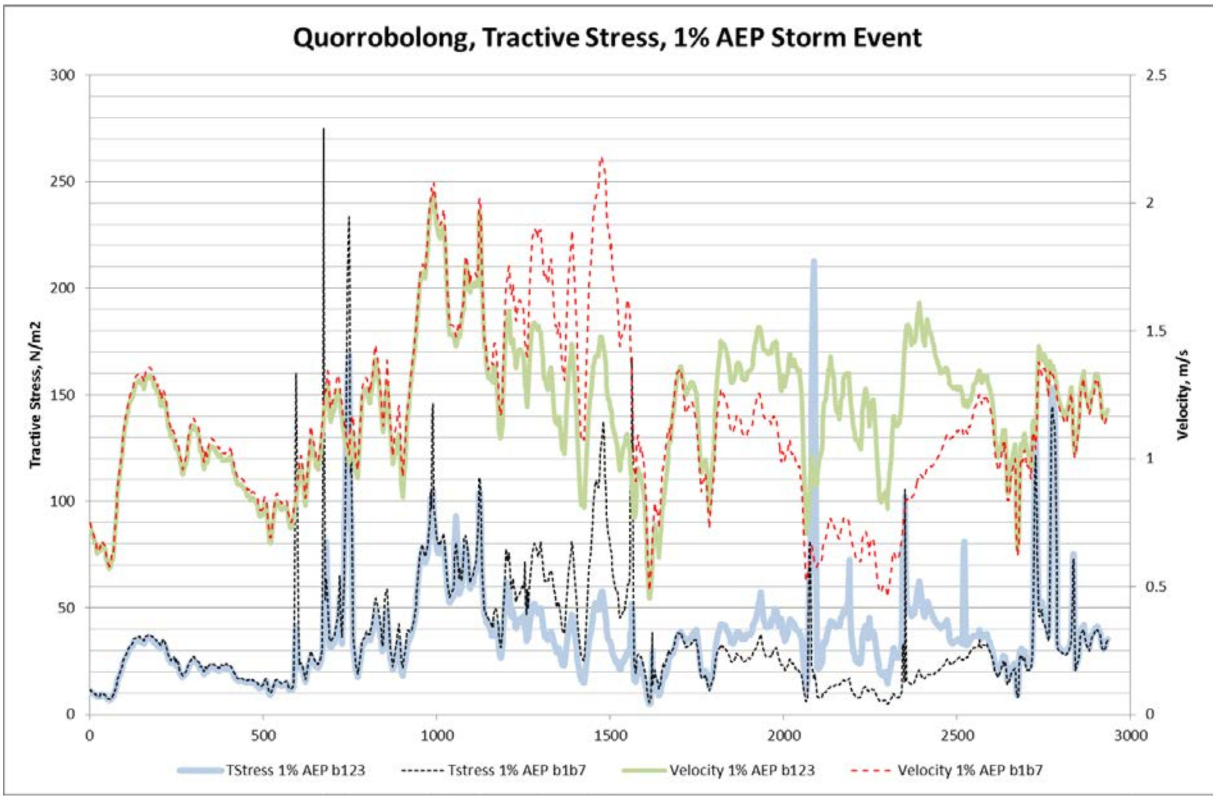
Channel stability can be impacted by flow velocities and bed shear stresses (tractive stress). Graphs displaying the relationship between velocity and tractive stress for the 100% AEP, 5% AEP, 1% AEP flood events and the PMF event for Quorrobolong Creek are shown in **Graph 3.1** to **Graph 3.4.** Graphs displaying the relationship between velocity and tractive stress for the 100% AEP, 5% AEP, 1% AEP flood events and the PMF event for the unnamed tributary of Quorrobolong Creek are shown in **Graph 3.5** to **Graph 3.8**.



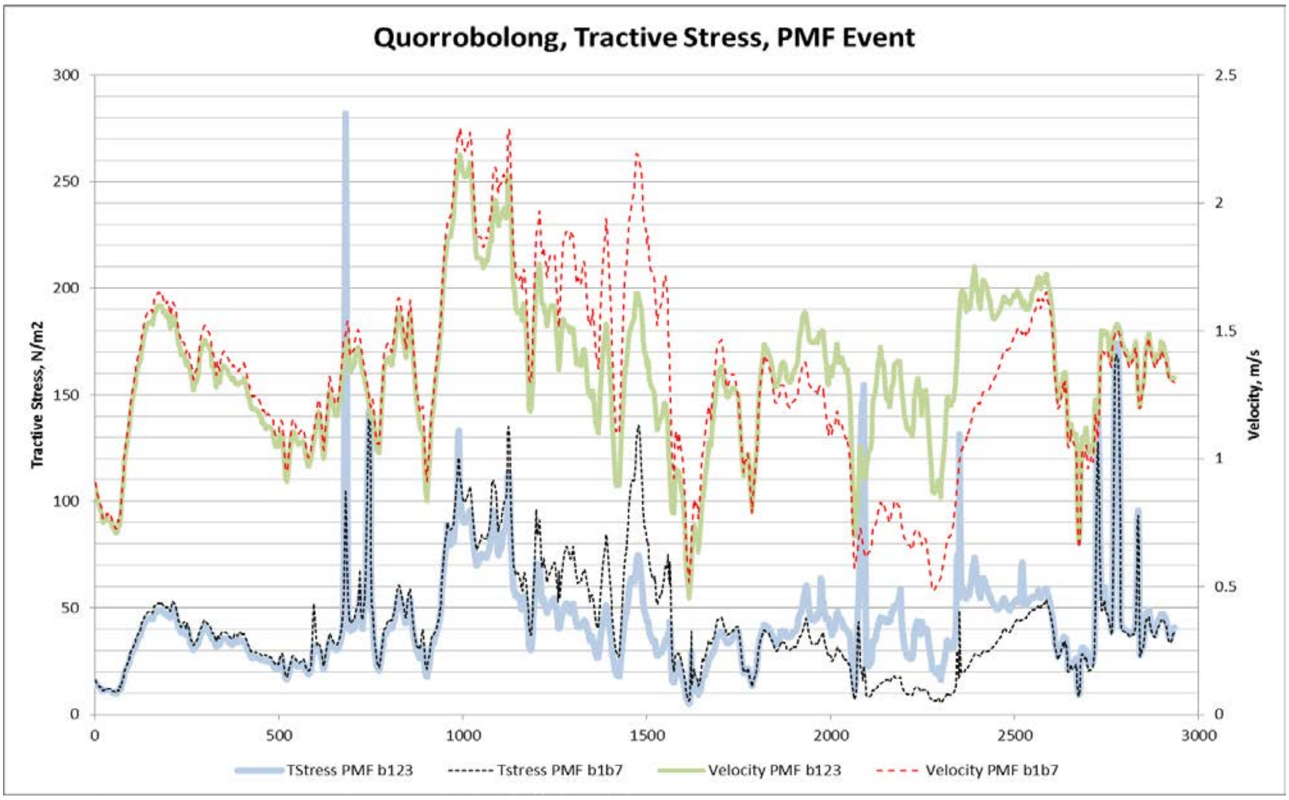
Graph 3.1 Tractive Stress and Velocity Relationship Quorrobolong Creek – 100% AEP storm event.



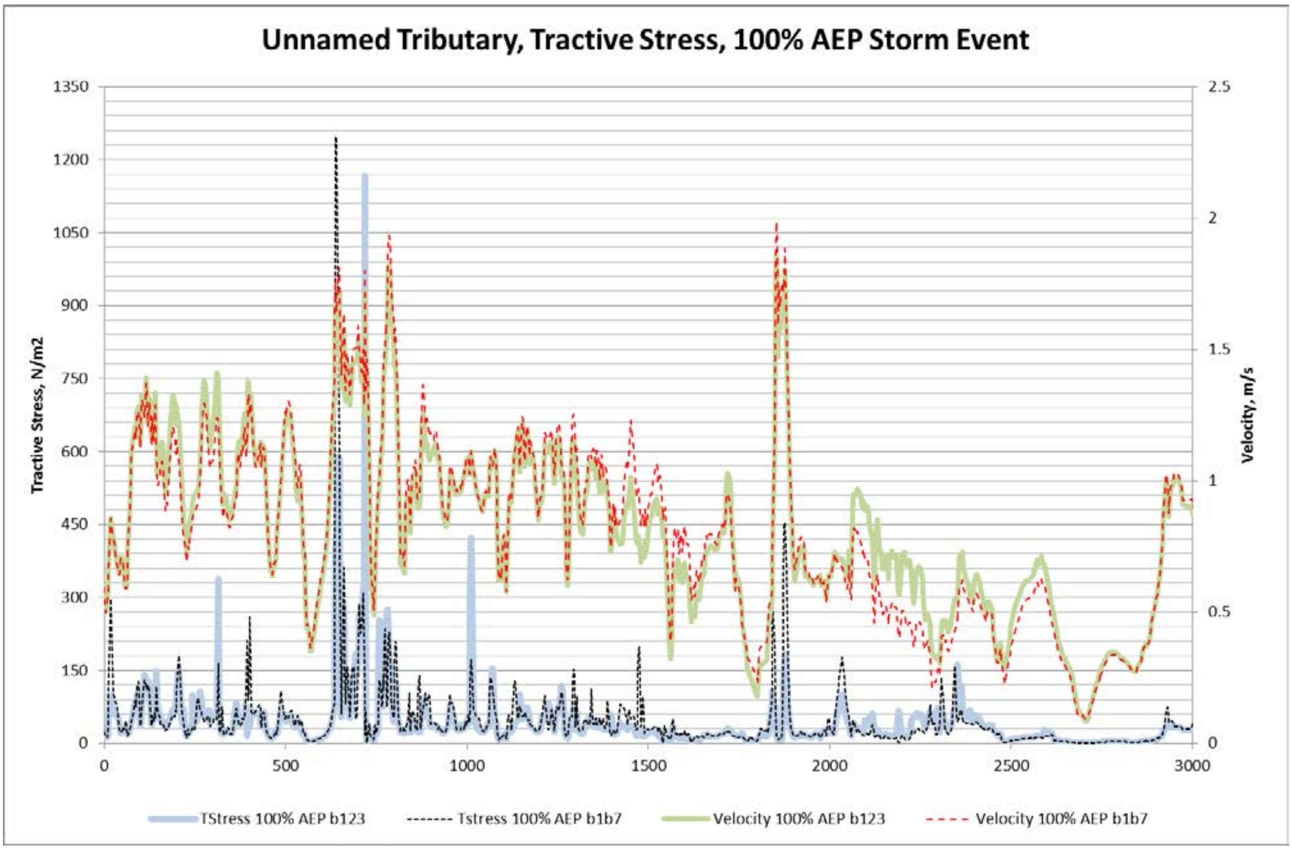
Graph 3.2 Tractive Stress and Velocity Relationship Quorrobolong Creek – 5% AEP storm event.



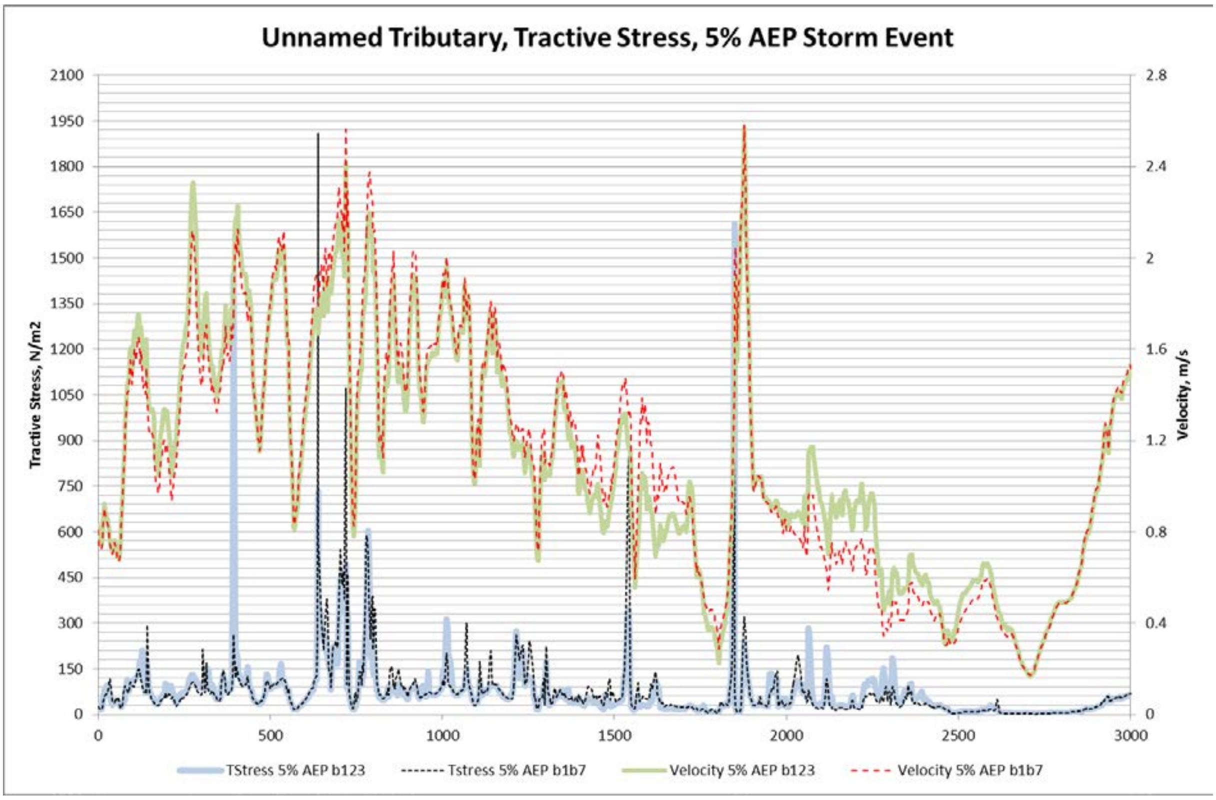
Graph 3.3 Tractive Stress and Velocity Relationship Quorrobolong Creek – 1% AEP storm event.



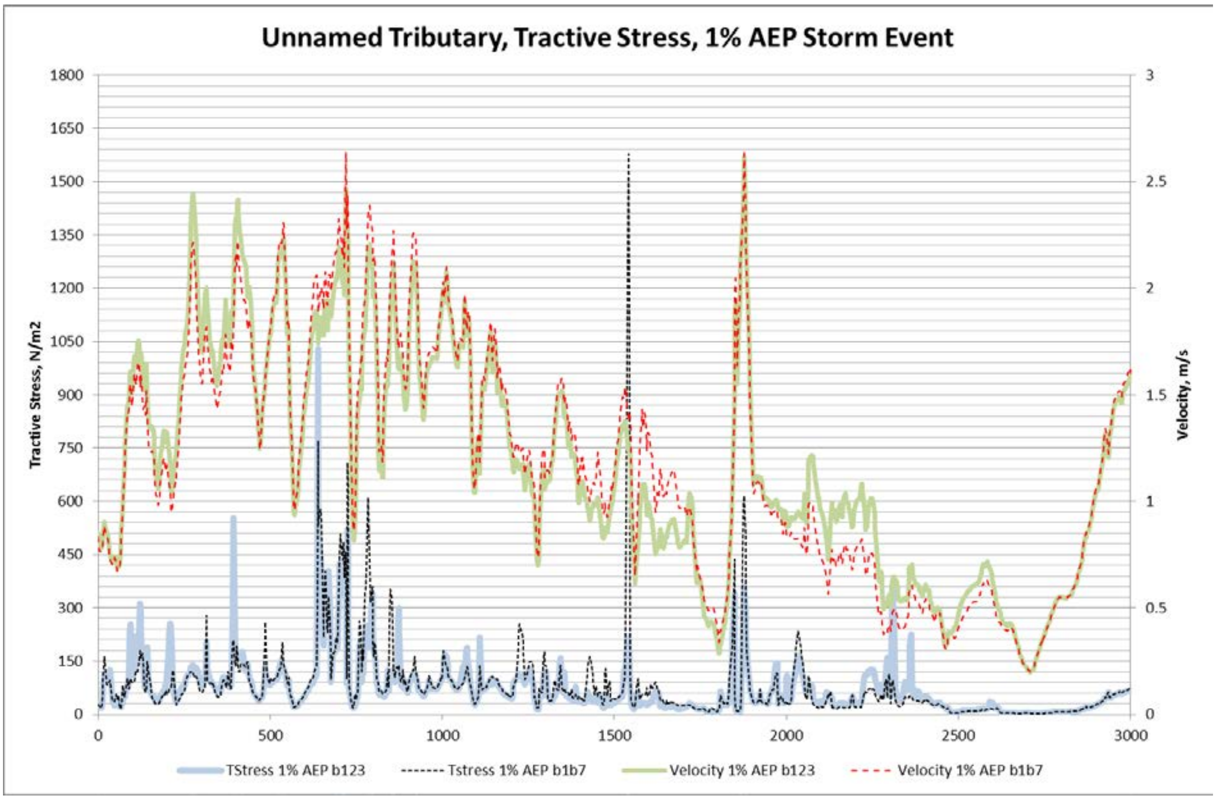
Graph 3.4 Tractive Stress and Velocity Relationship Quorrobolong Creek – PMF event.



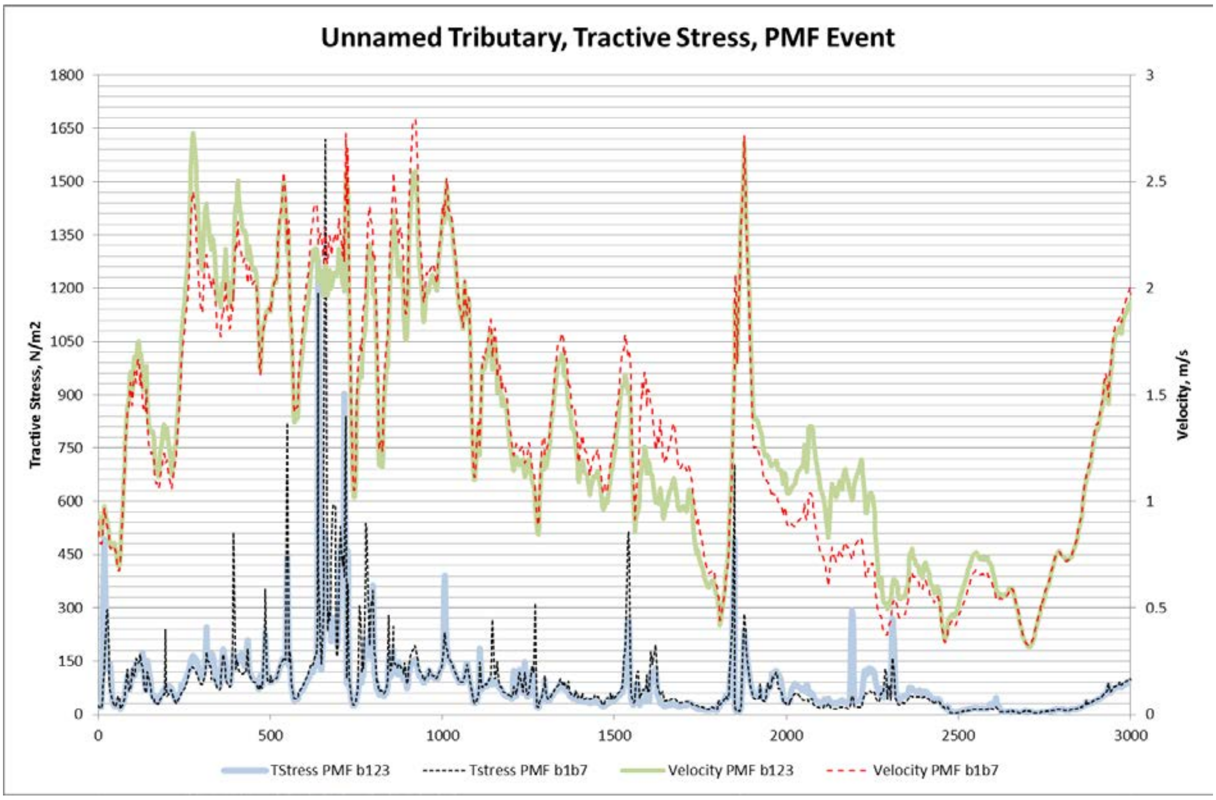
Graph 3.5 Tractive Stress and Velocity Relationship Unnamed Tributary of Quorrobolong Creek – 100% AEP storm event.



Graph 3.6 Tractive Stress and Velocity Relationship Unnamed Tributary of Quorrobolong Creek – 5% AEP storm event.



Graph 3.7 Tractive Stress and Velocity Relationship Unnamed Tributary of Quorrobolong Creek – 1% AEP storm event.



Graph 3.8 Tractive Stress and Velocity Relationship Unnamed Tributary of Quorrobolong Creek –PMF event.

As displayed in **Graphs 3.1** to **3.8** and **Table 3.4** and **3.6**, the modelling indicates that with the proposed modification the flow velocities in Quorrobolong Creek and the unnamed tributary will have localised increases and decreases for all modelled storm events. Modelling also indicates that the absolute maximum and minimum peak flow velocities along both Quorrobolong Creek and the unnamed tributary with the proposed modification will remain within similar ranges to those modelled for both the approved mining scenario and the proposed mining scenario.

Based on review of site inspection photographs and analysis of the modelling results contained within **Graphs 3.1 to 3.8**, the calculated tractive stresses for the proposed modification lie within the ranges modelled for Quorrobolong Creek and the unnamed tributary for the approved mining scenario. As such it is considered that the changes to velocities and tractive stresses are within the natural capacity / variability of the creek system and is unlikely to result in scouring of the channel.

To ensure no impacts from the proposed modification occur it is recommended that a channel stability monitoring program of the reaches of the creek systems where velocity and tractive stress changes are predicted via modelling is implemented.

3.3.2 Out of Channel

The maximum and average modelled increases in flow velocities for the 100%, 5% and 1% AEP storm events and PMF event for out of channel flooding are presented in **Table 3.6.** The range (minimum and maximum) of modelled flow velocities for the 100%, 5% and 1% AEP storm events and PMF event out of channel flooding are presented in **Table 3.7**.

Table 3.6 Maximum and Average Modelled Increase in Flow Velocity out of Channel

Watercourse	Maximum Modelled Increase				Average Modelled Increase				Average Modelled Decrease			
	100% AEP	20% AEP	1% AEP	PMF	100% AEP	20% AEP	1% AEP	PMF	100% AEP	20% AEP	1% AEP	PMF
Quorrobolong Creek upstream of Cony Creek junction	0.32	0.02	0.01	0.76	0.004	0.004	0.004	0.004	0.002	0.004	0.003	0.004
Quorrobolong Creek downstream of Cony Creek junction	0.25	0.25	0.24	0.50	0.05	0.05	0.05	0.04	0.02	0.06	0.06	0.06
Unnamed Tributary of Quorrobolong Creek	0.08	0.41	0.50	1.60	0.04	0.05	0.06	0.05	0.03	0.06	0.04	0.05

Table 3.7 Ranges in Flow Velocity out of Channel

Watercourse	Velocity Ranges, Approved				Velocity Ranges, Proposed			
	100% AEP	20% AEP	1% AEP	PMF	100% AEP	20% AEP	1% AEP	PMF
Quorrobolong Creek upstream of Cony Creek junction	0.05 - 0.83	0.06 - 1.09	0.06 - 1.14	0.13 - 1.43	0.05 - 0.83	0.06 - 1.09	0.06 - 1.14	0.13 - 1.43
Quorrobolong Creek downstream of Cony Creek junction	0.01 - 0.77	0.10 - 1.08	0.10 - 1.13	0.09 - 1.38	0.01 - 0.77	0.09 - 1.11	0.11 - 1.17	0.09 - 1.42
Unnamed Tributary of Quorrobolong Creek	0.05 - 1.00	0.10 - 1.34	0.11 - 1.4	0.06 - 1.60	0.06 - 1.00	0.1 - 1.36	0.1 - 1.42	0.07 - 1.62

With the proposed modification, it is predicted that maximum out of channel flow velocities for Quorrobolong Creek both upstream and downstream of the junction with Cony Creek will have localised increases and decreases for all modelled storm events. Modelling indicates that the absolute maximum and minimum peak flow velocities with the proposed modification will remain similar to those modelled for both the approved mining scenario and the proposed mining scenario. As such, similar to in channel flows, it is considered that the maximum flow velocities will remain within non-scouring ranges for the 100%, 5% and 1% AEP storm events and the PMF event as a result of the proposed modification within in Quorrobolong Creek.

With the proposed modification, it is predicted that maximum flow velocities in the unnamed tributary of Quorrobolong Creek will experience localised increases and decreases out of channel for all modelled storm events. The maximum modelled increase in out of channel flow velocity for the 100% AEP event was 0.08 m/s. The maximum modelled increase in out of channel flow velocity for the 5% AEP event was 0.41 m/s. The maximum modelled increase in out of channel flow velocity for the 1% AEP event was 0.5 m/s. The PMF event produced the largest maximum modelled flow velocity out of channel for the unnamed tributary of Quorrobolong Creek in the order of 1.6 m/s. Modelling indicates that the absolute maximum and minimum peak flow velocities out of channel for the unnamed tributary of Quorrobolong Creek with the proposed modification will remain similar to those modelled for both the approved mining scenario and the proposed mining scenario. As such, it is considered that the maximum flow velocities will remain within non-scouring ranges for the 100%, 5% and, 1% AEP storm events and the PMF storm events as a result of the proposed modification.

3.4 Flood Hazard

In order to assess the potential flood hazards associated with the proposed modification, the flood hazard categories outlined in Appendix G of the *Floodplain Development Manual* (2005) were utilised. The four flood hazard categories, in order of increasing hazard, are:

- Walking and vehicle access
- Vehicles unstable
- Wading unsafe (and vehicles unstable) and
- Damage to light structures.

Flood hazard category maps for the approved mining scenario and the proposed mining scenario for the 100% AEP, 5% AEP and 1% AEP storm events and PMF event are provided in **Appendix A** (Figures A9 to A12) and **Appendix B** (Figures B9 to B12).

Modelling for the 1% AEP flood event indicates that the access routes to properties in the LWB4-B7 Modification Area are currently flood free and will remain so with the proposed modification.

Modelling for the PMF event indicates that the existing driveway access route to property ID A08h01 in the LWB4-B7 Modification Area is flood free for the approved scenario, however will be partially inundated within a localised portion of the existing access route close to the dwelling with the proposed scenario. Modelling for the PMF event indicates that the flood hazard category for the existing access route to the dwelling will change from “No Flooding” for the approved scenario to “Vehicle Unstable” for the proposed scenario within the small area that is inundated in the PMF event. The dwelling on property ID A08h01 will remain flood free and will not be isolated due to flooding. In addition, there is an existing alternate access from this dwelling to Sandy Creek Road which would mitigate this potential impact.

Modelling of the PMF event also indicates that all other access routes to properties in the LWB4-B7 Modification Area are currently flood free and will remain so with the proposed modification.

A flood hazard category analysis was also undertaken for Sandy Creek Road. The analysis indicates that the road will remain in the “vehicles unstable” flood hazard category for the 1% AEP storm event and PMF event with the proposed modification. The analysis also indicates that the flood hazard category will decrease from the “vehicles unstable” category to “walking and vehicle access” for the 5% AEP storm event.

The modelling also predicts a decrease in the duration when the road is flooded:

- from approximately 3 hours 25 minutes to approximately 2 hours 40 minutes with the proposed modification during the 5% AEP storm event
- from approximately 4 hours 45 minutes to approximately 4 hours 15 minutes with the proposed modification during the 1% AEP storm event and
- from approximately 25 hours 25 minutes to approximately 23 hours 50 minutes with the proposed modification during the PMF event.

3.5 Flood Duration and Remnant Ponding

Flood model hydrographs on Quorrobolong Creek immediately downstream of the unnamed tributary and downstream of LWB4-B7 (refer to **Appendix B** - Figure B13 and Figure B14) are comparable to the flood hydrographs derived previously for the approved LWB1-B3 and Stage 2 and 3 mine plans, indicating that the proposed modification will have negligible effect on the flood response downstream of the mining area during the 100%, 5% and 1% AEP and PMF storm events.

There are predicted to be minor changes to the extent of remnant surface ponding in the area to be undermined (refer to **Figure 3.1** and **Appendix B** - Figure B15 and B16). The predicted impacts on remnant ponding are primarily confined to existing flow paths, paddocks and farm dams, with no predicted impact on access routes to, or within, the properties along Quorrobolong Creek or its unnamed tributary.

As shown on **Figure 3.1**, an increase in the extent of remnant surface ponding is predicted along an overflow channel south of Quorrobolong Creek on Austar owned land. The analysis indicates ponding up to 0.5 metres deeper may occur on the overflow channel from Quorrobolong Creek extending 100 metres to 125 metres further upstream than in the approved scenario. Statistical analysis of the daily rainfall volumes experienced from 1973 to 2006 indicates that this area may be inundated during an average year (50^{th} percentile) approximately 85 days per year, during a dry year (10^{th} percentile) approximately 31 days per year and during a wet year (90^{th} percentile) approximately 156 days per year.

A minor increase in the extent of ponding is predicted along the eastern edge of a farm dam located above the northern edge of LWB5 near dwelling ID A08h01 (refer to **Figure 3.1**). Modelling also indicates that there will be a minor increase in the extent of ponding associated with a culvert under Sandy Creek Road above LWB3.

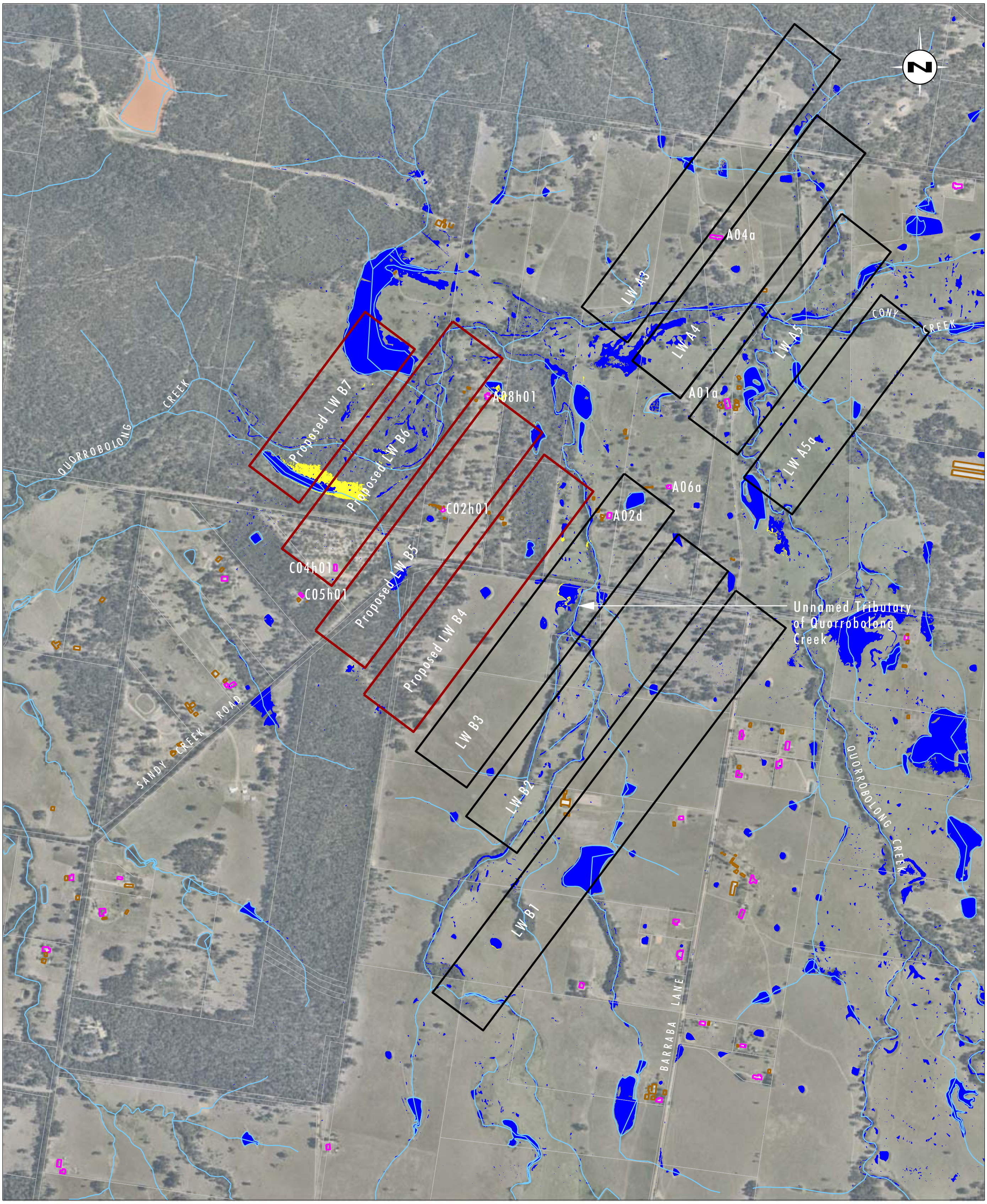


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure
- Remnant Ponding Approved LWA3-A19 and LWB1-B3
- Remnant Ponding Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

FIGURE 3.1

Remnant Ponding Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_063.dgn
20170515 15.20

3.6 Stream Flow and Channel Stability

The flood modelling analysis indicates that the proposed modification is unlikely to have a significant impact on the flow regimes of Quorrobolong Creek or its unnamed tributary, with only minor changes predicted in runoff regimes and peak discharges.

Based on the subsidence predictions (refer to **Section 2.0**), the maximum predicted subsidence associated with the extraction of LWB1 to LWB7 will result in maximum changes in longitudinal channel grade of approximately 0.40 per cent within Quorrobolong Creek channel (refer to **Appendix B** - Figure B15 and B16), and approximately 0.45 per cent within the drainage channels of the unnamed tributary of Quorrobolong Creek compared to the approved mining scenario channel conditions.

As the predicted changes in longitudinal channel grade are minor and lie within the natural variations in longitudinal grades of the drainage channels within the Quorrobolong Valley, it is considered that the proposed modification will not significantly alter the flow capacity or stream velocities within the existing channels relative to the existing ranges within the channels. It is also considered that there is minimal potential for channel realignment to occur as a result of the proposed modification as the modelled changes to the longitudinal channel grade and changes to flow velocities and tractive stresses are consistent with the ranges that occur naturally within the Quorrobolong Valley as discussed in **Section 3.3.1**.

The potential to increase erosion of the landform is also expected to be minimal due to the relatively small predicted changes in landform grades and modelled changes to out of channel flow velocities, combined with the high level of groundcover and limited amount of exposed soils in the area.

4.0 Summary and Conclusions

Analysis indicates that the maximum predicted subsidence associated with the proposed modification would have only a minor impact on the flood response in the surrounding area. Modelling indicates there will be some changes to the freeboard of ten dwellings during the 1% AEP flood event and/or PMF event however there will be no flooding of dwellings. Modelling indicates that no dwellings will have their freeboard reduced below the flood planning level (1%AEP flood event plus 500 mm freeboard) as a result of the proposed modification.

The main area that is likely to be affected by changes to the flood response is the section of Quorrobolong Creek downstream of the junction with Cony Creek from the northern most end of LWB6 downstream to the southernmost end of LWB7, with changes predicted to both peak flood depths and flow velocities. To ensure there are no significant impacts as a result of velocity induced scouring or erosion it is recommended that a channel stability monitoring program of these reaches where velocity and tractive stress changes are predicted via modelling are implemented.

The modelled changes to flood hazard categories and flood extents as a result of the proposed modification are considered to be negligible. No access routes to private properties will be adversely affected as a result of the proposed modification for the 1% AEP flood event. A small portion of the existing access route to dwelling ID A08h01 may be inundated during the PMF event however the dwelling will remain flood free and will not be isolated. In addition, there is an existing alternate access from this dwelling to Sandy Creek Road which mitigates this potential impact. The modelling indicates that Sandy Creek Road will continue to be flood affected during the 1% AEP storm event and the PMF event, with the road remaining impassable to vehicles during the flood peak but with a shorter modelled duration of flood inundation over the road.

Minor changes to remnant ponding are predicted as a result of the proposed modification, and relate primarily to a predicted increase in the extent of remnant ponding within an approximately 1.5ha area along an overflow channel south of Quorrobolong Creek on Austar owned land.

5.0 References

Mine Subsidence Engineering Consultants (MSEC), 2017. Austar Coal Mine: Longwalls B4 to B7 Subsidence Predictions and Impact Assessment for the Natural and Built Features in Support of the Modification Application for Longwalls B4 to B7 at the Austar Coal Mine, prepared for Austar Coal Mine Pty Ltd.

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Umwelt (Australia) Pty Limited, 2015. Flooding and Drainage Assessment Longwall B1-B3 Modification, prepared for Austar Coal Mine Pty Ltd.

APPENDIX A

Model Results – Approved Mining Scenario

umwelt

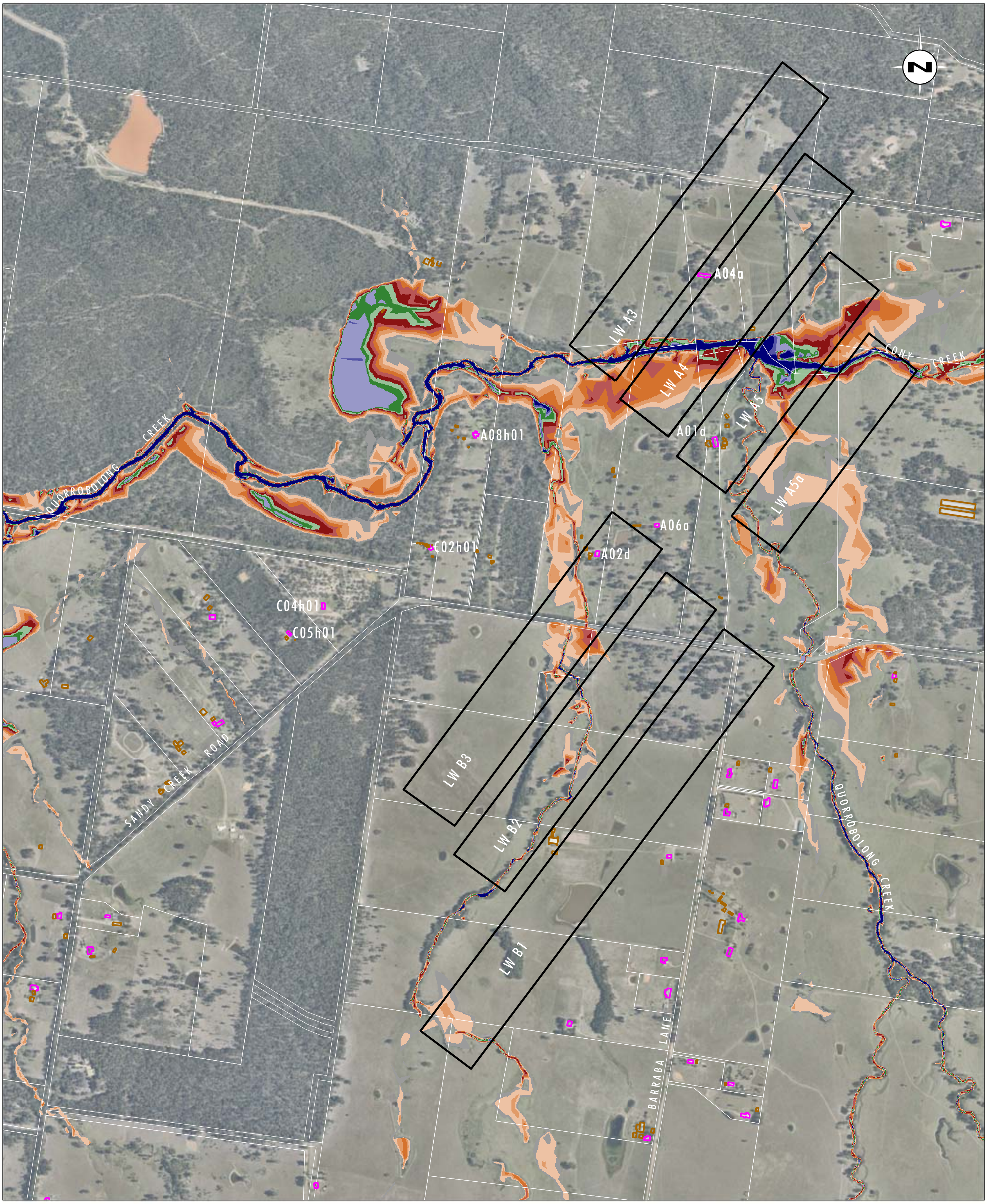


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017), MSEC (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

Approved LWA3-A19 and LWB1-B3 Longwall Panels
Dwelling
Other Structure

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE A1

100% AEP Storm Event: Maximum Modelled Flood Depths, Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_034.dgn
20170515 15.29

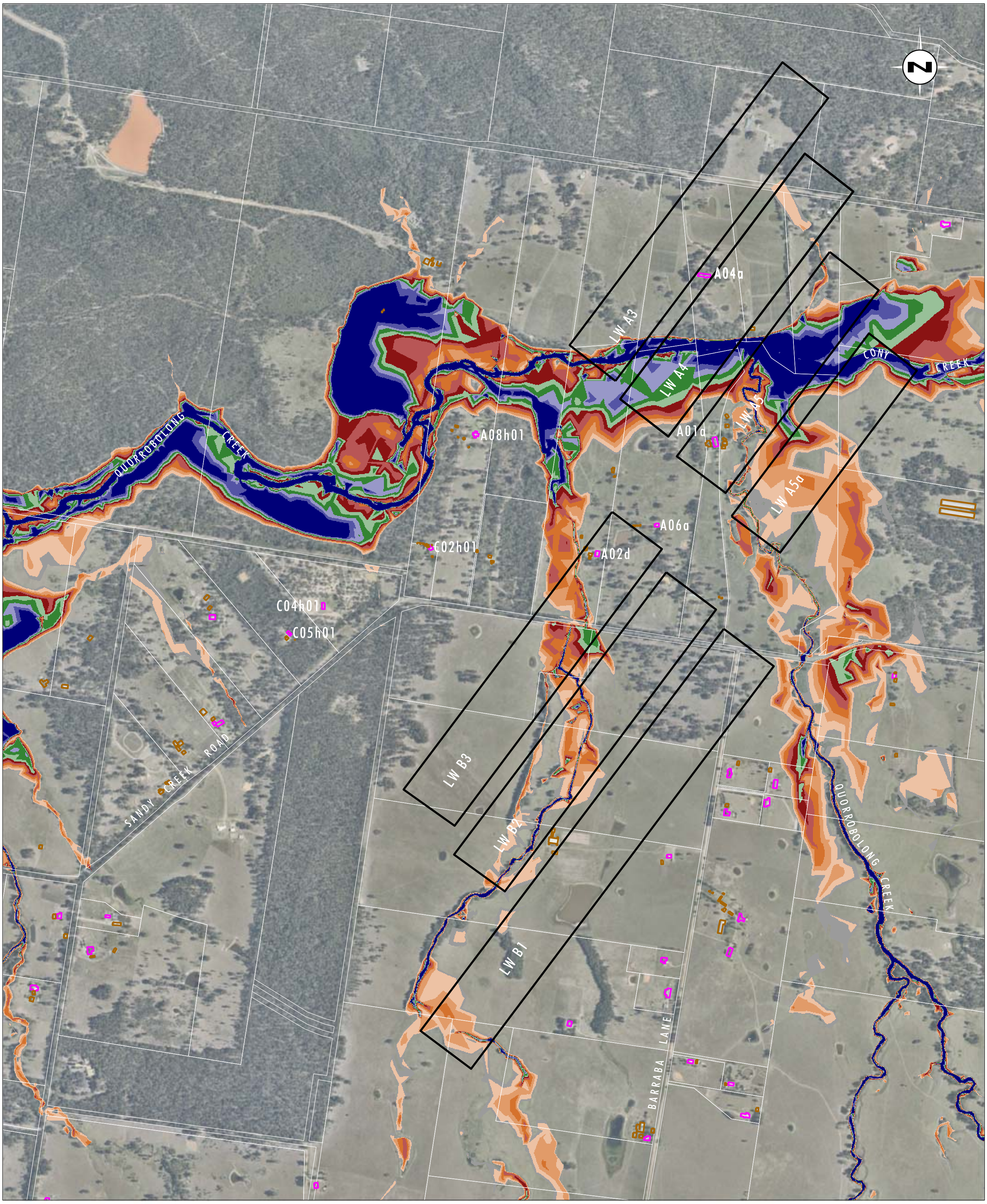


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE A2

5% AEP Storm Event: Maximum Modelled Flood Depths, Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_037.dgn
20170515 15.31

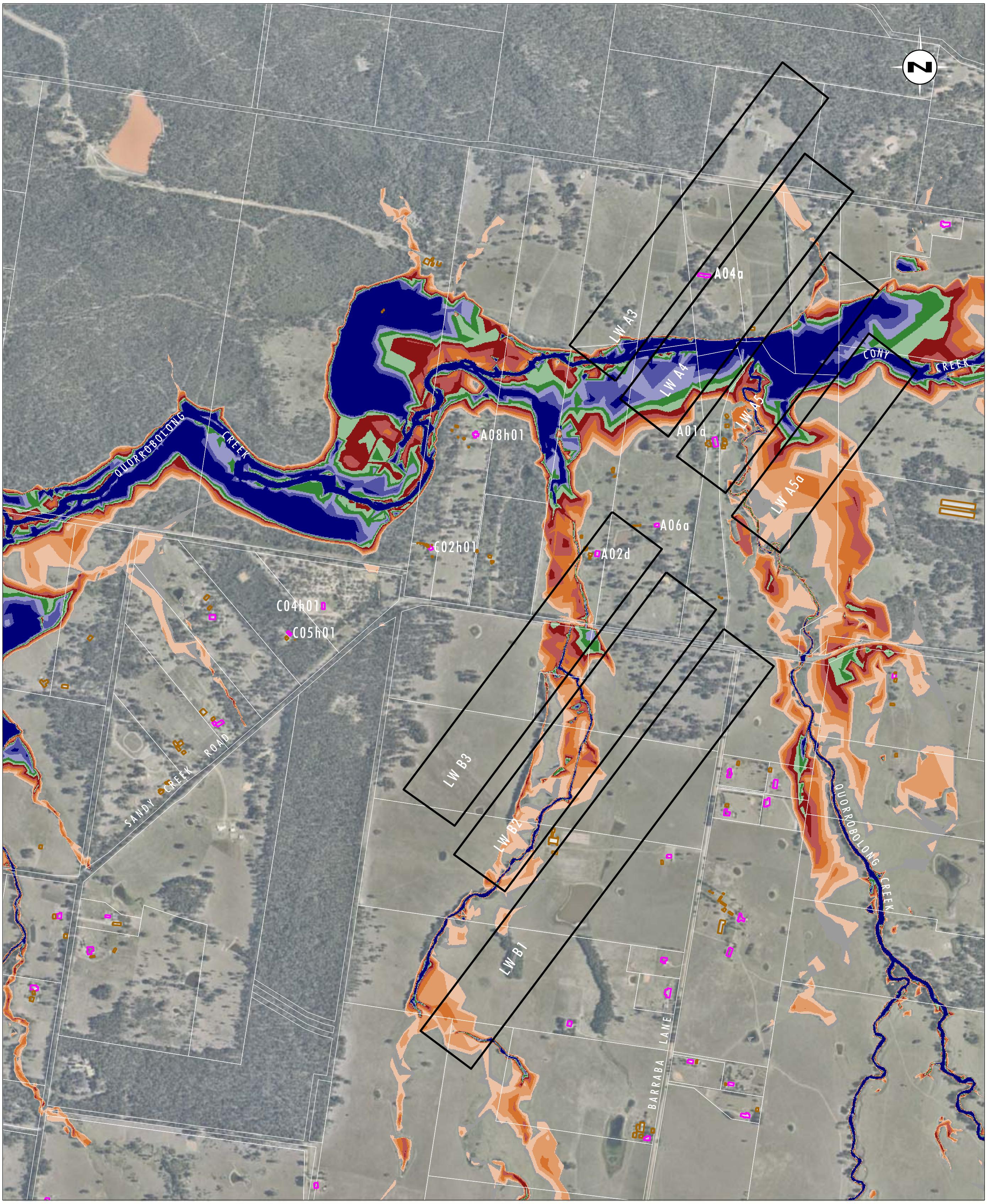


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

Approved LWA3-A19 and LWB1-B3 Longwall Panels
Dwelling
Other Structure

Water Depth (m)

Range [0.001 : 0.100]
Range [0.100 : 0.300]
Range [0.300 : 0.500]
Range [0.500 : 0.700]
Range [0.700 : 0.900]
Range [0.900 : 1.100]
Range [1.100 : 1.300]
Range [1.300 : 1.500]
Range [1.500 : 1.700]
Range [1.700 : 1.900]
Range [>1.900]

FIGURE A3

1% AEP Storm Event:
Maximum Modelled Flood Depths,
Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_036.dgn
20170515 15.30

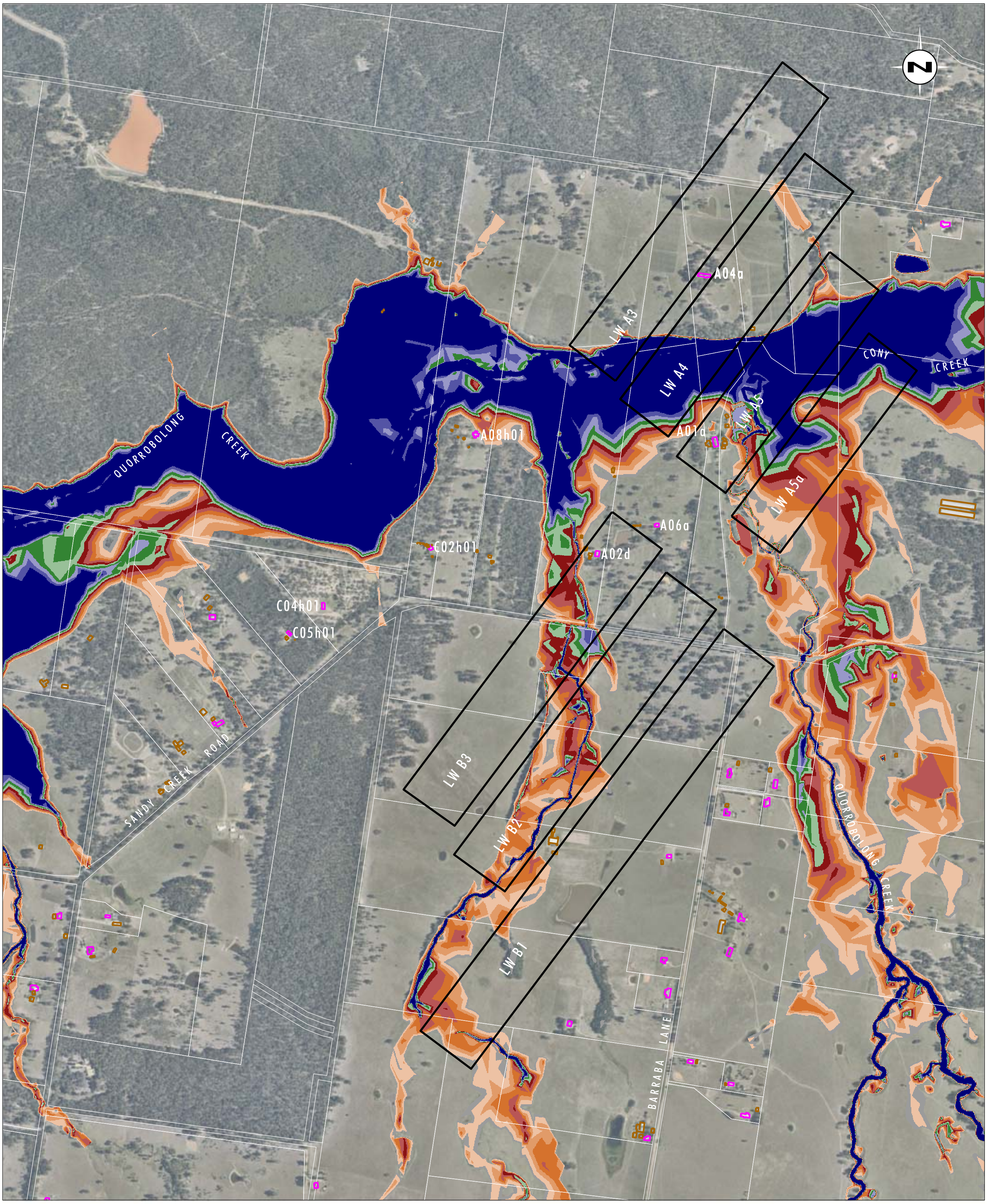


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE A4

PMF Event: Maximum Modelled Flood Depths, Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_038.dgn
20170515 16.29

umwelt

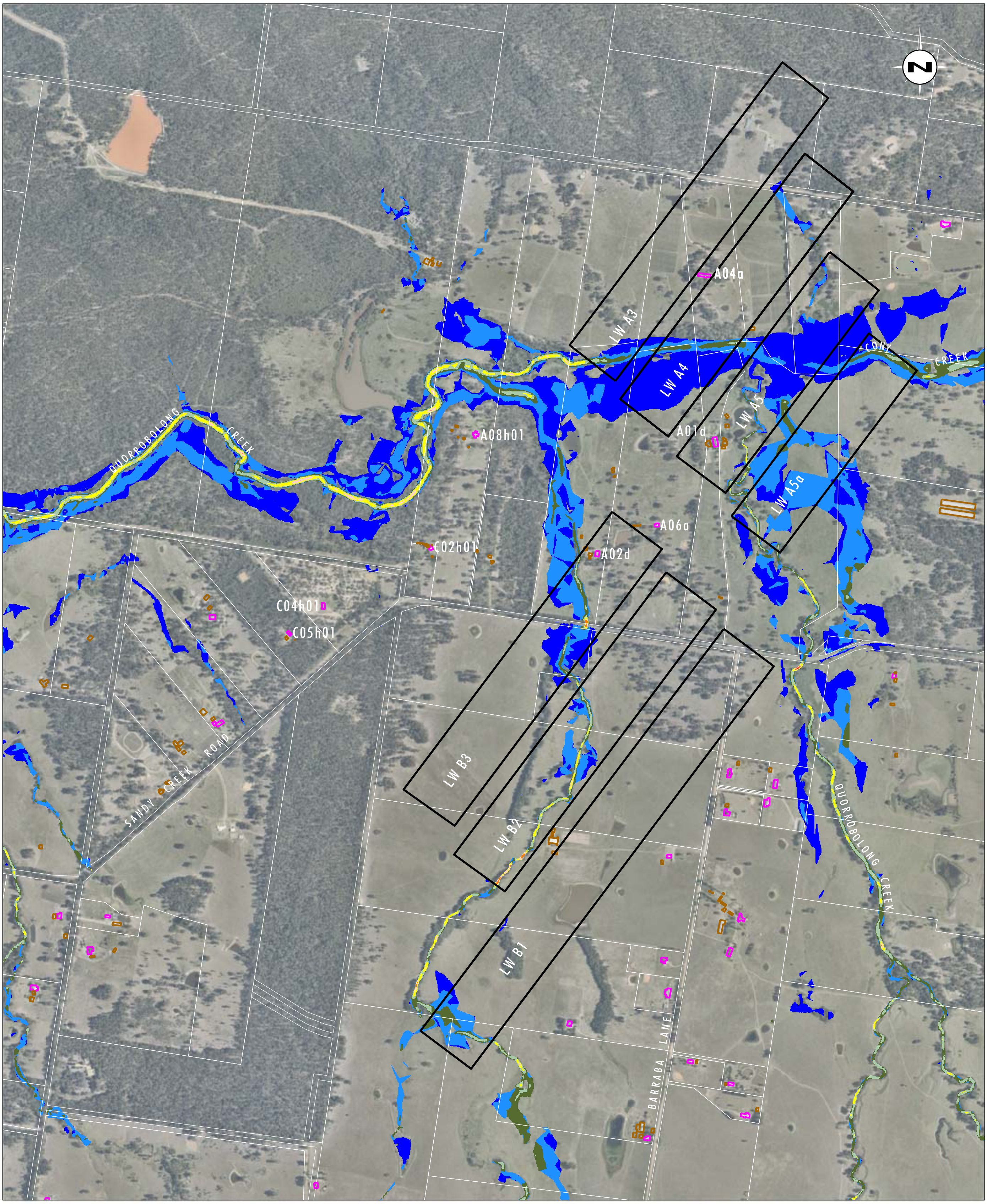


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Velocity (m/s)

- Range [0.100 : 0.250]
- Range [0.250 : 0.500]
- Range [0.500 : 0.750]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [1.250 : 1.500]
- Range [1.500 : 1.750]
- Range [1.750 : 2.000]
- Range [2.000 : 2.250]
- Range [2.250 : 3.000]

FIGURE A5

100% AEP Storm Event: Maximum Modelled Flow Velocities, Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_039.dgn
20170515 16.28

umwelt

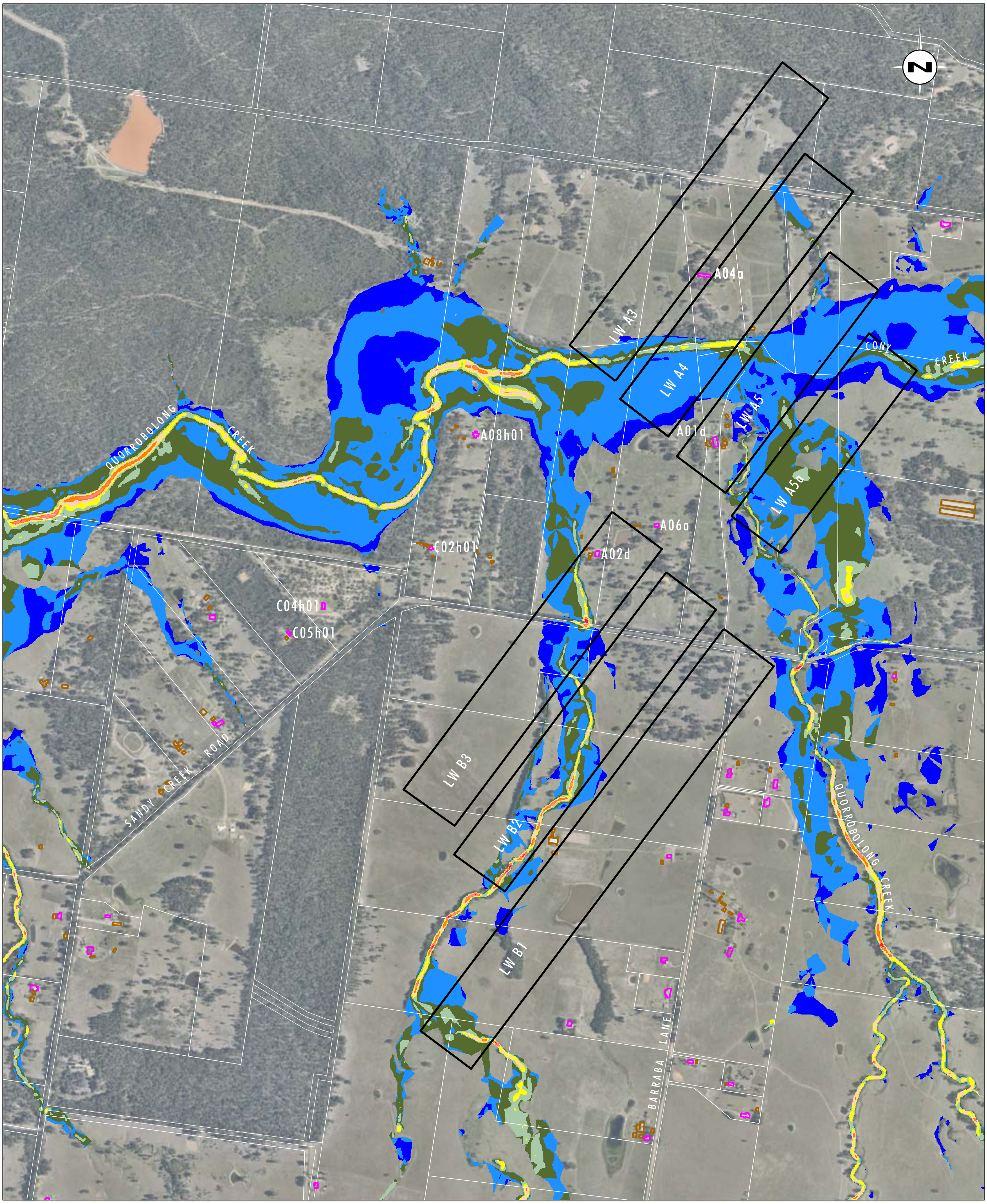


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

Approved LWA3-A19 and LWB1-B3 Longwall Panels
Dwelling
Other Structure

Water Velocity (m/s)

Range [0.100 : 0.250]
Range [0.250 : 0.500]
Range [0.500 : 0.750]
Range [0.750 : 1.000]
Range [1.000 : 1.250]
Range [1.250 : 1.500]
Range [1.500 : 1.750]
Range [1.750 : 2.000]
Range [2.000 : 2.250]
Range [2.250 : 3.000]

FIGURE A6

5% AEP Storm Event: Maximum Modelled Flow Velocities, Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_041.dgn
20170515 16.32

umwelt

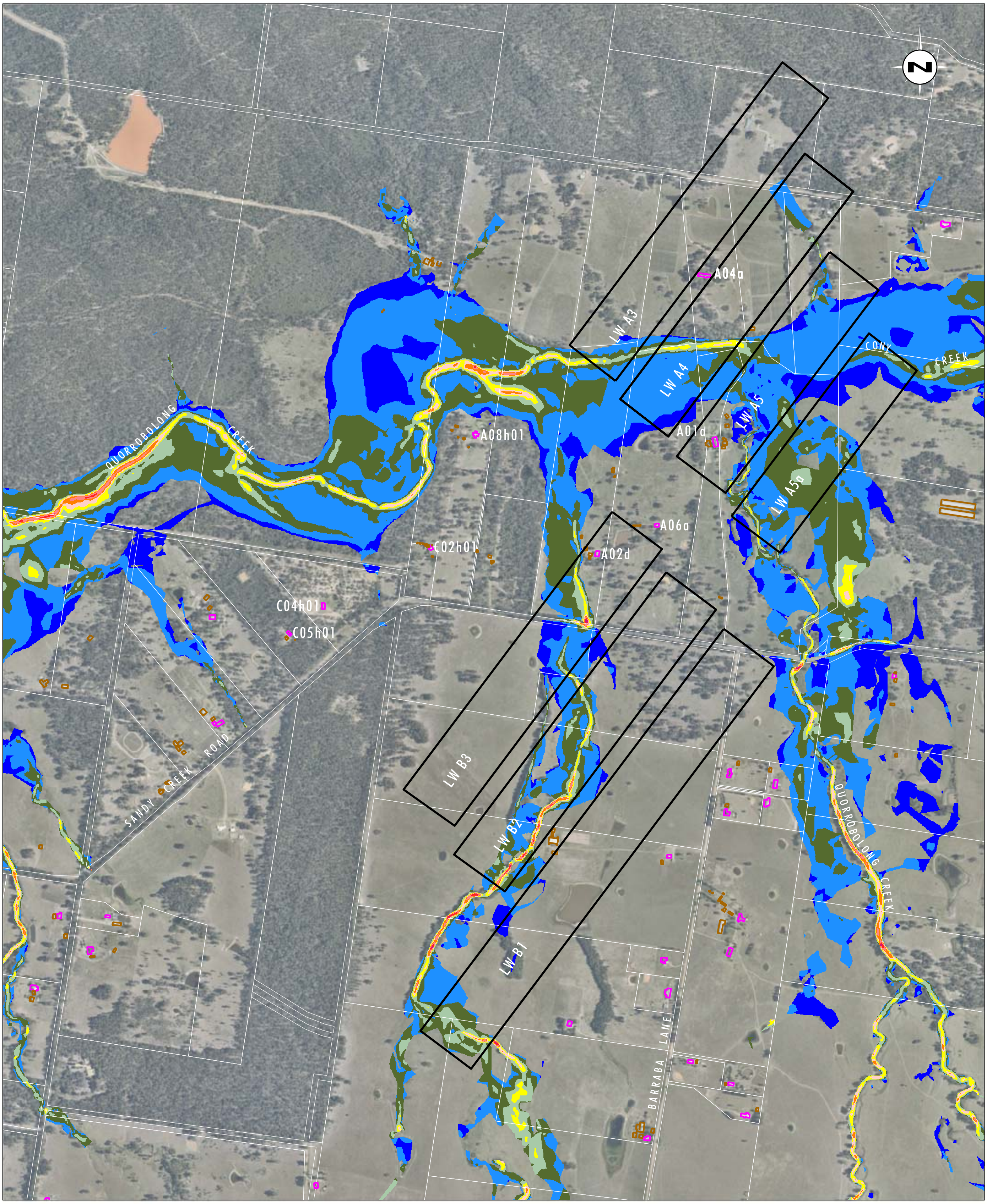


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Velocity (m/s)

- Range [0.100 : 0.250]
- Range [0.250 : 0.500]
- Range [0.500 : 0.750]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [1.250 : 1.500]
- Range [1.500 : 1.750]
- Range [1.750 : 2.000]
- Range [2.000 : 2.250]
- Range [2.250 : 3.000]

FIGURE A7

1% AEP Storm Event: Maximum Modelled Flow Velocities, Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_040.dgn
20170515 16.31

umwelt

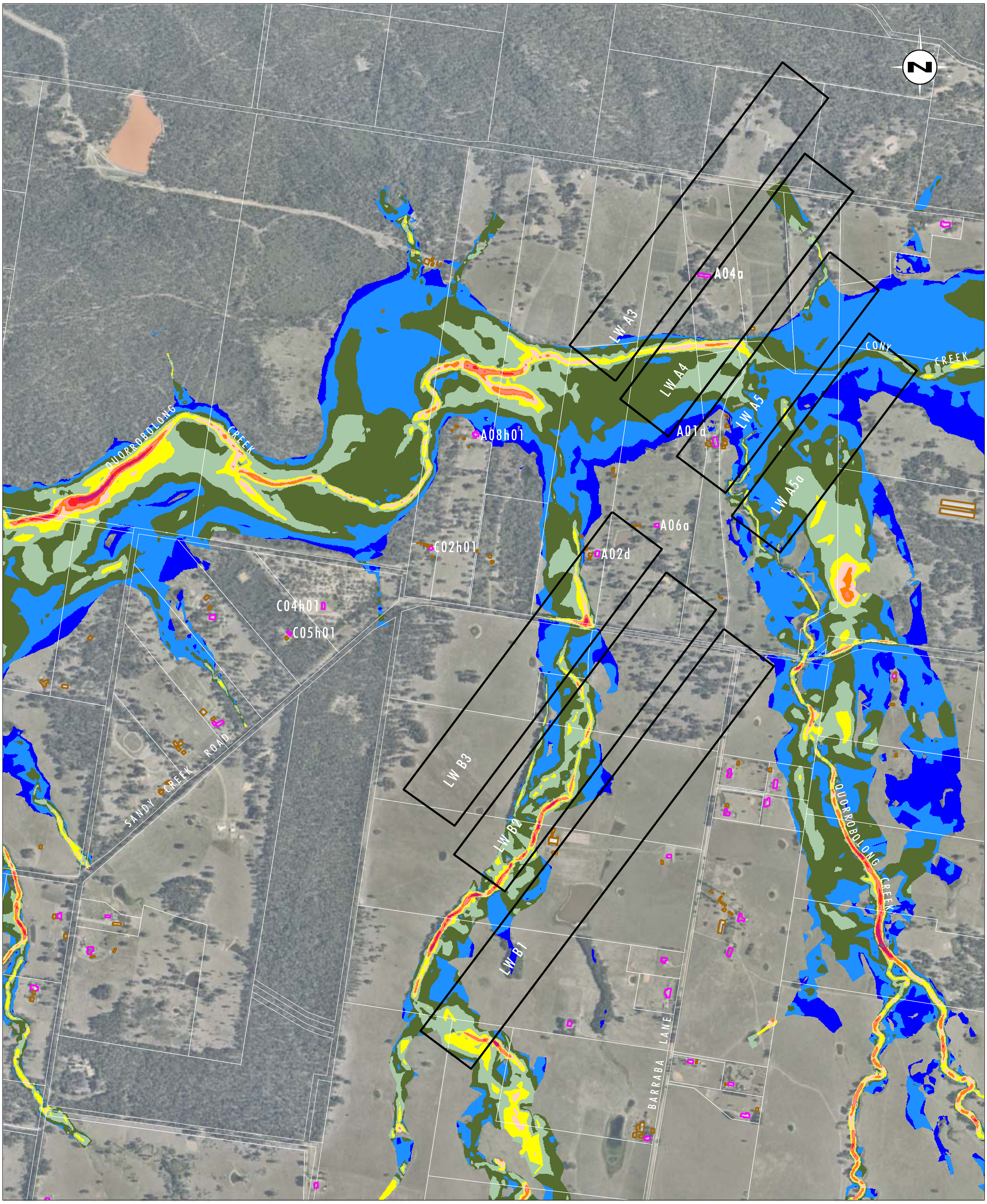


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

Approved LWA3-A19 and LWB1-B3 Longwall Panels
Dwelling
Other Structure

Water Velocity (m/s)

- Range [0.100 : 0.250]
- Range [0.250 : 0.500]
- Range [0.500 : 0.750]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [1.250 : 1.500]
- Range [1.500 : 1.750]
- Range [1.750 : 2.000]
- Range [2.000 : 2.250]
- Range [2.250 : 3.000]

FIGURE A8

**PMF Event:
Maximum Modelled Flow Velocities,
Predicted Subsidence Approved LWA3-A19 and LWB1-B3**

File Name (A4): R03/3900_042.dgn
20170515 16.36

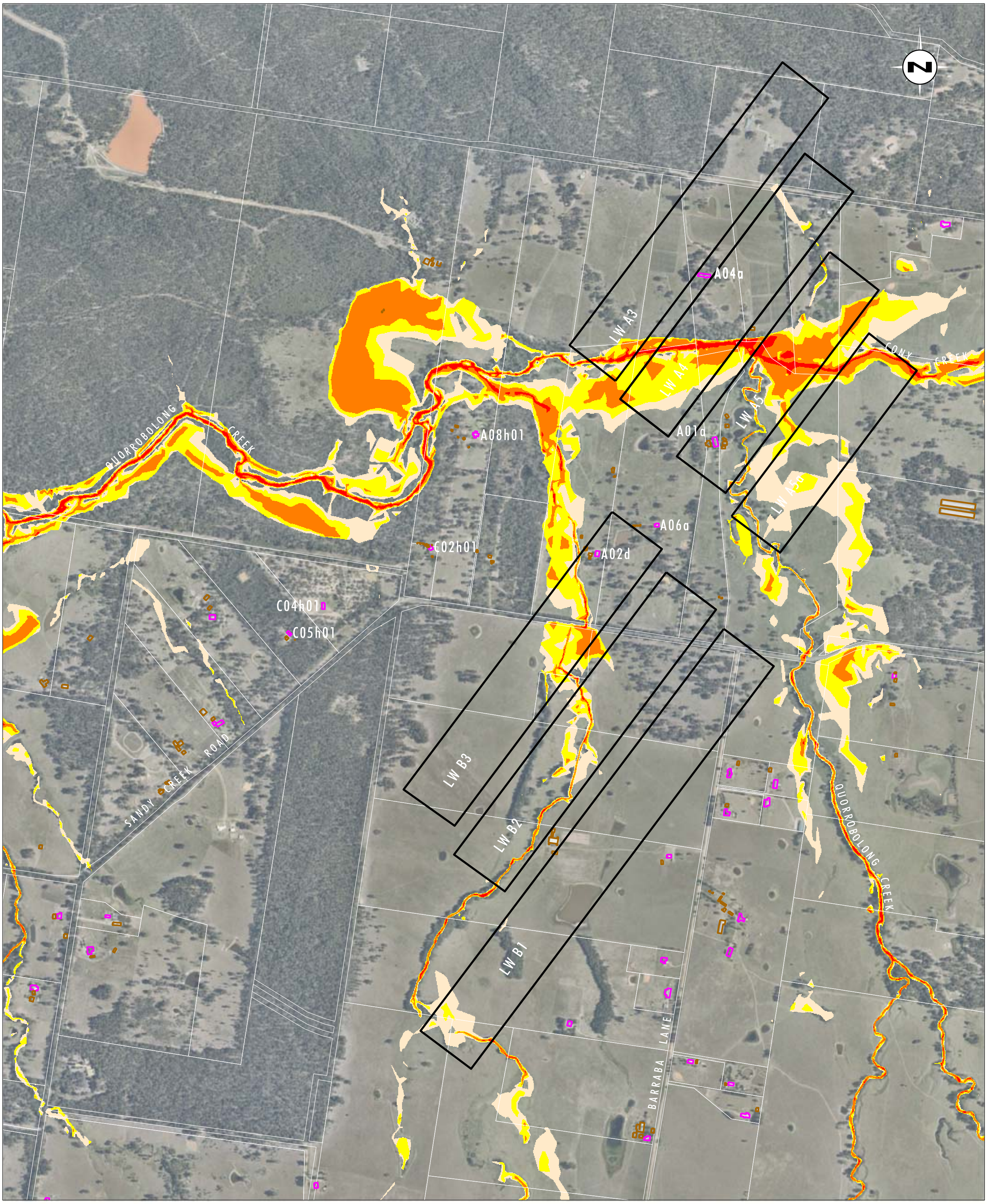


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE A9

100% AEP Storm Event: Maximum Modelled Flood Hazard, Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_043.dgn
20170515 16.37

umwelt

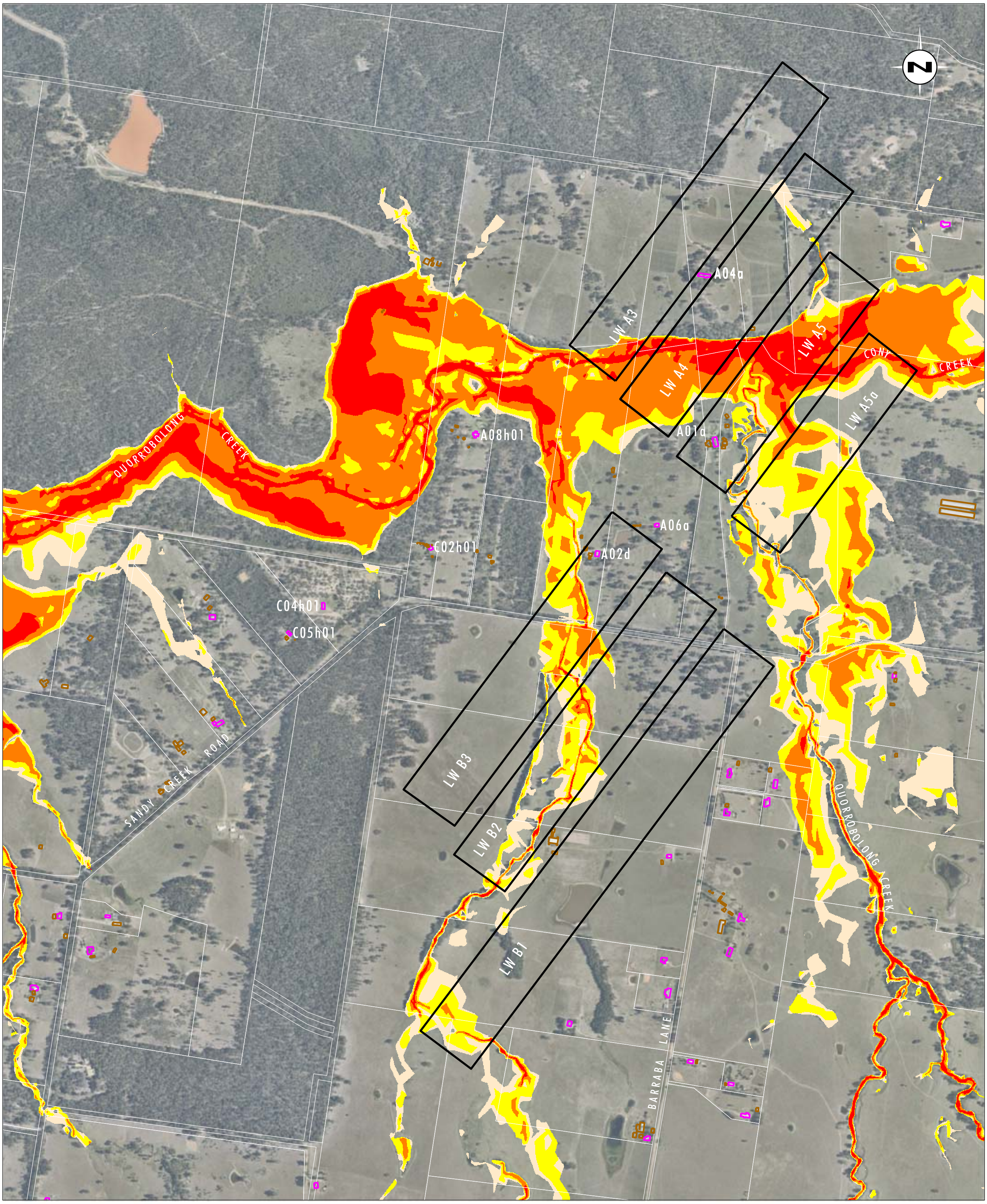


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE A10

5% AEP Storm Event:
Maximum Modelled Flood Hazard,
Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_045.dgn
20170515 16.39

umwelt

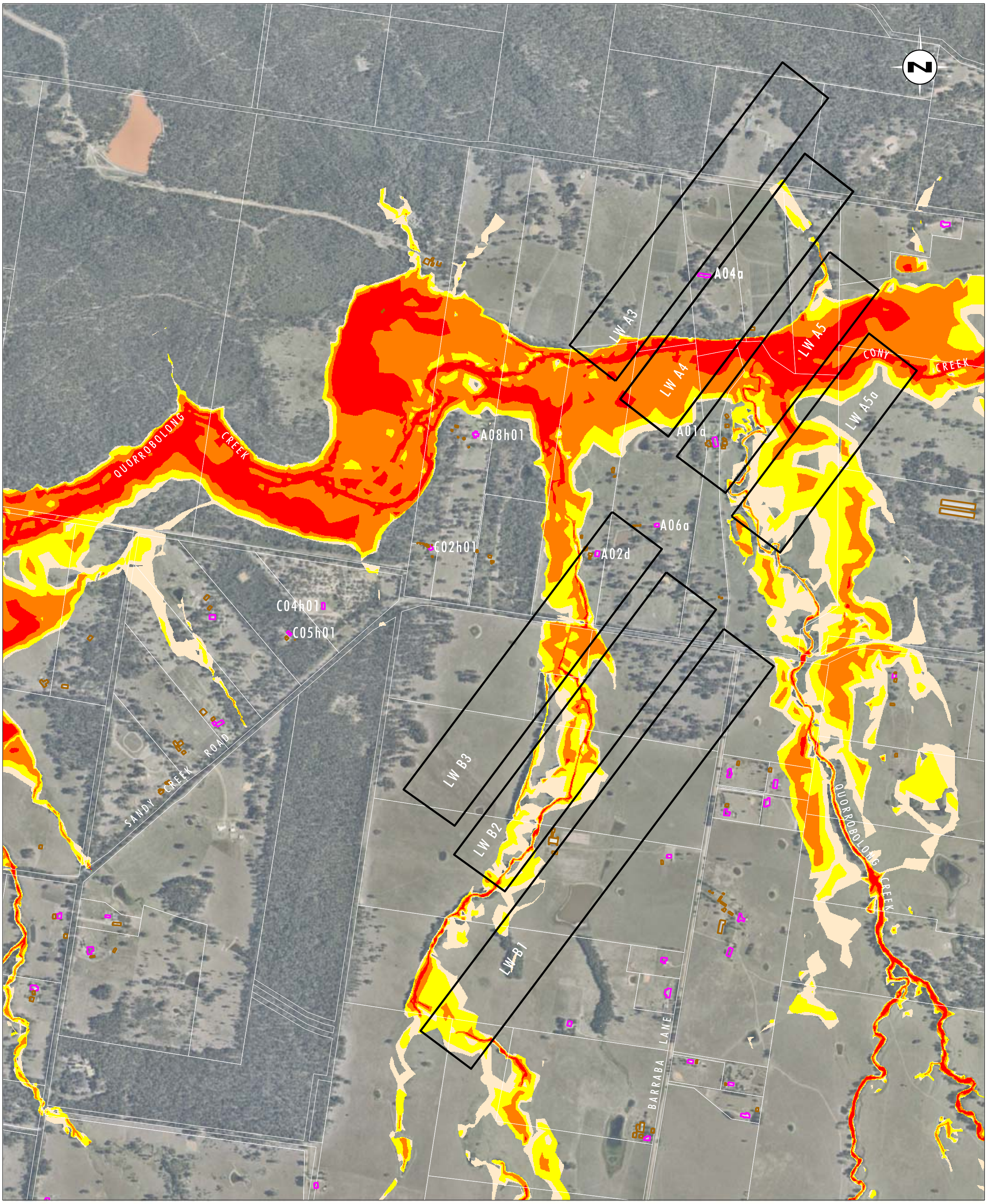


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE A11

1% AEP Storm Event: Maximum Modelled Flood Hazard, Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_044.dgn
20170515 16.38

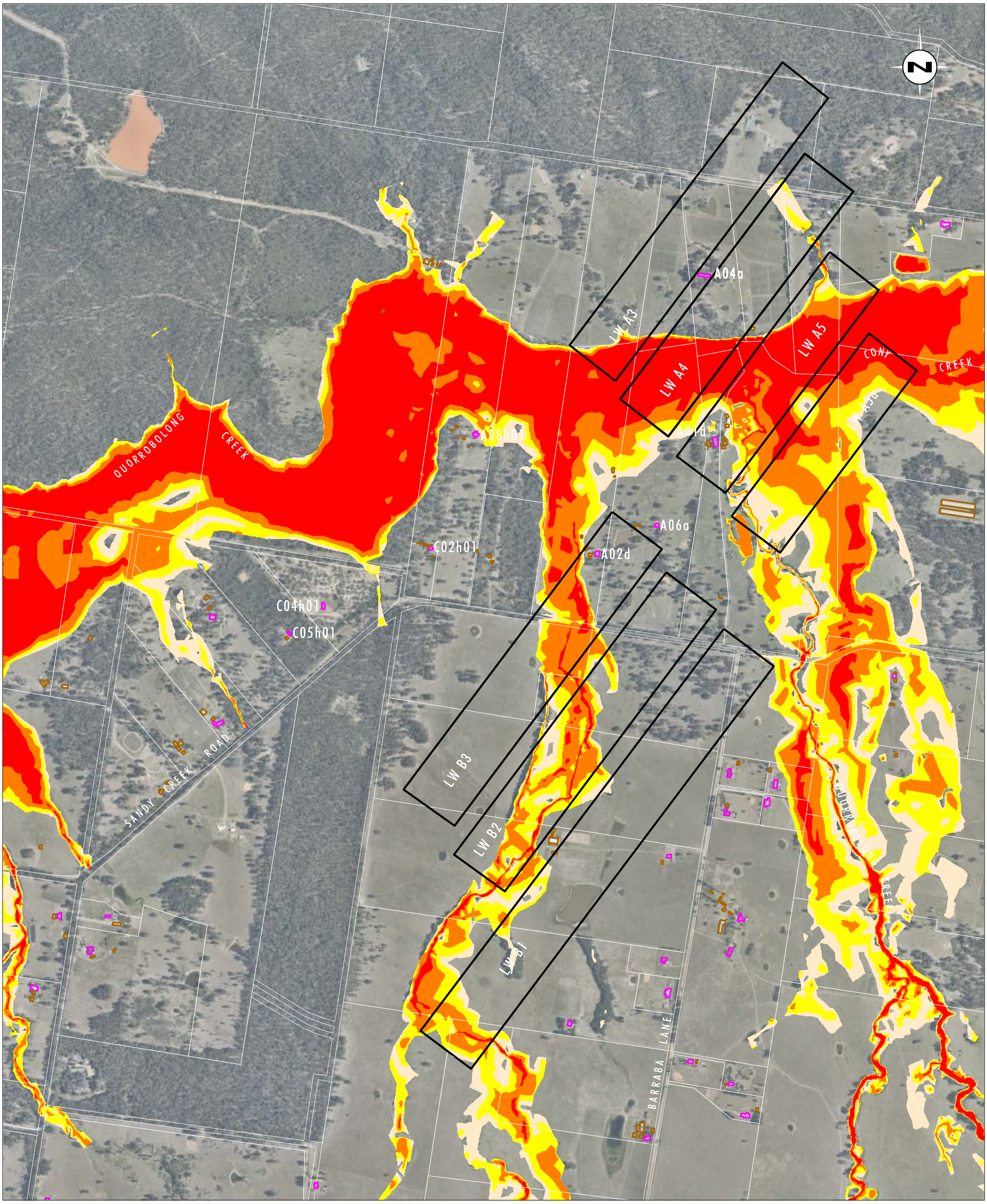


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE A12

PMF Event:
Maximum Modelled Flood Hazard,
Predicted Subsidence Approved LWA3-A19 and LWB1-B3

File Name (A4): R03/3900_046.dgn
20170515 17.13

APPENDIX B

Model Results – Proposed Modification

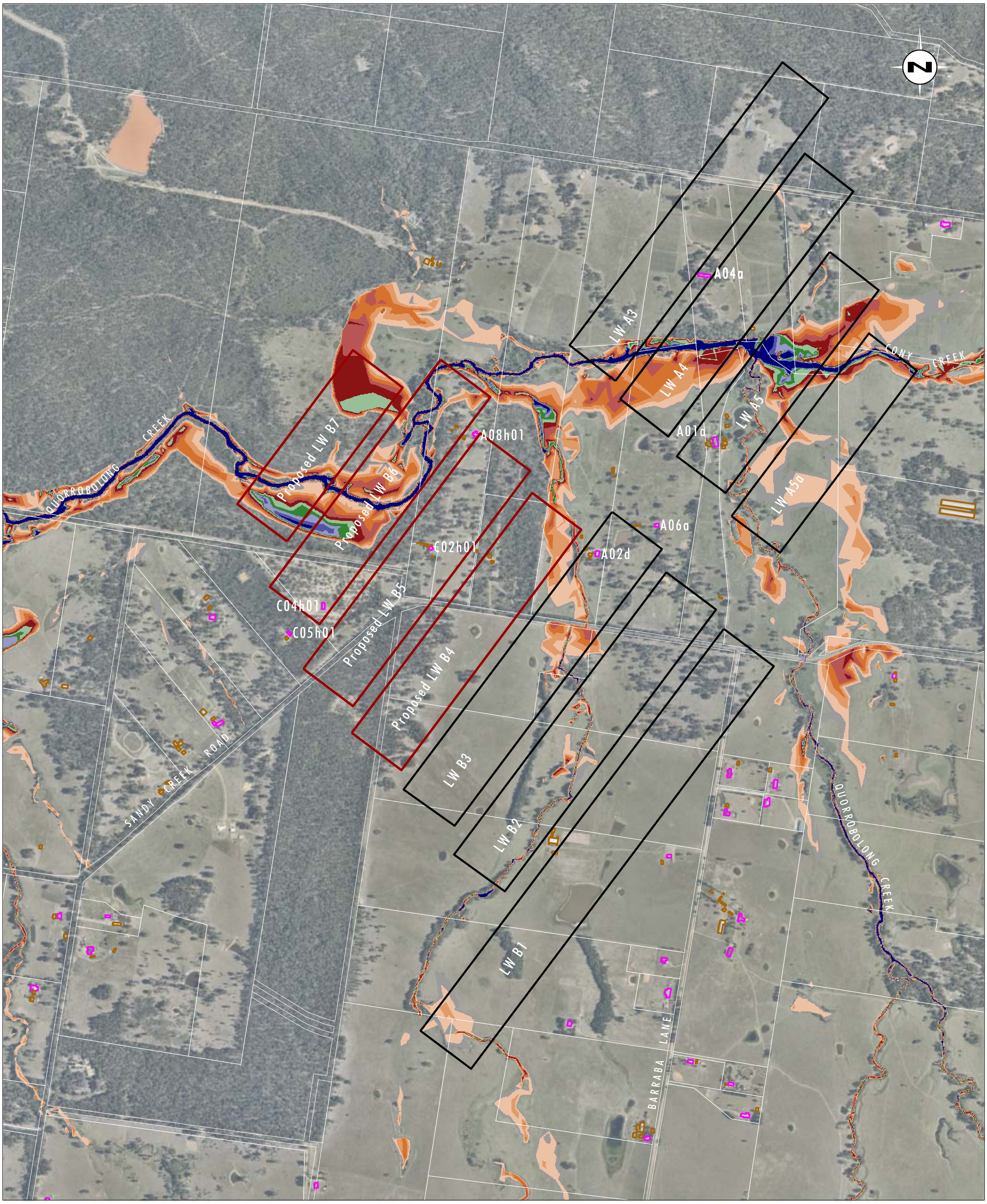


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE B1

100% AEP Storm Event: Maximum Modelled Flood Depths, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_047.dgn
20170516 8.49

umwelt

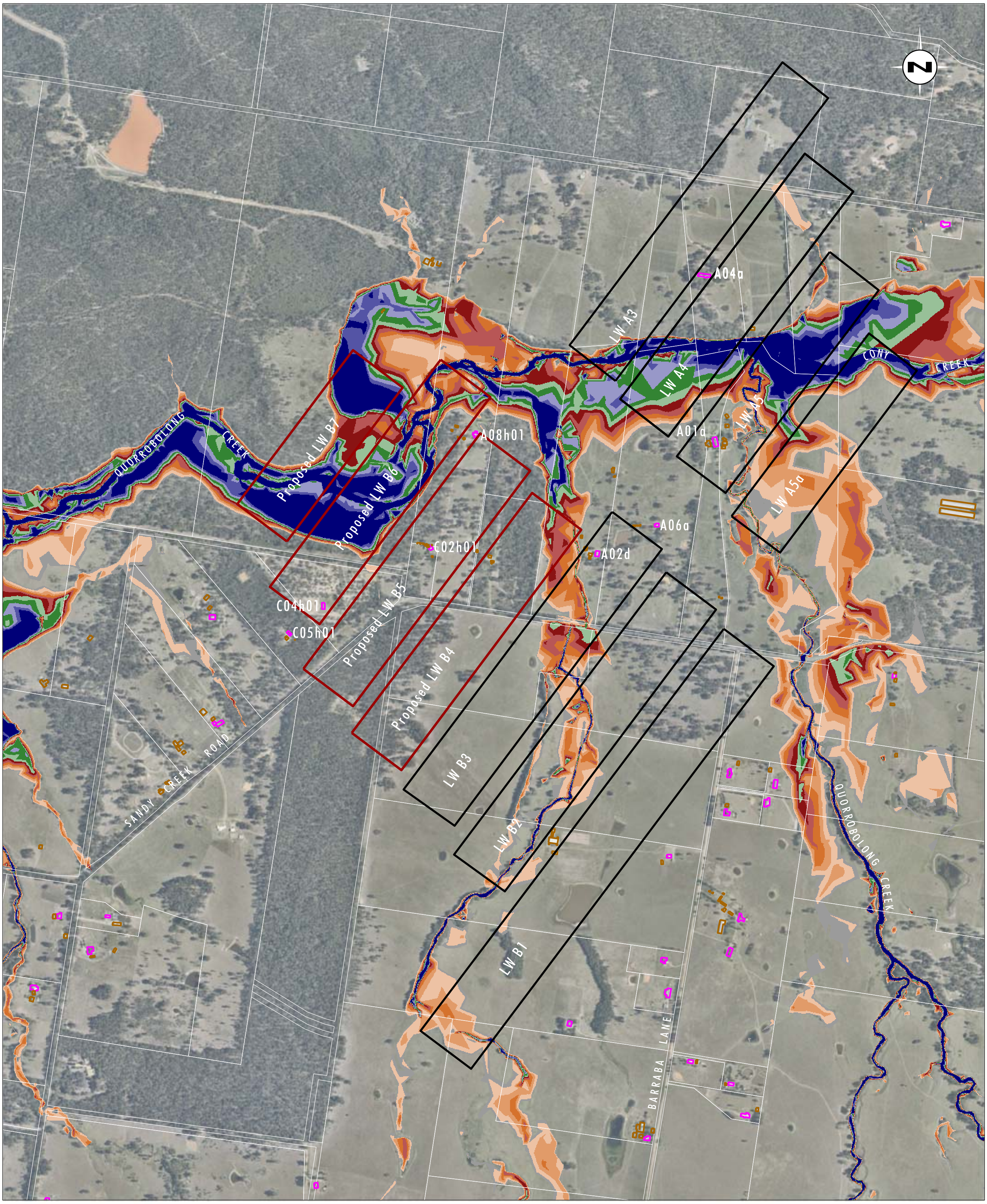


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE B2

5% AEP Storm Event: Maximum Modelled Flood Depths, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_049.dgn
20170516 8.53

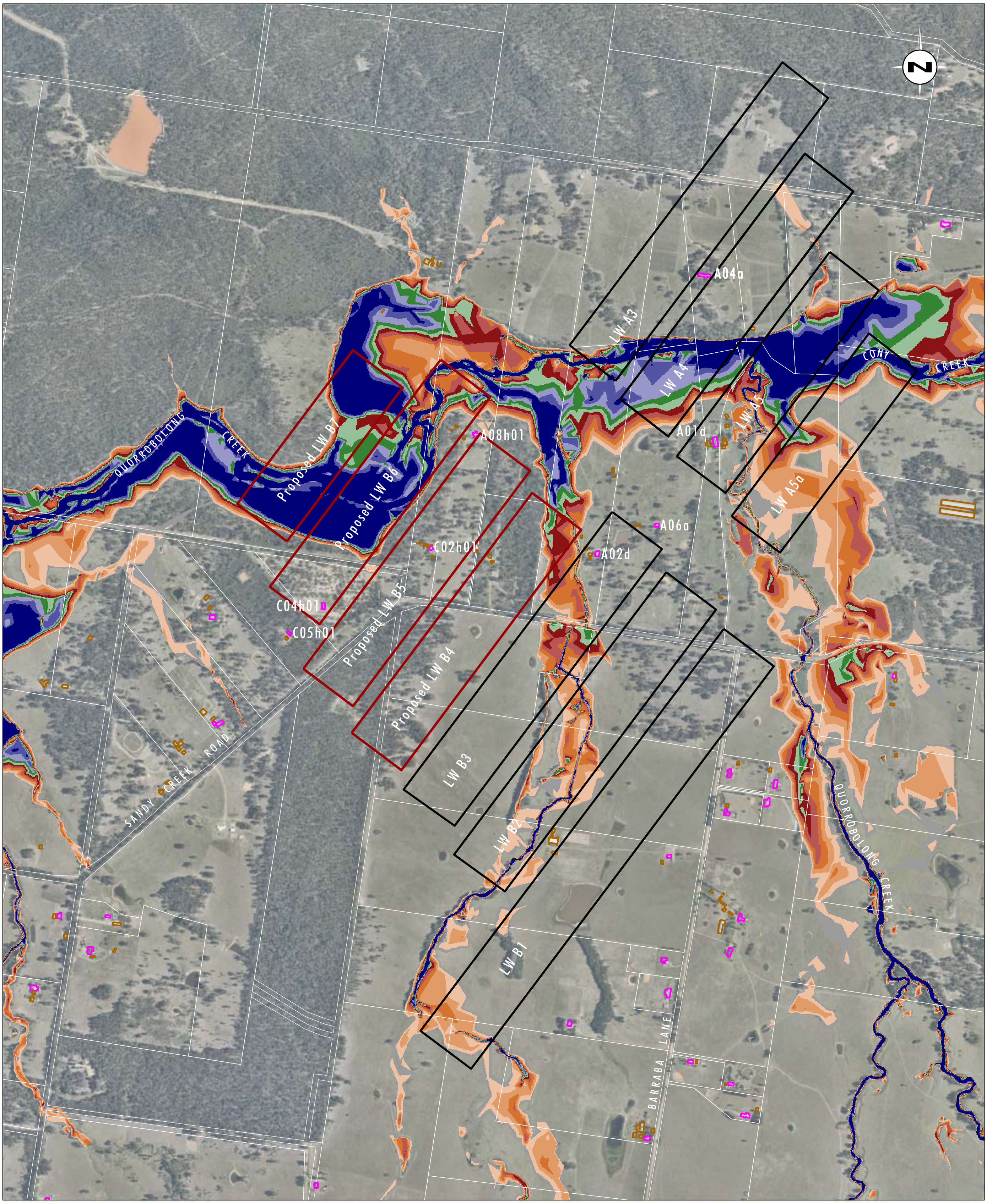


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE B3

1% AEP Storm Event: Maximum Modelled Flood Depths, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_048.dgn
20170516 8.51

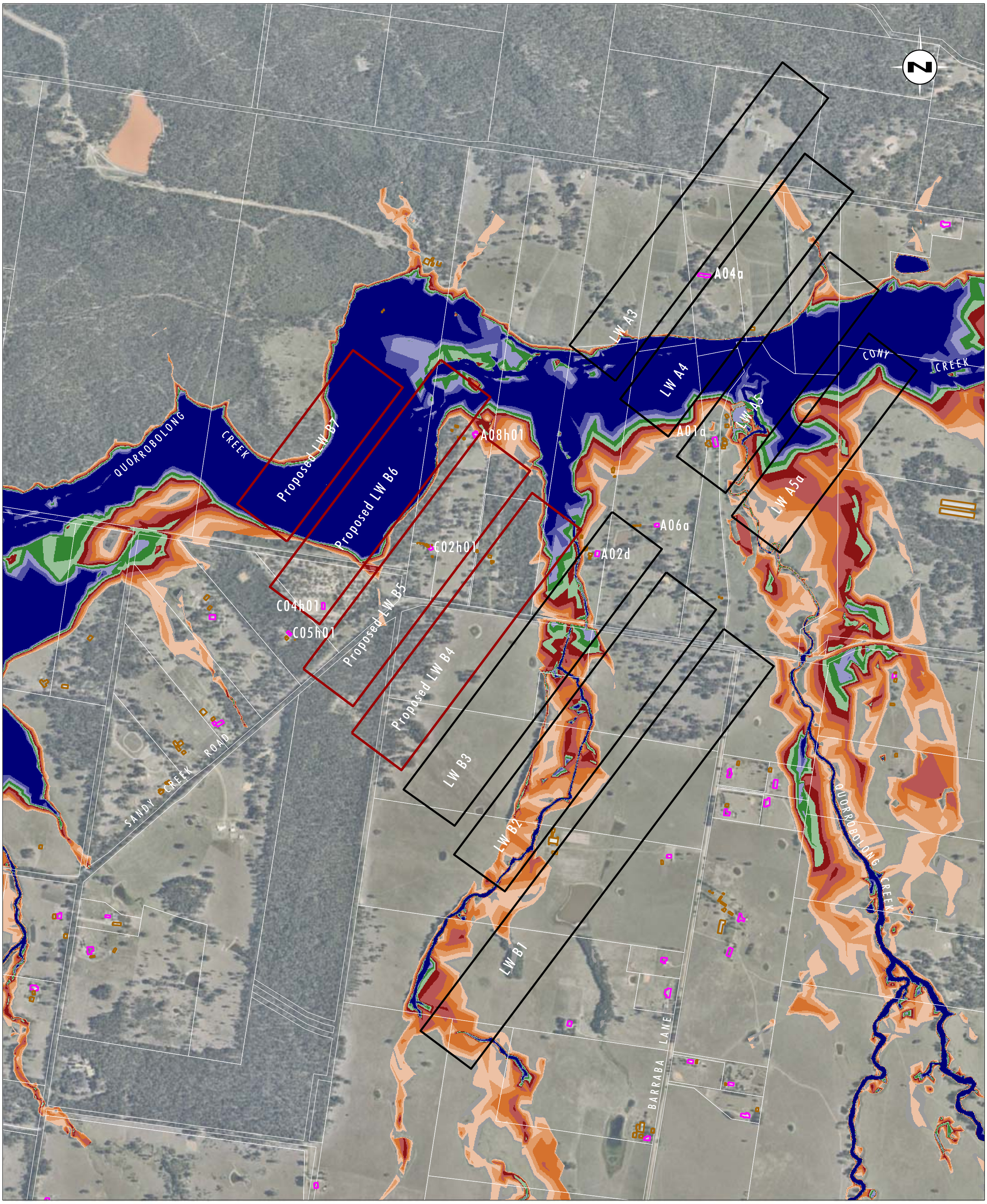


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Depth (m)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE B4

PMF Event: Maximum Modelled Flood Depths, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_050.dgn
20170516 11.44

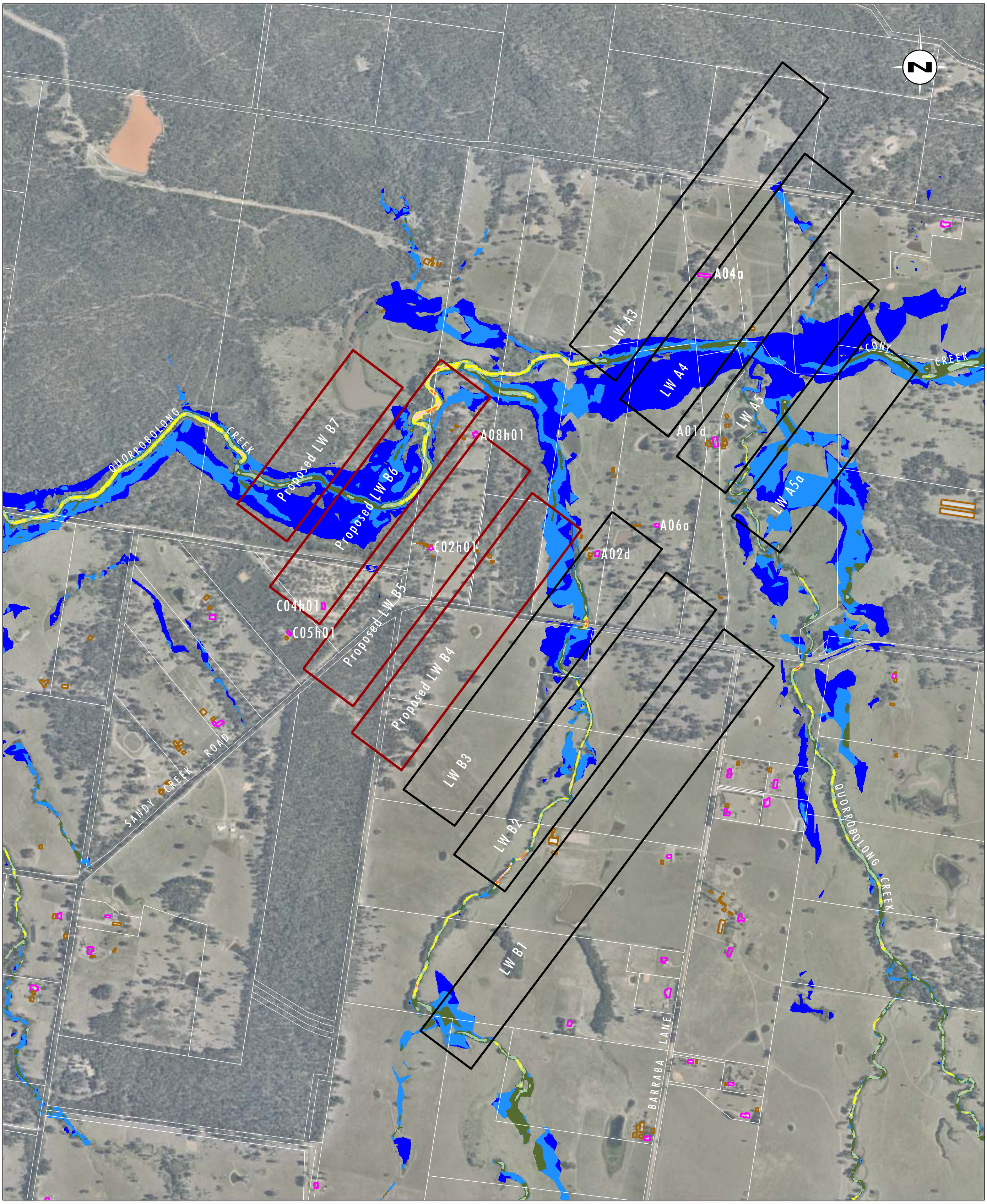


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Velocity (m/s)

- Range [0.100 : 0.250]
- Range [0.250 : 0.500]
- Range [0.500 : 0.750]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [1.250 : 1.500]
- Range [1.500 : 1.750]
- Range [1.750 : 2.000]
- Range [2.000 : 2.250]
- Range [2.250 : 3.000]

FIGURE B5

100% AEP Storm Event: Maximum Modelled Flow Velocities, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_051.dgn
20170516 11.46

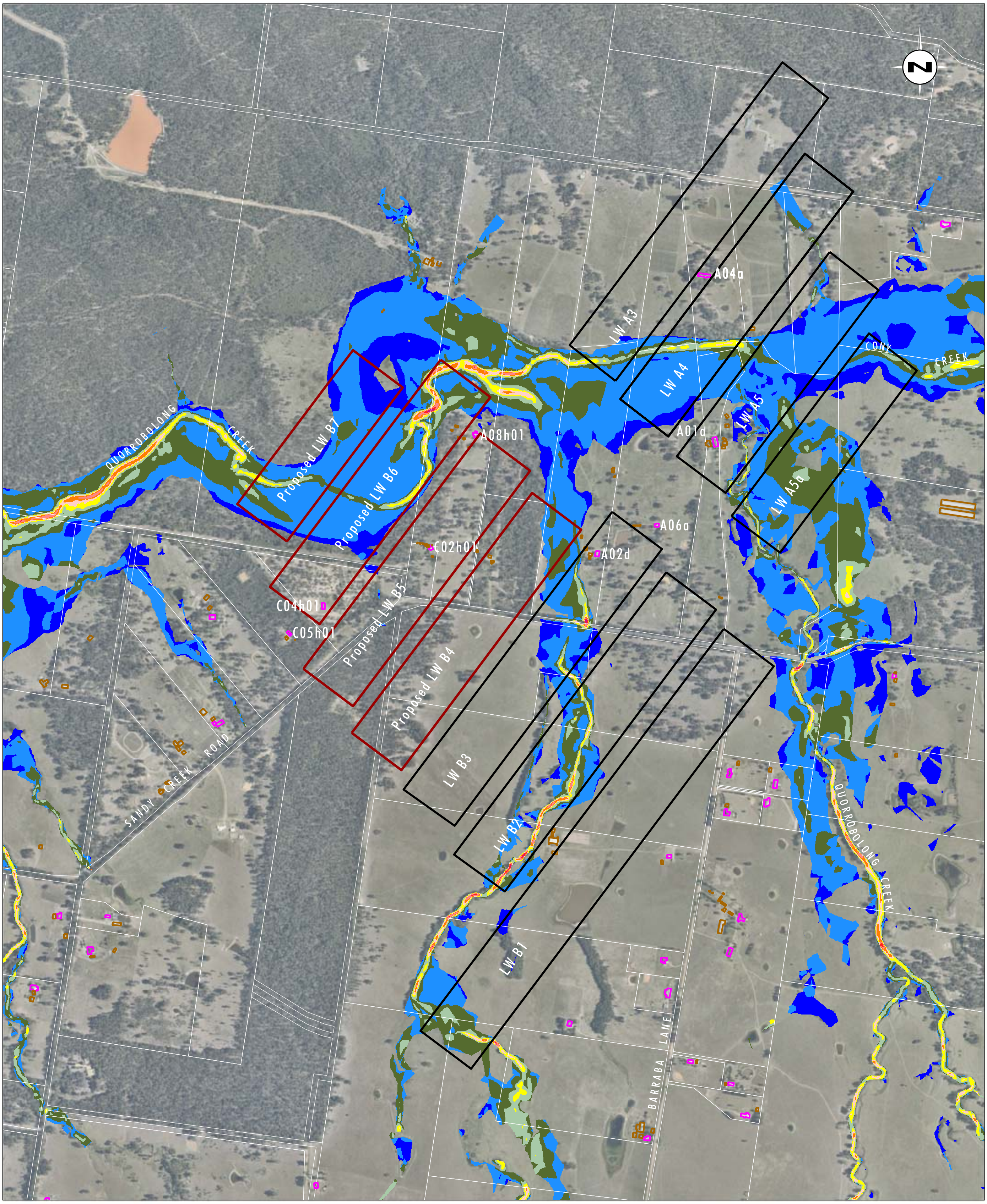


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Velocity (m/s)

- Range [0.100 : 0.250]
- Range [0.250 : 0.500]
- Range [0.500 : 0.750]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [1.250 : 1.500]
- Range [1.500 : 1.750]
- Range [1.750 : 2.000]
- Range [2.000 : 2.250]
- Range [2.250 : 3.000]

FIGURE B6

5% AEP Storm Event: Maximum Modelled Flow Velocities, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_053.dgn
20170516 11.32

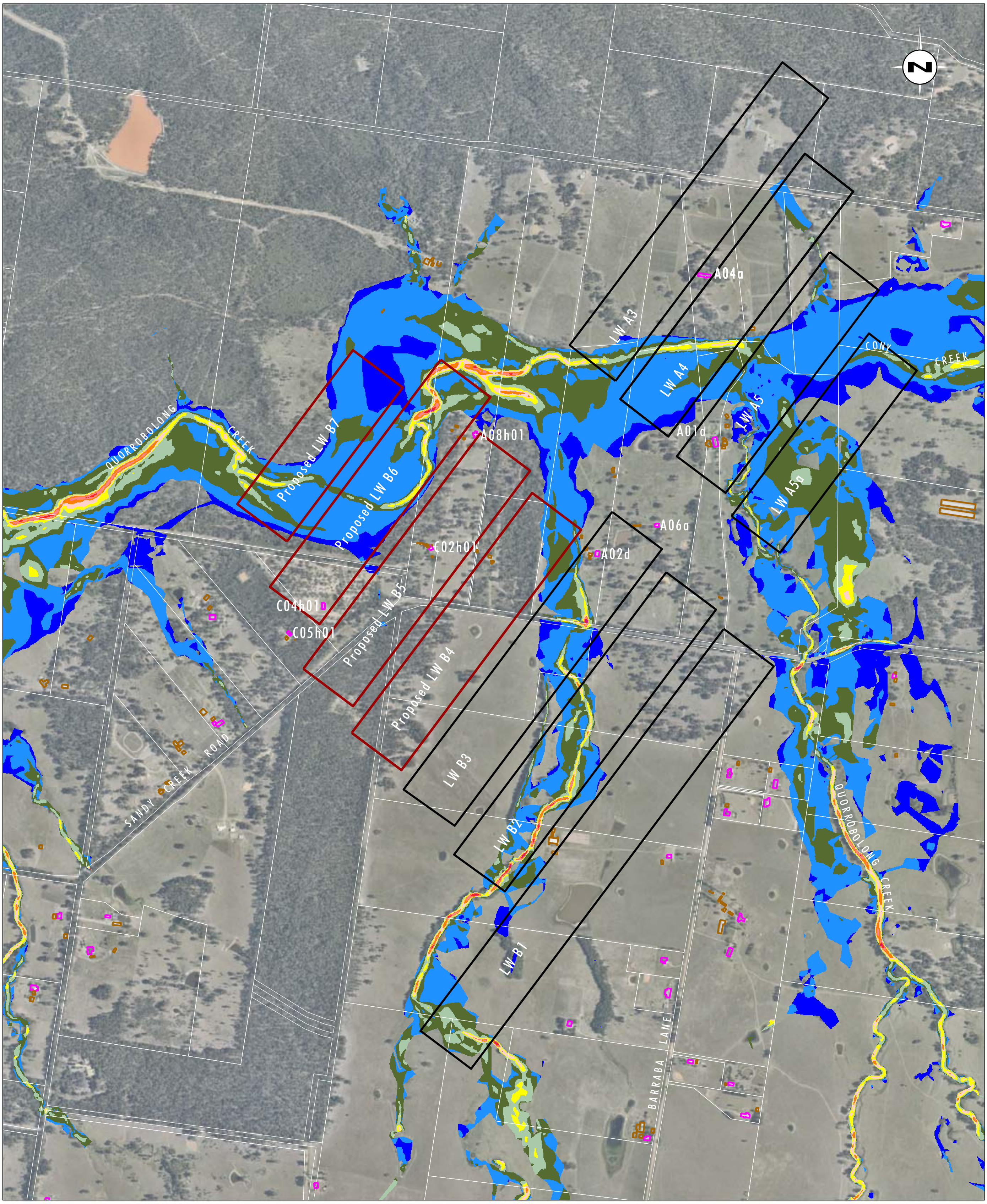


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Velocity (m/s)

- Range [0.100 : 0.250]
- Range [0.250 : 0.500]
- Range [0.500 : 0.750]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [1.250 : 1.500]
- Range [1.500 : 1.750]
- Range [1.750 : 2.000]
- Range [2.000 : 2.250]
- Range [2.250 : 3.000]

FIGURE B7

1% AEP Storm Event: Maximum Modelled Flow Velocities, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_052.dgn
20170516 11.31

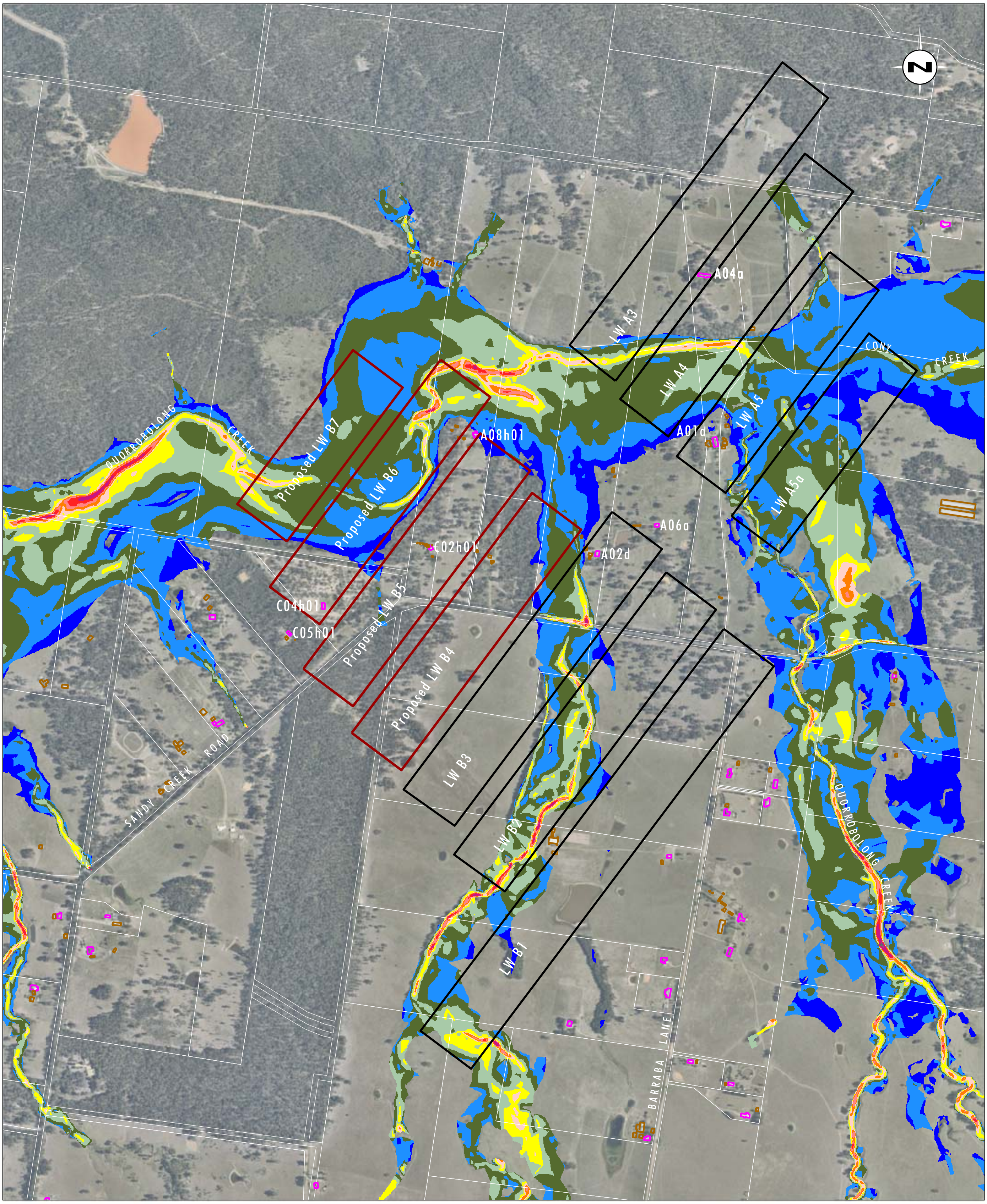


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Water Velocity (m/s)

- Range [0.100 : 0.250]
- Range [0.250 : 0.500]
- Range [0.500 : 0.750]
- Range [0.750 : 1.000]
- Range [1.000 : 1.250]
- Range [1.250 : 1.500]
- Range [1.500 : 1.750]
- Range [1.750 : 2.000]
- Range [2.000 : 2.250]
- Range [2.250 : 3.000]

FIGURE B8

PMF Event: Maximum Modelled Flow Velocities, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_054.dgn
20170516 11.33

umwelt

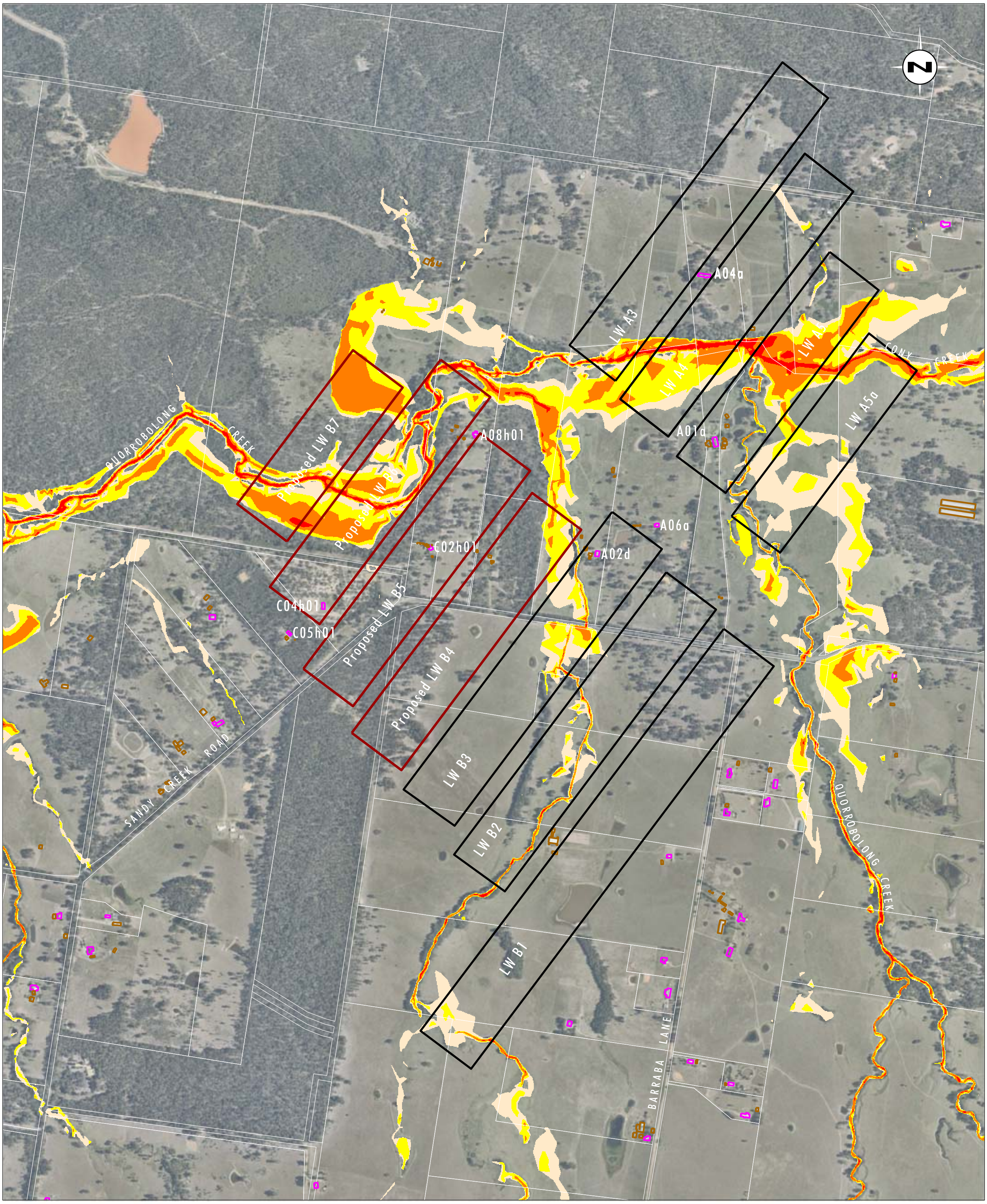


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE B9

100% AEP Storm Event: Maximum Modelled Flood Hazard, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_055.dgn
20170516 11.35

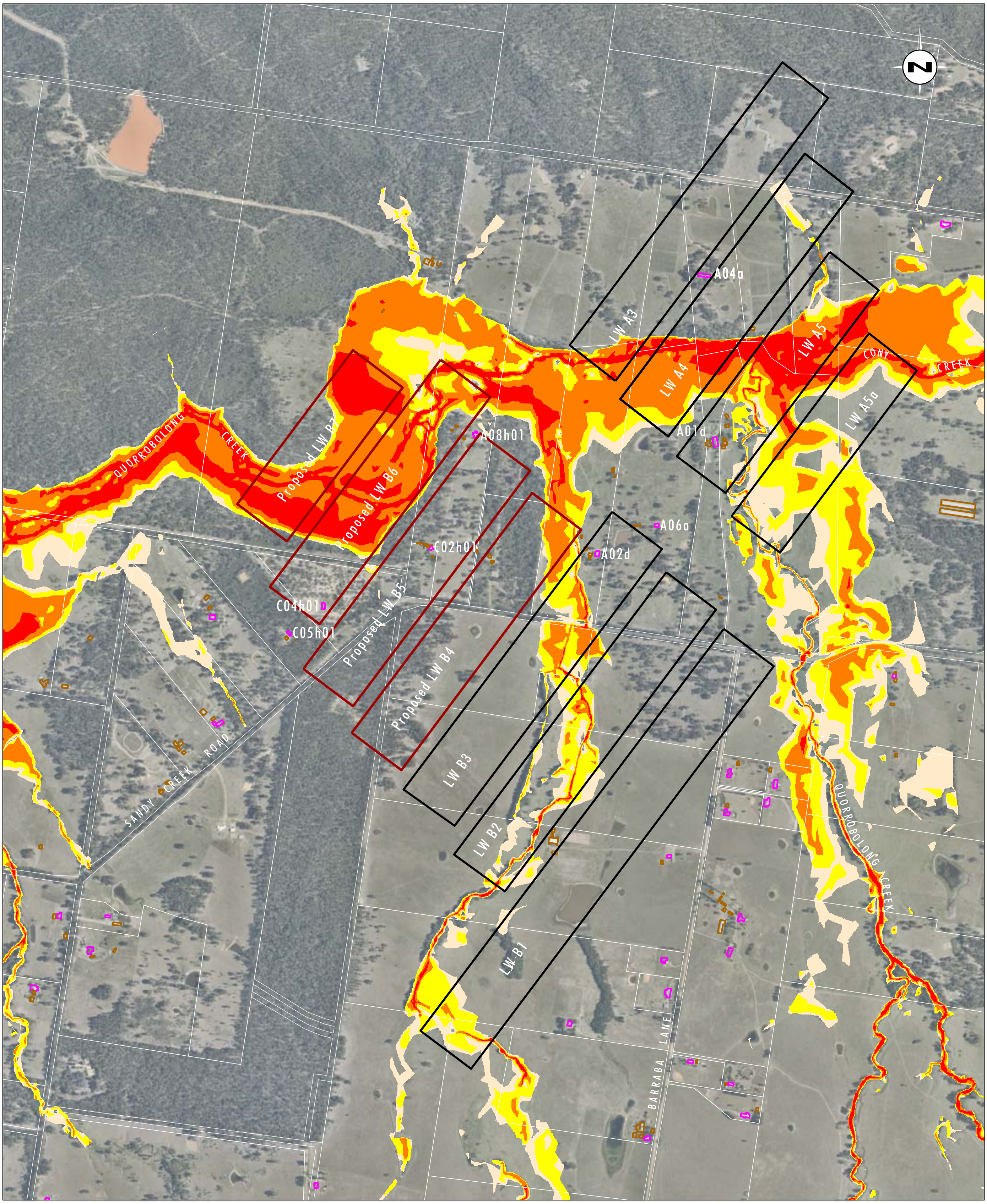


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE B10

5% AEP Storm Event: Maximum Modelled Flood Hazard, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_057.dgn
20170516 11.40

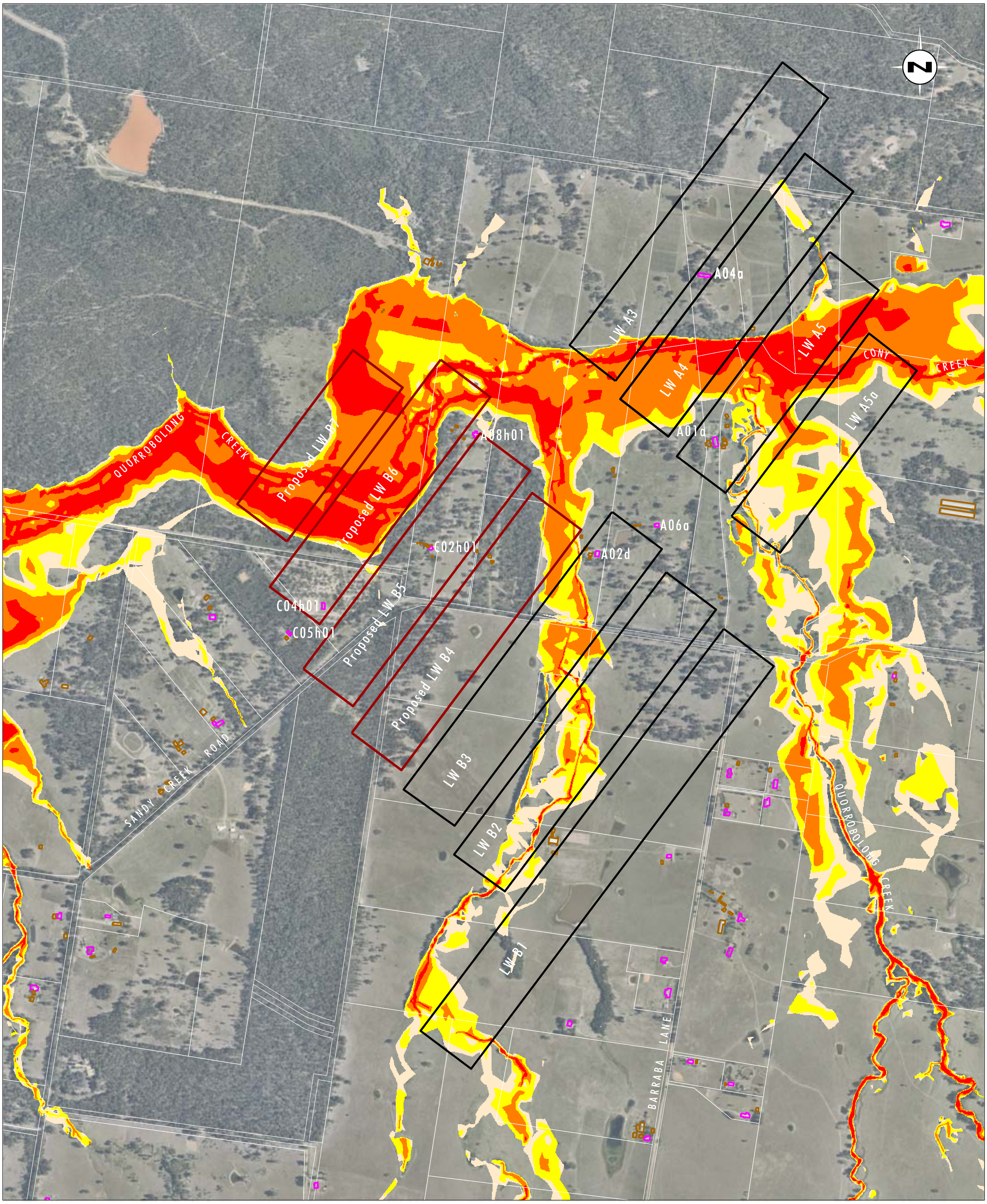


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE B11

1% AEP Storm Event: Maximum Modelled Flood Hazard, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_056.dgn
20170516 11.37

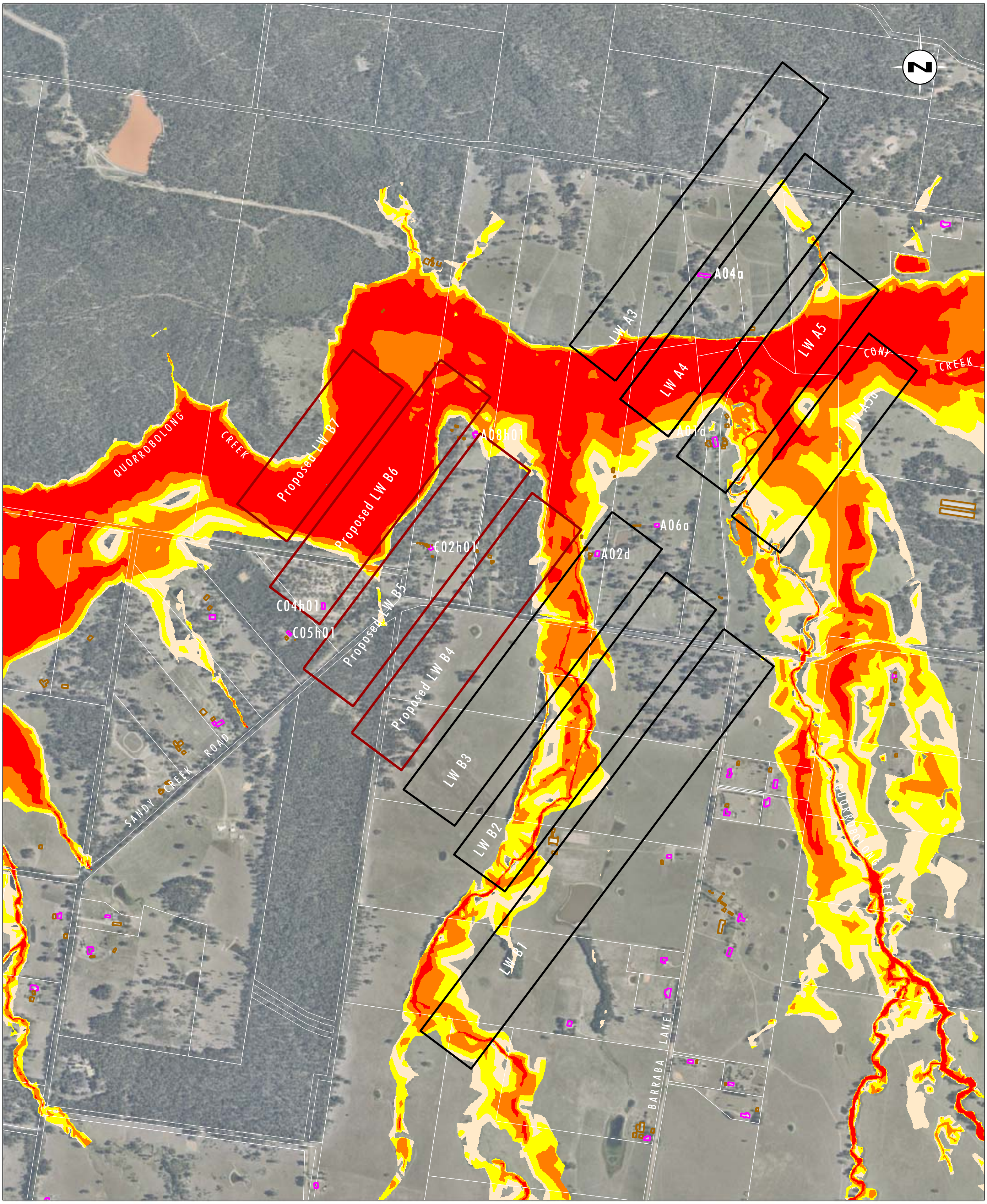


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure

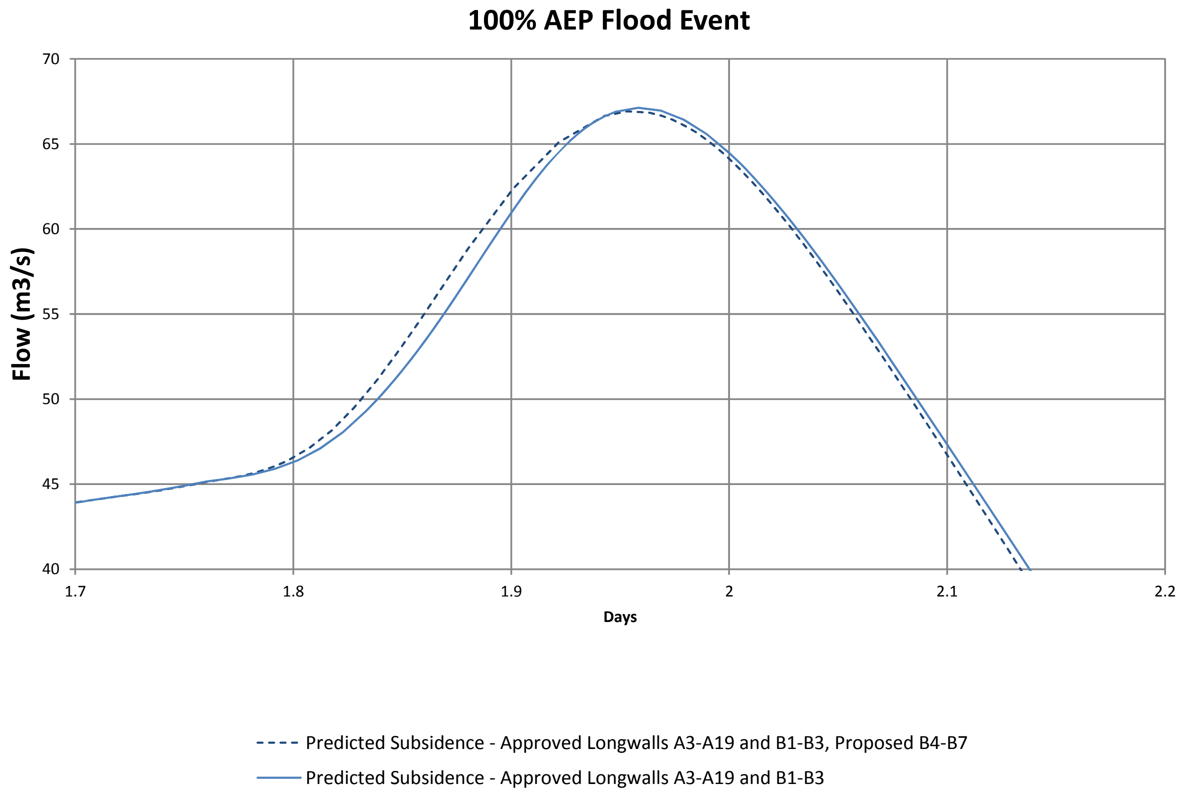
Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE B12

PMF Event: Maximum Modelled Flood Hazard, Predicted Subsidence Approved LWA3-A19 and LWB1-B3, Proposed LWB4-B7

File Name (A4): R03/3900_058.dgn
20170516 11.41



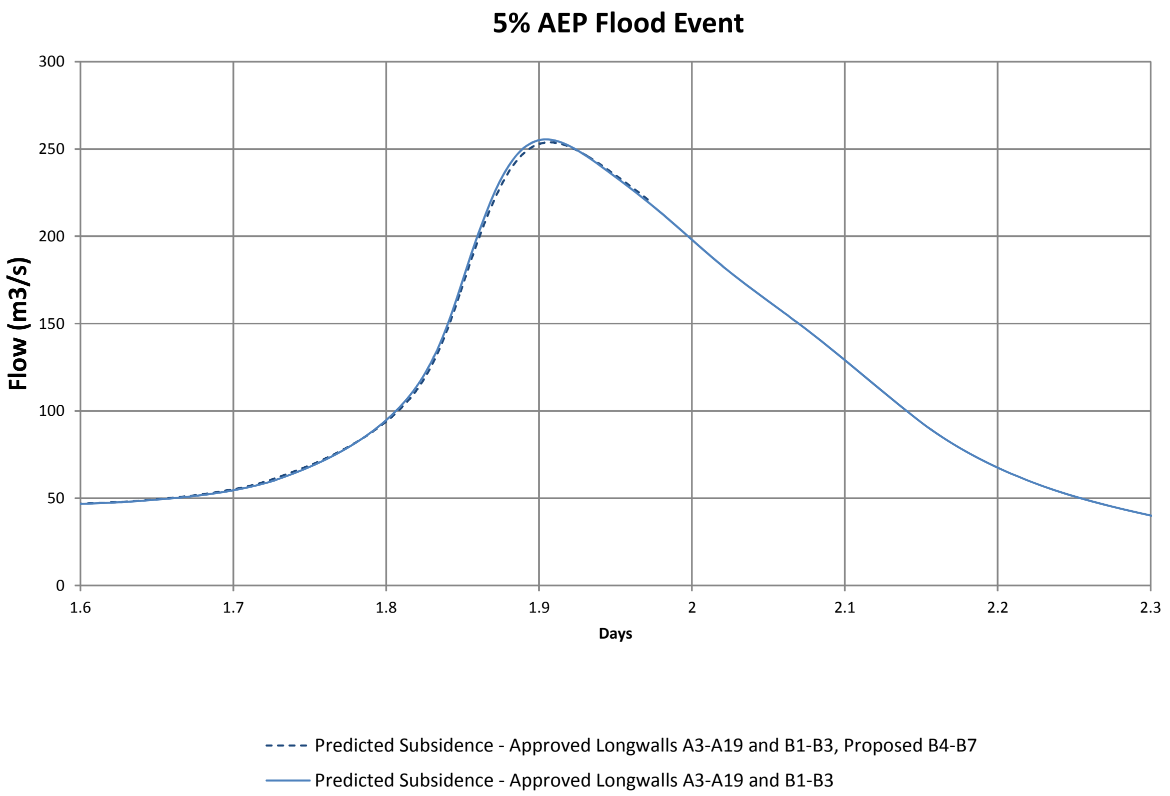
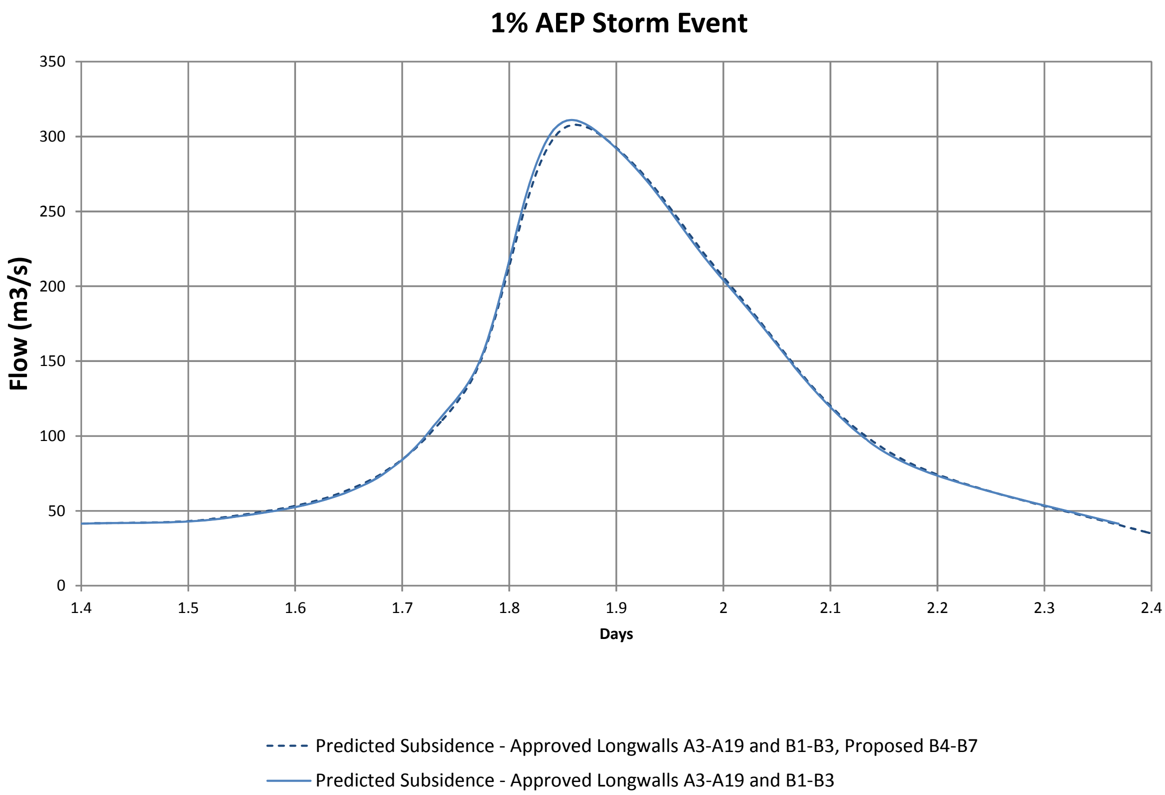


FIGURE B13

Predicted Flood Hydrographs 100% AEP and 5% AEP Storm Events, Quorrobolong Creek Downstream of Proposed LWB4-B7 Modification Area



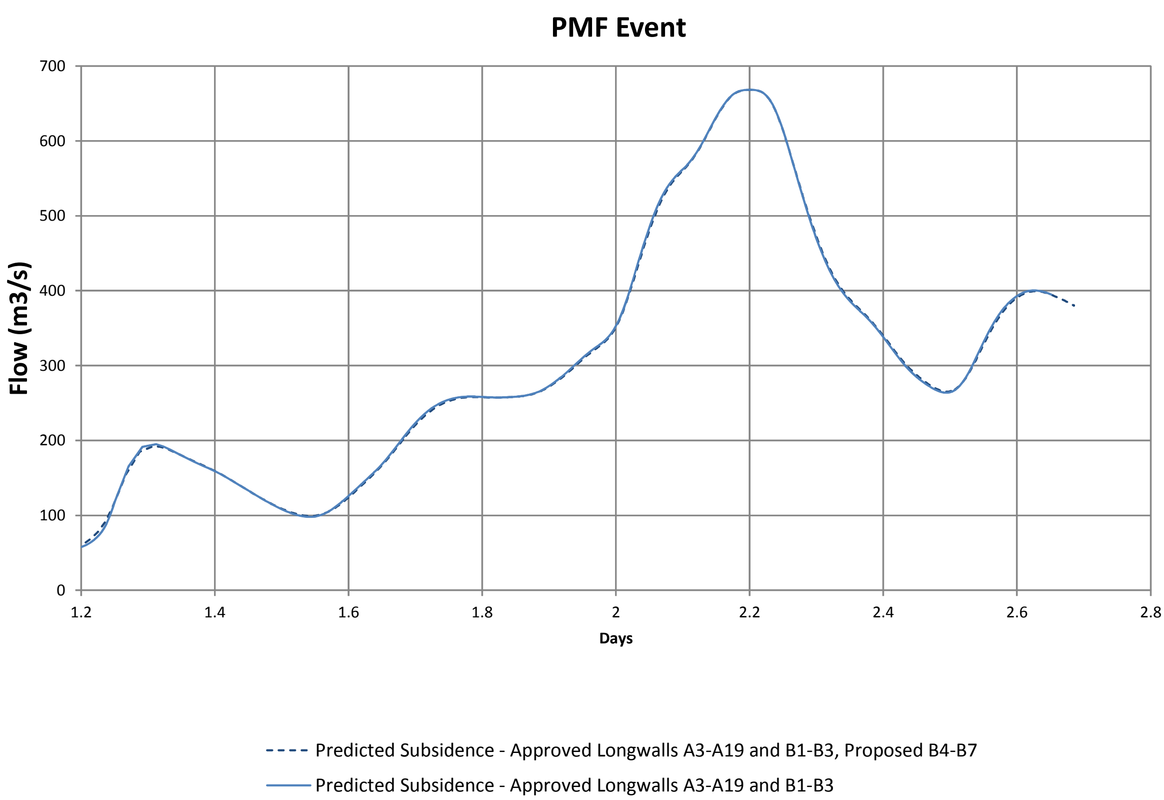


FIGURE B14

Predicted Flood Hydrographs 1% AEP and PMF Storm Events, Quorrobolong Creek Downstream of Proposed LWB4-B7 Modification Area

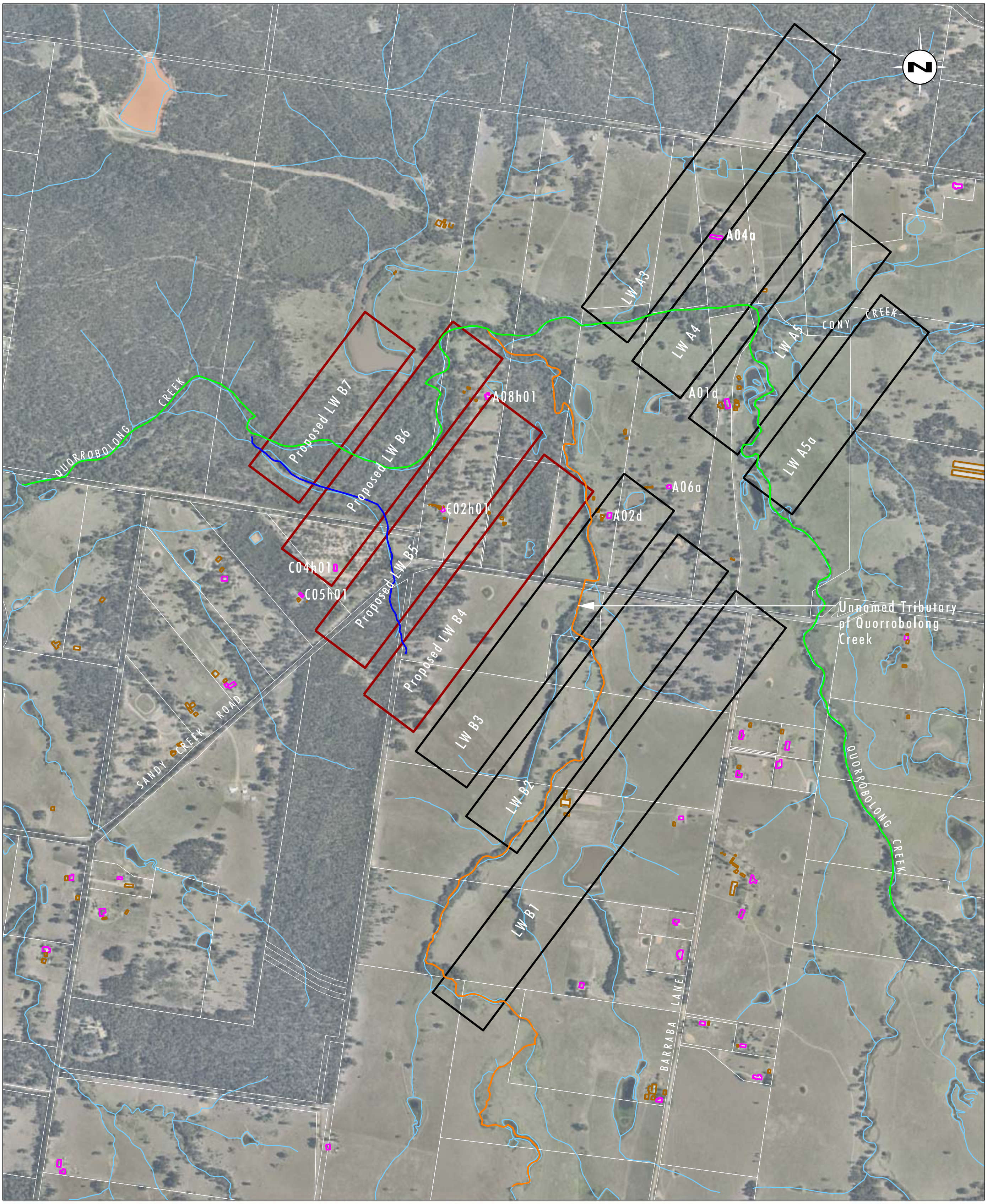


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

0 0.25 0.5 1.0km
1:20 000

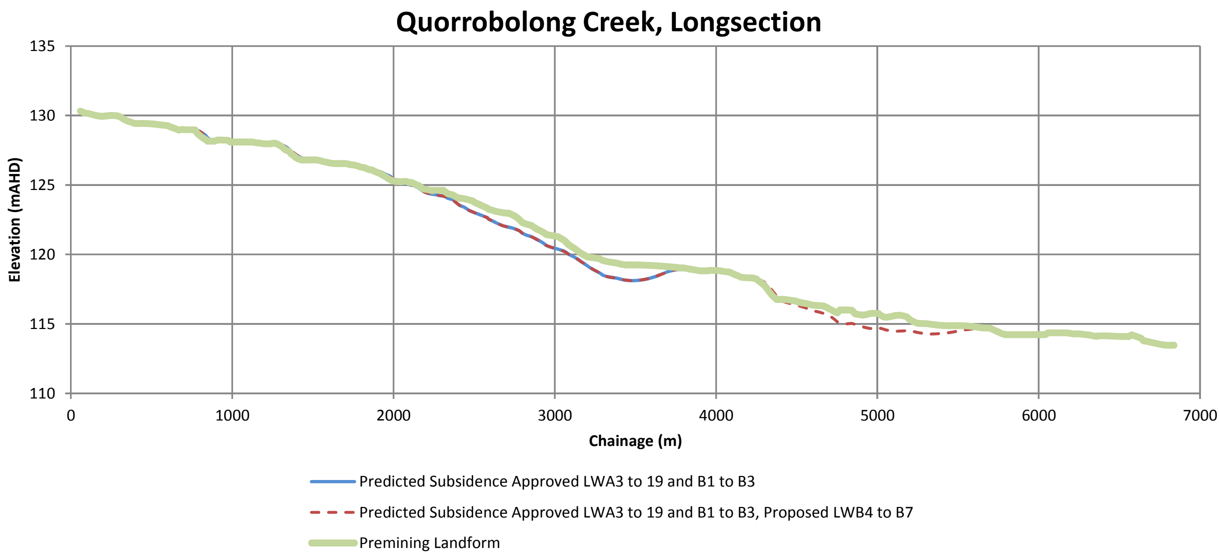
Legend

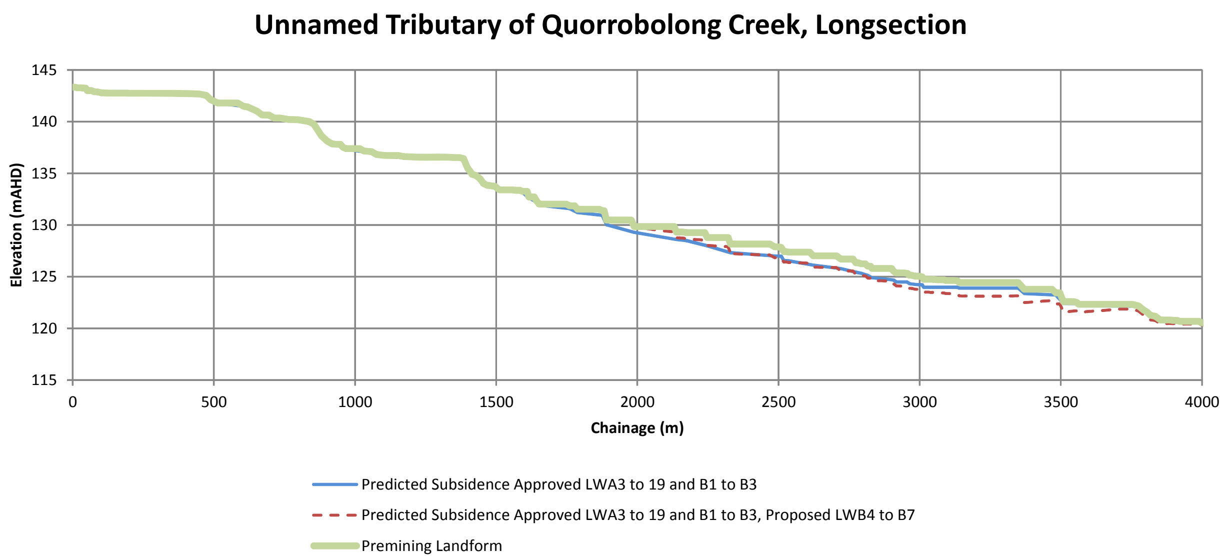
- Proposed LWB4-B7 Longwall Panels
- Approved LWA3-A19 and LWB1-B3 Longwall Panels
- Dwelling
- Other Structure
- Quorrobolong Creek
- 1st Order Tributary
- Unnamed Tributary of Quorrobolong Creek

FIGURE B15

Quorrobolong Creek and Unnamed Tributary of Quorrobolong Creek, Long Sections Plan View

File Name (A4): R03/3900_061.dgn
20170516 11.43





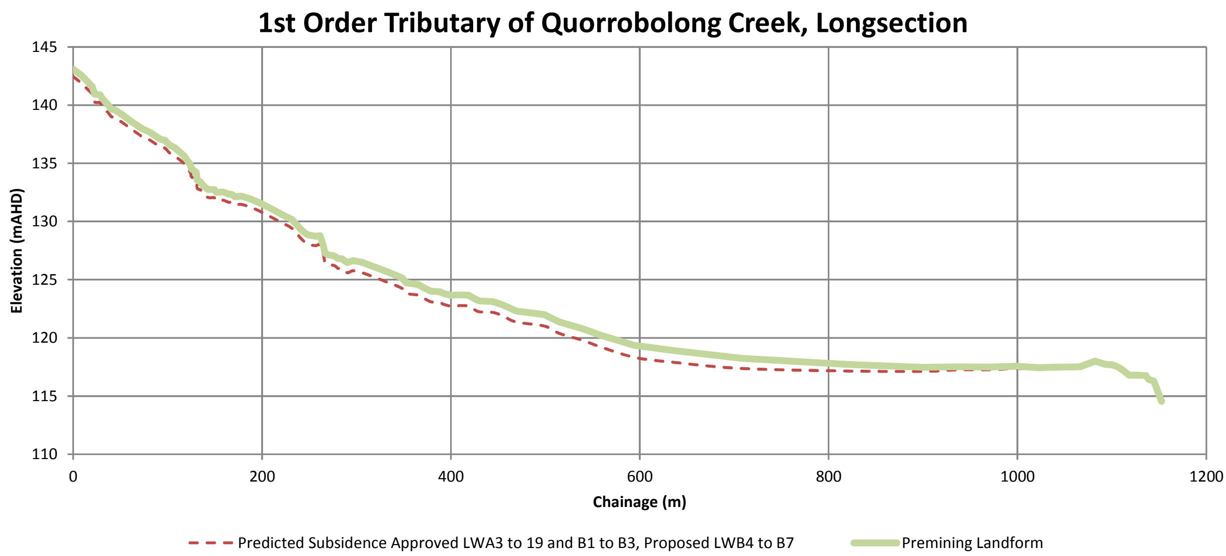


FIGURE B16

Quorrobolong Creek, Unnamed Tributary and 1st Order Tributary of Quorrobolong Creek Profiles

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APPENDIX 4

Groundwater Assessment

Dundon Consulting Pty Limited

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25 May 2017

Yancoal Australia Ltd
Level 26, 363 George Street
Sydney NSW 2000

Attention: Mark Jacobs

Dear Mark,

Re: Austar Coal Mine – LWB4-LWB7 Modification – Groundwater Assessment

1. Background

The Austar Coal Mine is an underground mine located about 10 km southwest of Cessnock in the Newcastle Coalfields of NSW. The Austar Coal Mine incorporates the former Pelton, Ellalong, Cessnock No. 1 (Kalingo) and Bellbird South Collieries and is located in an area which has been an active mining area over many years. The locations of the Austar Coal Mine and previous underground workings in the area are shown on **Figure 1**.

The Austar Coal Mine is owned by Yancoal Australia Limited (Yancoal), and operated by its wholly owned subsidiary Austar Coal Mine Pty Ltd (Austar). Following its purchase in 2004, Austar recommenced underground mining in the Bellbird South Colliery area in 2005 under Development Consent DA29/95 (the Bellbird South Consent), later employing the Longwall Top Coal Caving (LTCC) mining method after modifications to the Bellbird South Consent were approved. Austar has completed coal extraction from the Greta Seam from the Bellbird South Colliery area (Longwalls A1 and A2 in Stage 1, Longwalls A3 to A5A in Stage 2), and from the Austar Coal Mine Stage 3 area (Longwalls A7 and A8) employing the LTCC mining method. Austar has approval to mine Longwalls A9 to A19 in Stage 3.

Austar gained approval on 29 January 2016 to modify Development Consent DA29/95 to allow the transfer and processing of coal from three additional Longwalls LWB1, LWB2 and LWB3, which are located to the south of the previously mined Longwalls A2 to A5A and east of Longwalls 1 to 9A at the (former) Ellalong Colliery (**Figure 2**). Austar is now seeking approval for a further Modification to DA29/95 to allow mining and processing of coal from four further longwalls LWB4, LWB5, LWB6 and LWB7 (LWB4-B7 – the proposed Modification), which are located immediately to the north of the approved LWB1 to LWB3 (see **Figure 2**).

Umwelt (Australia) Pty Ltd (Umwelt) has been engaged by Yancoal to prepare an Environmental Assessment (EA) for the proposed Modification. This letter report presents a qualitative groundwater impact assessment for the proposed four additional longwall panels, which has been carried out by Dundon Consulting Pty Ltd to support the EA. A review of existing available groundwater information was carried out by Umwelt to support the preparation of this groundwater impact assessment.

2. Nature of the Modification

In summary, the proposed Modification comprises the following:

- transfer and processing of coal from LWB4-B7 via the existing Bellbird mains; and
- extending the development consent area of the Bellbird South Consent to encompass LWB4-B7 (the proposed Modification Area – refer to **Figure 2**).

No other changes to the approved mining operations or existing surface facilities are proposed as part of the modification.

The proposed longwalls will have void lengths of approximately 1,125 m (LWB4), 1,105 m (LWB5), 1,065 m (LWB6) and 725 m (LWB7), and a void width including first workings of approximately 237 m (MSEC, 2017). The Greta Seam thickness in the proposed Modification area ranges from 3.7 to 4.8 m, and it is proposed that a constant seam thickness of 3.4 m will be mined by conventional longwall mining methods.

The locations of the proposed LWB4 to LWB7 are shown on **Figure 2**.

3. Groundwater Impact Assessment Requirements

Umwelt has been engaged by Yancoal to prepare an EA to support the proposed Modification, and their scope of work included aspects of groundwater assessment, viz:

- Review existing Austar Coal Mine subsidence and groundwater monitoring data;
- Review the October 2007 Connell Wagner groundwater assessment for the Austar Coal Mine;
- Review the 2013 Aurecon groundwater verification report following completion of LWA5;
- Review the draft subsidence impact assessment for the proposed Modification;
- Collate relevant groundwater monitoring results; and
- Undertake preliminary assessment relevant to the proposed Modification.

The above groundwater review and preliminary assessment work has been carried out by Umwelt and provided to Dundon Consulting Pty Ltd as briefing material to support the preparation of a qualitative groundwater impact assessment for the proposed Modification by Dundon Consulting Pty Ltd.

4. Description of Existing Hydrogeological Environment

The existing hydrogeological environment has been extensively described in previous groundwater reports, including the RPS Aquaterra (2014) groundwater monitoring and modelling plan for EL6598, and the Connell Wagner (2007) groundwater impact assessment report on future mine development at the Austar Coal Mine. The summarised description of the existing hydrogeological environment below draws heavily on these documents supplemented by the results of groundwater monitoring.

4.1 Climate

The lower Hunter Valley area where the Austar Coal Mine is located experiences a warm temperate climate, with seasonal variations from hot wet summers to mild dry winters. Rainfall in the region is generally summer dominant, and rainfall is less than potential evaporation for most months of the year.

4.2 Topography and Drainage

The following general descriptions of the site topography and drainage are derived mainly from the 2008 Flooding and Drainage Assessment for Stage 3 (Umwelt, 2008).

The proposed longwall panels are located beneath the Quorrobolong Valley, within which the Quorrobolong Creek / Cony Creek drainage system flows in a westerly direction across the mine area, eventually flowing into Wollombi Brook which in turn flows into the Hunter River. The main drainages of the Quorrobolong Valley are Quorrobolong Creek, Cony Creek and Sandy Creek. These creeks are largely ephemeral and are often present as a series of disconnected pools during the dry season. The catchment area of the Quorrobolong valley upstream of the Ellalong Bridge (about 2 km west of the proposed Modification Area) is approximately 80 km^2.

The surface elevations within the valley floor are around 130 mAHD, while the elevation rises to around 440 mAHD at the Myall Range to the south and to around 200 mAHD at the Broken Back Range to the north.

The two northernmost proposed longwall panels (LWB6 and LWB7) partly underlie the main Quorrobolong Creek drainage. LWB4 and LWB5 are located beneath the southern flank of the valley, and the eastern end of LWB4 extends beneath the small alluvial floodplain associated with a small, unnamed, north-flowing tributary of the main system. The area within the valley floor has been predominantly cleared for grazing. The creek lines on the valley floor mostly support riparian vegetation.

4.3 Stratigraphy and Structural Geology

The Austar Coal Mine extracts coal from the Greta Coal Seam of the Late Permian aged Greta Coal Measures.

The Greta Coal Measures (GCM) comprises the Neath Sandstone, Kurri Kurri Conglomerate, Kitchener Formation (including the Greta Seam) and the Paxton Formation, and all units are predominantly sandstone, conglomerate and coal. The top of the GCM is about 20 m or so above the top of the Greta Seam.

The GCM is overlain by a thick sequence of sedimentary rock including conglomerate, sandstone and siltstone of the Branxton Formation, and other higher units of the Maitland Group, which extend from the coal measures to outcrop. The project stratigraphy is summarised in **Table 1**. The geology of the proposed Modification Area and surrounds is presented on **Figure 3**.

Table 1: Austar Coal Mine Stratigraphic Summary (after Hawley and Brunton, 1995)

Age	Stratigraphy		Lithology
Late Permian	Maitland Group	Mulbring Siltstone	Siltstone with minor claystone and sandstone lenses.
		Muree Sandstone	Sandstone with minor conglomerate and siltstone
		Branxton Formation	Conglomerate and sandstone towards base, siltstone becoming more common towards top
	Greta Coal Measures	Paxton Formation	Conglomerate and micaceous sandstone with minor claystone and siltstone beds. Coal (Pelton Coal Member) and coaly shale.
		Kitchener Formation (including the Greta Seam)	Coal with minor claystone, siltstone and sandstone
		Kurri Kurri Conglomerate	Orthoconglomerate, minor sandstone, siltstone, claystone and coal near base.
		Neath Sandstone	Sandstone, minor conglomerate siltstone and claystone
Early Permian	Dalwood Group	Farley Formation	Fossiliferous silty sandstone
		Rutherford Formation	Siltstone and minor sandstone, with thin limestone and marl horizons (Pokolbin area)
		Allandale Formation	Lithic sandstone and conglomerate containing abundant invertebrate fossils
		Lochinvar Formation	Poorly fossiliferous siltstone, claystone and sandstone and interbedded basalt flows.

Structurally the Austar Coal Mine is situated on the south-eastern limb of the Lochinvar Anticline. The Greta Seam outcrops to the north near Cessnock, and dips variably to the south-east with a general dip of around 5 to 6 degrees. Within the current mining area, the seam occurs at depths ranging up to 740 m. In the proposed Modification Area, the expected depth of cover will be between 400 m and 505 m (MSEC, 2017).

Seam thickness generally increases eastward with thicknesses of up to 7 m in the Stage 3 mining area, and it is known to split along the eastern margin of the current mine area, with an interburden lens of siltstone, claystone and sandstone known as the Kearsley Lens.

Extensive faulting and deformation is associated with the Lochinvar Anticline, with a number of prominent fault zones controlling the longwall panel layouts, notably the Swamp Fault Zone, Quorrobolong Fault and the Abernethy Fault Zone. Dykes are also present in the Austar Coal Mine and have been intersected in the historical and current workings. The most prominent of these, the Central Dyke, runs parallel with the Quorrobolong Fault and forms the eastern boundary of the Stage 2 mining area.

A thin veneer of colluvium is believed to occur over the lower valley slopes, grading into alluvium associated with the main creeks and tributary streams.

4.4 Hydrogeological Units

Within the proposed Modification Area, two aquifer systems are identified, firstly the unconsolidated surficial material that includes alluvium, colluvium and weathered bedrock, and secondly the Permian hard rock aquifer system. A third potential source of water that needs to be considered in the assessment of groundwater impacts is the water stored in abandoned mine voids (RPS, 2014; Connell Wagner, 2008).

The main sources of water that make up the groundwater regime relevant to the Austar Coal Mine operations and proposed developments in the area are as follows:

- Alluvial aquifer system associated with the Quorrobolong Creek / Cony Creek drainages and their tributaries (minor localised aquifer).
- Non-alluvial hard rock aquifers (referred to as fractured rock aquifers in previous Austar Coal Mine groundwater assessment reports, and now formally termed 'porous' rock aquifers). The principal water bearing components of the hard rock aquifer system are the coal seams, which are relatively more permeable than the interburden and overburden sediments. Some fractured zones are present within the upper parts of the Branxton Formation.
- Water stored within abandoned underground mine voids.

Groundwater within the alluvial aquifer in the proposed Modification Area is part of the Congewai Creek Management Zone of the Upper Wollombi Water Source and is regulated under the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (WSPHUAWS). The non-alluvial groundwater is regulated under the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources (WSPNCFPRGWS). Both the alluvial and non-alluvial groundwater are regulated by the *Water Management Act 2000*.

4.4.1 Alluvial Aquifer System

Distribution and Nature of Alluvium

The alluvial aquifer system comprises very poorly developed alluvial and/or colluvial/eluvial deposits within the floodplain of Quorrobolong Creek and its tributaries. For simplicity, these unconsolidated materials are loosely described collectively as "alluvium". The estimated areal extent of alluvium associated with these creeks as shown on **Figure 4** has been derived initially from the 1995 published 1:100,000 scale map of the Newcastle Coalfield Regional Geology, and refined by Umwelt from topographic analysis.

Quorrobolong Creek and its tributaries comprise a series of ephemeral creeks which only flow after consistent or heavy rainfall. The alluvium associated with these surface drainage features in the vicinity of the proposed modification is generally shallow and low yielding (Connell Wagner, 2007). This is evidenced from the drilling logs of a number of bores in the alluvial floodplain, viz:

- A DPI Water[1] monitoring bore (GW080974) located close to the southeast corner of the proposed modification area, in the alluvium of the unnamed tributary overlying LWB1-B3 (**Figure 4**). The log of this bore indicates the alluvium is 6 m thick in this location with a standing water level of 1 m and a yield of 2 L/s. Monitoring records for this bore from 2010 to 2014 (NOW on-line groundwater database) indicate a water level ranging between 0.5 and 2.3 m below ground level, suggesting a saturated alluvium thickness at this bore site varying seasonally between 3.7 and 5.5 m.
- Between 2006 and 2011, Austar installed four shallow monitoring bores – AQD1073A (GW202493), WBH1 (GW202494), WBH2 (GW202495) and WBH3 (GW202496) in the vicinity of Quorrobolong Creek to the east/northeast of the proposed Modification Area. Locations are shown on **Figure 4**. AQD1073A was drilled in July 2006, and WBH1 to WBH3 in July 2011. Logs of these bores record only silts and clays grading downwards into weathered siltstone and

[1] NSW Department of Primary Industries, water division. Previously known as NSW Office of Water (NOW).

fine-grained sandstone rock. RPS (2014) interpreted a thickness of alluvial sediments ranging up to 6.2 m in AQD1073A, WBH2 and WBH3, but the driller's logs and photographs of cores from AQD1073A suggest that most of the unconsolidated material drilled in these four bores would be better described as colluvium or residual soils (extremely weathered rock). The log of WBH1 indicates less than 1 m of alluvial or colluvial material.

- Austar installed a new monitoring bore MB03 within the alluvium overlying panel LWB2 on 2 July 2016. This was installed to monitor for any impacts from extraction of panel LWB2 on the alluvium of the unnamed tributary which traversed LWB1 to LWB3. The log of this bore shows an alluvium depth of 8 m. Groundwater level has ranged between 1.5 and 1.7 m below ground level over the period July to December 2016. This suggests a saturated alluvium thickness in this location of 6-6.5 m. The bore was screened from 1 to 9 m below surface, and gravel-packed between a bentonite seal at 0-1 m depth and the bottom of the hole at 10 m, so that the bore is open to the full alluvial sequence as well as the uppermost 2 m of Permian basement.

Groundwater Levels

Groundwater level hydrographs are plotted for all five alluvium monitoring bores on **Figure 5**. This figure also shows the Rainfall Cumulative Deviation (RCD) curve, which is a plot based on the difference between observed monthly total rainfalls and the long-term average monthly total rainfall, accumulated as a continuing total deviation between the two. In this case, the monthly rainfall data from the nearest reliable BOM station, ie Pokolbin Jacksons Hill Station No 061329 (approximately 10 km to the north of the Austar Coal Mine) were used to generate the RCD curve.

The RCD curve is a useful tool to assess whether there are any mining-induced impacts on the groundwater. In times of above average rainfall, the RCD will show an upward trend, while periods of below-average rainfall will result in a downward trend. The role of rainfall infiltration as a primary mechanism for groundwater recharge is shown by a similar trend in the groundwater level hydrographs. If there is an ongoing divergence over time in the trends between the groundwater levels and the RCD curve, it may indicate a mining-induced drawdown effect, which can be difficult to see otherwise because of short term fluctuations in groundwater level.

The RCD curve is superimposed on the hydrographs on **Figure 5**. It can be seen that over the period of monitoring, there is no noticeable divergence between the RCD trend and the groundwater level hydrograph trends, suggesting no mining related impacts have occurred.

Groundwater Quality

Monitoring data from the Austar Coal Mine monitoring bores indicates that the shallow groundwater intersected by these bores is of variable quality over time, with reported EC values ranging from 33 µS/cm to 8,491 µS/cm. A plot of EC versus time for the five alluvium monitoring bores is shown in **Figure 5**. AQD1073A has been monitored since June 2010, WBH1 to WBH3 since July 2011, and MB03 since September 2016.

Figure 5 shows that the EC was generally above 2,500 µS/cm between July 2010 and April 2011, then less 1,000 µS/cm between July 2011 and July 2015 (although the EC started to trend higher in late 2013), and from September 2015 EC started rising sharply. During 2016, EC was in the range 2,500 to 8,500 µS/cm in all bores. Bore MB03 located above LWB2 reported EC values above 4,000 µS/cm on both the occasions it has been sampled in the second half of 2016.

It has been suggested (AGE, 2016a) that the EC measurements before June 2016 may be unreliable due to the sampling methodology employed by a previous monitoring contractor. It is not possible to confirm whether the notably higher ECs after January 2016 are due to a changed sampling methodology, or whether there are other factors involved.

However, there is no evidence that the increase in EC is due to mining effects. The higher ECs since June 2016 are observed in all five bores, four of which are located in the main Quorrobolong Valley floodplain and the fifth of which is located within an unnamed tributary, and thus is in a different sub-catchment.

It is also noted that at the time of the rise in EC, there was no mining activity in Stage 3 (which underlies bores AQD1073A and WBH1 to WBH3); and the longwall extraction from LWB2 which underlies MB03 did not reach that bore until November 2016

The RCD curve is superimposed on the EC plots on **Figure 5**. Up until January 2016, there appeared to be a close (albeit inverse) relationship between the RCD curve and the EC trend, indicating that the groundwater salinity variations over time are probably related to recharge. In times of above average rainfall, and therefore active recharge, the groundwater salinity was lower than in times of low rainfall, and hence no or only limited recharge. However, the observations after January 2016 are not consistent with such a relationship. EC values are all higher than previously recorded, at a time when the RCD curve was rising or steady.

It is considered therefore that the changes in EC may be due to improved sampling methodology since June 2016, and that the prior EC values may be unreliable. This would mean that the prevailing salinity of surficial groundwater within the alluvium and regolith is higher than previously thought, and generally above 2,500 µS/cm EC.

Beneficial Use Potential

The alluvial/colluvial aquifer associated with Quorrobolong Creek and its tributaries within the proposed Modification Area is limited in extent and depth, and is associated with ephemeral streamflow. The groundwater quality is variable, and is susceptible to elevated salinities, at least in periods of low or no rainfall recharge, if not at all times.

The alluvial aquifer system is therefore not characterised as a “highly productive” groundwater source or a highly connected surface water source, as defined by the NSW Aquifer Interference Policy. The lack of registered bores within the area also indicates that the alluvial aquifer in the vicinity of the proposed Modification Area has limited potential for use as a water supply for stock, domestic or other consumptive purpose.

4.4.2 Non-alluvial Hard Rock Aquifer System

Distribution and Nature of Hard Rock Aquifer System

‘Porous rock’ aquifers within the Permian hard rocks are limited to the Branxton Formation and the Greta Coal Seam itself.

Branxton Formation

The Branxton Formation is part of the non-coal bearing marine sequence of the Maitland Group which overlies the Greta Coal Measures. The sandstone is generally strong and massive with a silica and or clay matrix. Due to the massive nature and very low interstitial permeability (<10^{-3} m/d) of the Branxton Formation it contains few if any major water bearing zones and is not likely to provide a viable source of groundwater (Connell Wagner, 2007). Nevertheless, zones of jointing or fracturing associated with major faults may form localised aquifers. The sequence has very low vertical permeability, and there is very little potential for leakage between any water-bearing zones or aquifers.

Two registered bores listed on the DPI Water groundwater database and located close to the eastern corner of the proposed Modification Area targeted the Branxton Formation strata. These were DPI Water monitoring bore GW080973 and private stock bore GW054676 shown on **Figure 4**.

Stock bore GW054676 was drilled to a depth of 39.6 m and intersected a shale water bearing zone between 10.1 m and 24.4 m below ground level. The bore reportedly (RPS, 2014) had a low yield (approximately 1 L/s) and poor water quality (10,000 to 16,000 µS/cm EC). The owner of bore GW054676 has advised Austar that the bore has been decommissioned and backfilled, as the water was too saline to use.

DPI Water monitoring bore GW080973 was drilled in September 1995 to a depth of 95 m and did not intersect any reported water bearing zones. DPI Water has advised that as the bore was dry, it was abandoned and backfilled.

DPI Water also has a monitoring bore GW080975 at a location approximately 35 m north of the LWB4 take-off line, which was drilled to a depth of 30 m, intersecting a low-yielding (1L/s) water-bearing zone in shale between 26 and 27 m below surface.

Drilling of coal investigation holes at the Austar Coal Mine indicates potential water-bearing zones in the Branxton Formation at a depth of around 100 to 130 m and at 170 m below ground level at bore locations across the mine area. Connell Wagner (2007) concluded that the importance of these water bearing zones as a water resource is likely to be minimal, since the water quality is poor (generally greater than 10,000 µS/cm EC) and the yield is low (generally less than 1 L/s).

Coal Measures

The Greta Coal Measures also have very low rock mass permeability (hydraulic conductivity less than 10^{-3} m/d), but they contain occasional layers which have slightly higher permeability (Connell Wagner, 2007), generally the coal seams and occasional fracture or bedding plane features.

The coal seams are normally relatively more permeable than the interburden lithologies due to the presence of cleats and fractures in the coal, and are therefore the main water-bearing zones in the coal measures. For this reason the coal seams represent the major 'aquifer' units purely by comparison with the much less permeable interburden strata, and their importance as an aquifer is generally minimal due to the poor quality groundwater as well as limited yield potential. Hitchcock (1995) concluded that the coal measures in the Newcastle Coalfield 'have a poor resource potential with low yielding aquifers of high salinity'.

Groundwater Levels / Pressures

In the vicinity of the proposed Modification, water levels are monitored at bore NER1010 (GW201408), which is located above and within the footprint of the proposed longwall panel LWB5, near its northern end. Bore NER1010 is a standpipe piezometer 102 m deep, and screened from 20 to 102 m in the Branxton Formation.

The water level hydrograph for NER1010 is shown on **Figure 6**. The water level in NER1010 is at around 15 to 25 m below ground surface, ie between 100 and 110 mAHD (**Figure 6**), deeper than the shallow alluvium/colluvium standpipe piezometers MB03, AQD1073A, WBH1, WBH2 and WBH3, where water level is within 10 m of the ground surface. The water level elevation at MB03 is around 126-127 mAHD, while at the other four bores it is around 120 to 124 mAHD (**Figure 5**).

Groundwater levels are clearly deeper in the Branxton Formation than in the surficial aquifer (alluvium/colluvium/regolith), showing that there is potential for downward percolation of water from the surficial groundwater into the underlying hard rocks, if hydraulic connection were to exist.

The RCD curve plotted on **Figure 6** shows a broad correlation with the overall trend on the NER1010 hydrograph. The hydrograph shows periodic rapid rises in water level in response to rainfall events and rapid recession, but these short-term features are superimposed on a more slowly trending rise in level during periods of rising RCD and decline during periods of falling RCD. A similar broad correlation between the hydrographs for the shallow surficial groundwater and the RCD can be seen, but the response in the hard rock groundwater is larger in magnitude. This is likely due to the much lower specific yield value for the hard rock relative to the alluvium/colluvium, and the actual volume of groundwater recharge occurring in the hard rock is likely to be very much less than in the surficial aquifer system.

Groundwater pressures at greater depth in the hard rocks have also been monitored at a number of multi-level vibrating piezometer bores, the closest to the proposed Modification Area being AQD1121, which is located about 1500 m east of the proposed LWB4 to B7 longwall panels, and two monitoring bores MB01 and MB02 located slightly further away (around 2500 m northeast), above the Stage 3 longwall panels (see locations on **Figure 4**).

MB01 and MB02 were installed in 2015, both screened in the Branxton Formation. MB01 is screened between 75 m and 174 m below ground level, which includes a groundwater inflow from a permeable zone intersected at a depth of 168 m. MB02 was installed in an existing deep exploration hole, which was grouted up to 140 m below surface and then casing and screen installed above that depth.

The water level in MB01 is more than 120 m below ground level (ie below around 40 mAHD), while in MB02 water level is around 14 to 16 m below ground level, at 117 to 119 mAHD.

MB01 and MB02 hydrographs are shown for the period 2015-2016 on **Figure 7** (together with the other bores in the monitoring network, both alluvium and Permian for comparison).

MB02 shows periodic responses to purging prior to sampling. Water level drops on 5 September, 29 September, 6 October and 3 November 2016 caused by purging prior to sample collection are clearly visible on the hydrograph (**Figure 7**). The slow water level recovery after each purging event is indicative of a low formation permeability. On each purging/sampling occasion, the water level has not yet fully recovered from the previous purging occasion to the pre-September 2016 water level.

A marked drawdown event occurred in MB01, starting on 19 August and still in progress four months later on 8 December 2016. **Figure 7** shows that the water level in MB01 started a sharp decline on 19 August 2016, coinciding with a vibration event that was recorded on the Austar Coal Mine vibration monitors. The bore is installed in close proximity to mapped faults, and it has been suggested by AGE (2017) that the water level decline may be due to draining of a fault of higher permeability which was intersected by the bore. Alternatively, it could be due to a partial formation collapse in the annulus, which may be blocking or restricting groundwater connection between the bore and the main zone of permeability at 168 m depth.

AQD1121 was installed in February 2015, and comprises 6 vibrating wire piezometers set at depths ranging from 280 to 617.8 m below surface (Douglas Partners, 2015). Depth of cover above the Greta Seam is 607 m.

Monitoring results are presented in **Figure 8**, which is a composite plot of hydrostatic head profiles for several dates between installation and the present time.

Figure 8 shows a number of relevant features:

- There is substantial depressurisation of the strata at depth, below at least 500 m, shown by the divergence of the hydrostatic head profile plots from the hydrostatic line which has a 45º slope as shown by the dotted lines on **Figure 8**.
- The hard rock strata are unlikely to be saturated above a depth of about 60-70 mAHD (ie about 80 m below surface), shown by projecting the hydrostatic head traces back to the zero piezometer pressure axis. There may be perched groundwater above this elevation, but the top of continuous saturation would be at around 60-70 mAHD.
- The greatest depressurisation is around the level of the Greta Seam, with the lowermost two piezometers showing about 300 m of depressurisation (ie 300 m displacement from the hydrostatic line.
- The two most recent dates plotted in **Figure 8** show substantial recovery in hydrostatic pressures in all but the two lowermost piezometers at and just below the Greta Seam. This recovery has occurred even at the piezometer located just 27 m above the Greta Seam roof, where the maximum hydrostatic pressure reduction of 300 m recorded in May 2015 has been reduced to a reduction of only 120 m by December 2016. No such recovery has been observed at the Greta Seam level.
- A temporary depressurisation of about 25 m had been seen at the 400 m level piezometer, which is 207 m above the Greta Seam roof. Subsequent monitoring showed that the pressures had fully recovered at this piezometer by August 2015, and by December 2016 were higher than pre-longwall extraction. The small depressurisation effect seen at the 400 m piezometer is interpreted to have been a temporary response to bed dilation rather than due to fracture effects extending to this height above the seam level. The bed dilation causes an increase in effective rock porosity, which is accompanied by a drop in water level as the water in storage redistributes into the increased available storage in the rock.

The AQD1121 water level data indicate that there is very limited or negligible hydraulic inter-connection between the groundwater in the hard rocks and surficial groundwater in the alluvium, colluvium and weathered bedrock zone. The AQD1121 pressure responses suggest that direct hydraulic connection from the goaf through the overlying strata following longwall extraction is likely to be minimal above 207 m above the seam.

Another vibrating wire piezometer monitoring AQD1077, where monitoring has now ceased as the piezometers failed following subsidence, was located approximately 3 km north from the northern end of the proposed LWB4-B7. Cover depth above the Greta Seam was approximately 440 m, and the piezometer showed similar results to AQD1121, with no noticeable depressurisation at the piezometer located 240 m above the Greta Seam.

The results from AQD1121 and AQD1077 indicate that there is unlikely to be direct hydraulic connection from the goaf to the ground surface following mining of the proposed LWB4-B7, where the depth of cover above the Greta Seam is expected to be between 400 m and 505 m.

Groundwater Quality

Water quality sampling from monitoring bore NER1010 has been undertaken quarterly since July 2010. MB01 and MB02 have only been monitored since June 2016.

The Permian groundwater salinities show a similar range to that in the surficial groundwater present in the alluvium, colluvium and weathered bedrock. EC in NER1010 ranged between 148 and 1658 µS/cm between July 2010 and September 2016 (**Figure 6**). However, the sample collected in December 2016 had a much higher EC at 5,203 µS/cm. Salinities in MB01 and MB02 in 2016 were in the range 6,000 to 7,500 µS/cm EC.

As with the alluvium bores, the higher salinity reported in NER1010 in December 2016 may be more representative of the Branxton Formation groundwater salinity, as suggested by AGE (2016a).

Former stock bore GW054676 was reported to have a salinity in the range 10,000 to 16,000 µS/cm EC (RPS, 2014), which is believed to be more typical of salinity in the Branxton Formation, away from sources of local recharge from rainfall infiltration.

Groundwater deeper in the Branxton Formation and in the Greta Coal Measures is saline to highly saline. Monitoring shows that water inflow to the Austar Coal Mine has high salinity and generally low pH, as well as elevated dissolved iron (Connell Wagner, 2007), as in **Table 2** below:

Table 2: Mine Water Quality Data (Connell Wagner, 2007)

Location	pH	EC (µS/cm)	Fe (mg/L)
Ellalong goaf (No 2 Shaft pump)	4.7	18,733	575
West Pelton goaf	6.8	8,350	52
East Pelton goaf	3.8	11,960	851
LW13 flank hole (adjacent to Kalingo workings)	3.8	15,382	507
LWA1 13 C/T flank hole (adjacent to Aberdare Central workings)	3.9	11,823	1,700

The sources listed in **Table 2** are all believed to comprise a mixture of in situ groundwater and stored water, and the water stored in former mine workings has probably undergone some increase in salinity over time, but the salinity is ultimately derived primarily from the in situ groundwater within the coal measures.

Beneficial Use Potential

Based on generally low formation permeability and poor water quality, the porous rock groundwater sources within the proposed Modification Area are not characterised as “highly productive” groundwater sources, as defined by the NSW Aquifer Interference Policy as they do not meet the water quality and yield requirements for highly productive groundwater sources.

4.4.3 Water Stored in Former Mine Voids

There is a long history of underground mining in the region around the Austar Coal Mine. **Figure 1** shows a number of former mine workings (voids) adjacent to the Austar Coal Mine which are partially filled with water. Austar uses some of these voids as part of its approved water management strategy described in the Austar Site Water Management Plan (Austar, 2013). Austar returns excess mine water to former mine workings located up dip of Austar’s current operations.

The quality of water in these old mine workings is extremely poor as evidenced by groundwater quality data obtained for water entering Austar workings through coal barriers from old workings. These data (**Table 2**) show salinity values of 8,350 to 18,733 µS/cm or greater with pH generally ranging between 3.8 and 6.8 (Connell Wagner, 2007).

Consequently, while the yield of these abandoned mine voids would theoretically satisfy the definition of a highly productive aquifer, the quality of the water within the old workings means it has limited beneficial use potential.

5. Potential Impacts of the Modification

5.1 Impact Assessment Methodology

A comprehensive groundwater assessment for the Austar Coal Mine was prepared by Ian Forster of Connell Wagner in October 2007. This assessment is supported by a verification review of groundwater impacts following the completion of LWA5 in the Stage 2 mining area undertaken by Aurecon in 2013, and by groundwater monitoring undertaken within the Stage 2 and Stage 3 mining areas.

Based on the findings of these previous groundwater investigations and ongoing groundwater monitoring at Austar Coal Mine, assessment of groundwater impacts for the proposed modification has been based on review of past and current monitoring above and surrounding current and prior underground mining areas. This review shows no adverse impacts on any high quality water resource or beneficial user. In addition, the proposed modification is encompassed within an area that has already been extensively mined. Recent approval applications at Austar Coal Mine have been based on similar empirical assessments of groundwater impacts, and this is an appropriate assessment approach for the proposed modification, as further discussed below.

Historical mining has occurred in a number of surrounding collieries resulting in previous depressurisation of the coal seam. The locations of former collieries are shown on **Figure 1**. After completion of mining at these nearby mines, groundwater has been allowed to inflow to the goaf areas, allowing partial recovery in groundwater levels within the coal measures, but the monitoring undertaken by Austar has shown that recovery is still incomplete.

The currently active mining areas at the Austar Coal Mine comprise several interconnected mining areas to the south (downdip) of the historical mining areas (Pelton, Kalingo, Bellbird, Aberdare Central, Aberdare South and others at greater distance). The historical mines are physically disconnected from the Austar Coal Mine workings, being separated from them by unmined barriers which range from 40m (Pelton) to 100m (Kalingo) to greater than 250m (Aberdare Central and Aberdare South, and others more distant). Limited hydraulic connection to the Austar Coal Mine workings occurs through the barriers, via the Greta coal seam and to a lesser extent the near roof and floor coal measures sediments.

Mining at the Austar Coal Mine (and its predecessor Southland Colliery and Ellalong Colliery) has been ongoing for many years, and includes the Ellalong longwall panels which were mined between 1983 and 1988, and the Bellbird South longwalls (Southland and Austar Coal Mine Stages 1 and 2) between 1999 and 2013. Austar Coal Mine Stage 3 was commenced in 2013, and longwall panels LWA7 and LWA8 were completed before mining proceeded to the LWB1 to LWB3 mining area, located between Austar Coal Mine Stage 2 and the Ellalong mine area, and immediately to the south of the four longwalls proposed in the current modification (LWB4 to LWB7) (**Figure 1**).

Thus the proposed LWB4-B7 panels are completely surrounded by interconnected longwall panel areas of the Austar Coal Mine itself.

Within the Austar Coal Mine workings, groundwater levels/pressures in the Greta Seam are at similar or lower elevations than the seam floor level in the proposed LWB4-B7 panels. Therefore, the groundwater levels/pressures in the Greta Seam and the coal measures generally would already be substantially lowered before mining starts in LWB4-B7, particularly as a result of the prior mining of LWB1-B3 immediately south of and downdip of LWB4-B7.

The Greta Seam floor elevations in LWB4-B7 range from -385 mAHD to -285 mAHD, whereas the seam floor levels range to as low as -405 mAHD and -420 mAHD in LWB2 and LWB3 respectively. As LWB2 and LWB3 will be mined out before LWB4-B7 are commenced, there will be minimal groundwater remaining in the Greta Seam in LWB4-B7.

Consequently, the additional impacts from the proposed Modification overall are anticipated to be quite small. No increase in groundwater inflows is anticipated, and all water takes would be able to be accounted through existing licensing held by Austar. No adverse impacts on the alluvial groundwater have been observed to date, including the main alluvial floodplain of Quorrobolong Valley which directly overlies extracted longwall panels LWA3 to LWA5a, where monitoring bores have shown no change to groundwater levels associated with the mining of these four panels.

Accordingly, as there have been no adverse impacts on groundwater from mining to date, and for the reasons outlined above, the incremental impacts that may occur with the proposed modification are expected to be negligible. Consequently, we consider that the use of a numerical groundwater model is not warranted. Further, the magnitude of incremental impacts which could potentially occur as a result of the proposed Modification, as discussed in the following sections, are expected to be of similar order to or less than the typical uncertainty range associated with numerical groundwater models.

Following an empirical approach as for previous impact assessments, the possible incremental impacts associated with the proposed modification are discussed in the following sections.

5.1 Predicted Subsidence Impacts

MSEC (2017) has assessed the likely subsidence impacts of the proposed Modification. MSEC's main findings which have a bearing on potential groundwater impacts are summarised as follows:

- The depth of cover to the Greta Seam above the proposed longwalls LWB4, LWB5, LWB6 and LWB7 varies between a minimum of 400 m to a maximum of 505 m.
- The Greta Seam thickness within the mining area ranges from 3.7 to 4.8 m, and it is proposed that a constant seam thickness of 3.4 m will be mined by conventional longwall mining methods in the Modification Area.
- Maximum predicted surface subsidence magnitudes for the proposed longwalls are 1250 mm above LWB4, 1250 mm above LWB5, 1050 mm above LWB6 and 750 mm above LWB7.
- Further subsidence is predicted to occur above LWB1-B3, above what was predicted for LWB1-B3 in the previous MOD, as a result of the additional longwall panels.
- The cumulative predicted surface subsidence magnitudes are 1200 mm after extraction of LWB4, 1250 mm after extraction of LWB5, and 1350 mm after extraction of LWB6 and LWB7. The maximum predicted value of 1350 mm represents about 39% of the extraction thickness of 3.4 m and occurs over LWB3 as a result of the extraction of LWB1 to LWB7 (i.e. total cumulative predicted vertical subsidence).
- Predicted far-field horizontal movements resulting from extraction of the proposed longwall panels are very small.
- In relation to rock fracturing above the extracted panels, four deformation zones have been suggested by MSEC, viz
    - Caved or collapsed zone – loose blocks of rock detached from the seam roof, likely to contain large void spaces
    - Disturbed or fractured zone – in situ material that has sagged and suffered significant bending, fracturing, joint opening and bed separation, leading to large increases in both horizontal and particularly vertical permeability
    - Constrained or aquiclude zone – confined rock above the disturbed zone which has experienced insufficient disturbance to suffer significant fracturing or alteration of the original physical rock properties. Some bed separation and discontinuous vertical fracturing can occur. Some increase in horizontal permeability can occur, but minimal change to vertical permeability.
    - Surface zone – unconfined strata at the ground surface that can experience surface cracking or heaving, but no deep connective cracking.
- At the Austar Coal Mine, the combination of large cover depths and the bridging properties of the thick sandstones of the Branxton Formation limit the upward extent of connective cracking (ie **the disturbed or fractured zone**) above extracted longwall panels. Extensometers installed above panels LWA1 and LWA2 showed vertical fractured heights of 85 m for extensometer AQD1074 above LWA1, and 150 m for extensometer AQD1085 above LWA2. Similar heights are expected above the proposed LWB4-B7.
- The height of discontinuous fracturing above LWB4-B7 (ie **the constrained or aquiclude zone**) could extend to between 235 m and 355 m above the seam. This is well short of the

ground surface (between 400 and 505 m above the seam) at the four proposed longwalls. Hence, the zone of discontinuous fracturing is not expected to reach the ground surface.

- Surface cracking (ie **the surface zone**) in the soils above the proposed longwalls is not expected to be observed, based on the depth of cover, and observations of prior panel extractions at the Austar Coal Mine. Any surface cracking that might occur in the creek beds above the panels is expected to be minor and to infill naturally with subsequent streamflow events.

5.2 Mine Water Inflows

Mine inflows at the Austar Coal Mine are complex, and include water released from the coal measures and water stored in voids in abandoned former mine workings adjacent to the Austar Coal Mine. The contribution from old mine voids has been identified by Austar, as inflows were more prominent along the barriers between the Austar Coal Mine and the nearest former workings. Water from the former mines enters the Austar Coal Mine workings primarily through the Greta Coal Seam, which makes it difficult to distinguish from the contribution coming from dewatering of the coal seam and the floor and roof sediments.

Attempts have been made to quantify the contributions from in situ groundwater and void storages respectively. The most recent assessment was that reported in the 2013 draft groundwater verification review by Aurecon after completion of longwall LWA5 (Aurecon, 2013).

Aurecon (2013) commented that "... total water make is a noisy dataset, with numerous peaks and troughs". They reported that fluctuations are due principally to the location of mining activity. They note that net inflow increases when headings are being driven into new areas initially, and that after initial increases after new ground has been entered by the drives, the incremental increase in inflow rate tails off fairly quickly. They also note that there is usually not a noticeable increase in inflow rate when major geological structures are encountered in the mine, but rather when new areas are entered by the development headings.

Aurecon (2013) also concluded that cumulative water make by the mine has climbed fairly steadily over time. This would undoubtedly be due to the fact that mining is progressively extending into new areas generally down-dip to the south and southeast, creating exposure to more groundwater in the newly opened up mine areas.

Aurecon (2013) concluded that after each new increase in water inflow associated with drivage into a new area, the inflow rate settled down to a base level that was essentially the rate of seepage through the barriers from the water stored in voids in the adjacent former mine workings. They noted that at the time of their report, the base level of inflow was on a slow increasing trend over time.

In keeping with past experience at the Austar Coal Mine, it is expected that the proposed Modification will result in minimal increase in total water inflow to the mine, as the proposed panels are updip from the current LWB1 to LWB3 panels, into areas that are already substantially depressurised.

5.3 Impacts on Groundwater Levels / Pressures

5.3.1 Alluvium and Regolith

The proposed longwalls partly underlie the Quorrobolong Valley alluvial floodplain, and partly the alluvium associated with an unnamed tributary of Quorrobolong Creek. The very north-eastern end of LWB4 extends about 170 m beneath the tributary alluvium, while LWB6 and LWB7 both substantially underlie the main Quorrobolong Creek alluvium (**Figure 1**).

The impacts of previous mining on other parts of both of these alluvial areas provides confidence that the proposed extraction from LWB4 to LWB7 will have no noticeable impact on the alluvial groundwater resources.

Bore MB03 was installed in the alluvium of the unnamed tributary of Quorrobolong Creek at a location above LWB2. This bore was installed purely for the purpose of observing any impact from the extraction of the approved LWB1 to LWB3.

Longwall extraction from LWB2 started in July 2016 and was completed in February 2017. The panel face passed beneath the location of MB03 in November 2016. Water level monitoring in MB03 started in August 2016, 3 months before the longwall passed beneath the bore. The hydrograph

(**Figure 5**) shows the water level following a trend related solely to the rainfall pattern and has an identical trend with the other alluvial bores nearby, as well as the trend on the RCD curve. There is no interruption to this trend as the longwall passed beneath MB03. Monitoring confirmed that the mining of LWB2 produced subsidence of less than 150 mm at MB03. There is no visible subsidence trough in the alluvium above LWB2. No change in water level accompanying the onset of subsidence can be identified on the MB03 hydrograph.

Previously, mining of LWA4 and LWA5 had undermined the alluvium/colluvium monitoring bores AQD1073A, WBH1, WBH2 and WBH3 in March 2011 (LWA4) and August-October 2011 (LWA5), using the LTCC method. In that case also, the mining caused no observable drawdown of water levels in the surficial groundwater of the alluvium.

Based on these results, with a similar depth of cover above the proposed longwalls and a reduced extraction height (i.e. conventional longwall only) compared with the LTCC method, it is expected that the proposed Modification will have no adverse effect on groundwater levels in the surficial aquifer system.

A large part of LWB6 and LWB7 underlie the main Quorrobolong Valley alluvium, and a very small section of LWB4 underlies the alluvium associated with the unnamed tributary (**Figure 4**). Maximum cumulative surface subsidence predictions of 1250 mm above LWB4 and LWB5, 1050 mm above LWB6 and 750 mm above LWB7 (MSEC, 2017) mean that some of the alluvial floodplain will develop shallow subsidence troughs.

The parts of LWB1, LWB2 and LWB3 which underlie the unnamed tributary are also likely to develop slightly deeper subsidence troughs than previously predicted (Dundon, 2016), as a result of the proposal. To date, LWB2 has been completed, and Austar has advised (Mulhearn, pers comm) that up to 16 February 2017, maximum subsidence of 170 mm had been detected at the centreline of LWB2 within the alluvium associated with the tributary, but with no observable subsidence trough. This is slightly less than the 250 mm subsidence predicted after completion of LWB2 (MESC, 2016).

Within these troughs, there will likely be an initial drop in groundwater levels, as the base of the alluvium will subside by a similar magnitude to the ground surface. This decline in water levels will not represent a loss of groundwater from the alluvium, merely a drop in the aquifer as a whole. Experience elsewhere has shown that groundwater levels within the subsidence trough will quickly rise to re-establish equilibrium with the adjacent sections of the alluvium outside the subsidence zone, resulting in a greater thickness of saturated alluvium, and a shallower depth to the water table, with the water table re-establishing at about the same absolute elevation (in mAHD) as pre-extraction conditions.

No drop in groundwater level has been observed in monitoring bore MB03 coinciding with the subsidence above LWB2.

Apart from this small localised beneficial impact, no noticeable change in groundwater levels will be observed in the alluvium/colluvium/regolith aquifer after completion of the proposed Modification.

5.3.2 Branxton Formation

The bulk of the sediments overlying the Greta Seam are from the Branxton Formation.

The main water-bearing zones within the Branxton Formation are within the first 50 m or so below the base of weathering. Standpipe piezometer NER1010, which is located within the footprint of the proposed LWB5, monitors groundwater within the uppermost 100 m (approximately) of the Branxton Formation, and is screened from 20 to 102 m depth.

Groundwater is present at deeper levels of the Branxton Formation, in zones of fracturing. Bores MB01 and MB02 monitor deeper parts of the Branxton Formation above the Stage 3 mining area. They are located ahead of the completed longwall panels in Stage 3.

Water levels and salinity (EC) monitored in NER1010, MB01 and MB03 are plotted on **Figure 7**. This figure shows that the EC of groundwater in NER1010 is similar to the EC of groundwater in the shallow alluvium/colluvium/regolith bores, and like the alluvium showed generally low salinities until mid-2016. However the reliability of the sampling prior to June 2016 has been questioned (AGE, 2016a). If the salinity measurements after June 2016 are accepted as being more representative of the groundwater in the Branxton Formation at that site than earlier data, then the Branxton Formation groundwater intersected by this bore is saline, with EC greater than 1000 µS/cm, and possibly greater than 5,000 µS/cm (**Figure 7**). Salinity data for MB01 and MB02 are only available from June 2016 onwards. Both bores indicate saline water quality, with ECs between 6,000 and 7,500 µS/cm.

However, if the low salinity reported prior to June 2016 is reliable, it would suggest that the shallower Branxton Formation groundwater monitored in bore NER1010 may be subject to local recharge by infiltration of rainfall, like the alluvium/colluvium/eluvium monitored in the shallow bores in the Quorrobolong Valley floodplain.

The upper 100 m or so of the Branxton Formation has been targeted at times by local landowners in the Quorrobolong Valley as a potential water supply source. The only such bore near the proposed Modification Area (registered bore GW054676) produced a modest yield of saline groundwater, and the bore has been filled in because it was considered by the landowner to have no beneficial use value.

The uppermost 100 m of the Branxton Formation is at least 300 m above, and up to 405 m above the Greta Seam, above the proposed longwalls LWB4 to LWB7, and is therefore well above the predicted 150 m maximum height of connected fracturing from subsidence accompanying the proposed coal extraction from LWB4-B7, based on experience from extensometers above LWA1 and LWA2, and predictions by MSEC (2017).

The separation between the Greta Seam and the top 100 m of Branxton Formation is marginally less than the predicted 355 m maximum height of discontinuous fracturing (within the 'constrained zone') above the Greta Seam (MSEC, 2017). Discontinuous fracturing (ie the constrained zone as described by MSEC, 2017) could extend into the uppermost 100 m of the Branxton Formation above all of LWB7, the western third of LWB6 and the north-western corner of LWB5. Elsewhere within the Modification Area, some unaffected strata will remain between the predicted maximum height of discontinuous fracturing and the base of the uppermost 100 m of the Branxton Formation.

However, MSEC advise that any fracturing that does occur within the constrained zone will not result in an increase in vertical hydraulic conductivity, and will not result in direct hydraulic connection with the goaf. Any changes in the constrained zone will only affect horizontal hydraulic conductivity.

Across the Modification Area, there will always remain a significant thickness of either unaffected strata or constrained strata, as a buffer between near surface groundwater and the goaf. The thickness of the constrained zone remaining above the maximum height of continuous fracturing to the base of the uppermost 100 m of the Branxton Formation, will be at least 150 m above LWB7, 170 m above LWB6, 190 m above LWB5 and 215 m above LWB4.

Based on the experience above earlier longwalls LWA1 and LWA2, the maximum predicted continuous fracture heights reported by MESC (2017), and this significant buffer zone, groundwater levels in the uppermost 100 m or so of the Branxton Formation are predicted to be unaffected by the proposed Modification.

This prediction is also consistent with the hydrostatic head profiles from multi-level vibrating wire piezometer bores located close to extracted longwall panels (eg AQD1077) as discussed in Dundon (2015). AQD1077 showed that hydrostatic pressures are likely to be affected by subsidence induced fracturing up to at least 150 m above the seam, but not above about 200 m above the seam.

5.3.3 Coal Measures and Greta Seam

The Greta Coal Measures, including the Greta Seam, are predicted to be dewatered within the immediate proximity of LWB4-B7, and will also be substantially depressurised for some distance away from the longwalls, in a manner consistent with the already extracted longwall panels.

No beneficial users will be affected.

5.4 Impacts on Surface Streamflows

Impacts on surface streamflows are predicted to be negligible. Apart from the small localised beneficial impact within the subsidence trough across the Quorrobolong Valley floodplain when it is undermined by LWB6 and LWB7, and the small portion of the unnamed tributary above the north-eastern end of LWB4, the surficial groundwater will not be affected by the proposed Modification. Hence there will be no change to either baseflows or streambed leakage.

5.5 Impacts on Groundwater Recharge

As there are predicted to be no measureable impacts on the near surface groundwater in the alluvium/colluvium/regolith, groundwater recharge will be unaffected by the proposed Modification. Groundwater recharge occurs principally by direct infiltration of rainfall, and downward percolation into and through the alluvium/colluvium and weathered rock into the underlying Branxton Formation. Recharge to particular relatively more permeable zones within the Branxton Formation and the Greta Coal Measures likely occurs at some distance updip from the mine area, where those particular zones occur in subcrop beneath the surficial lithologies. This process will continue to occur and will be unaffected by the proposed Modification.

5.6 Groundwater Quality

As the region of connected fracturing due to subsidence is predicted to not extend to more than about 150 m above the Greta Seam, as a result of the proposed Modification (MSEC, 2017), there will be no possibility of any adverse impact on groundwater quality in either the alluvium/colluvium/regolith.

On worst case predictions of the possible heights of discontinuous fracturing (to a maximum of 355 m above the Great Seam), discontinuous fracturing may extend to between 45 m and 90 m below ground level above LWB7, between 65 m and 115 m above LWB6, between 90 m and 135 m above LWB5, and to between 110 m and 150 m. Therefore, above LWB7 and parts of LWB5 and LWB6, discontinuous fracturing may extend into the uppermost 100 m of the Branxton Formation, and could therefore cause temporary impacts on groundwater in that zone. However, this would not constitute connection to the mine, and any changes that might occur would be possible changes to the direction or rate of flow within the Branxton Zone. This is not expected to affect the water quality in the Branxton Formation or any other aquifer.

Salinity may increase over time in the mine inflow water from the deeper Greta Coal Measures, irrespective of whether the proposed Modification proceeds or not, partly from induced seepage from the less permeable parts of the coal measures, and partly through evaporation effects of recycling mine inflow water through the practice of storing excess water in the former mine workings of the Bellbird South Colliery updip from the current active mine area. It is considered that the proposed Modification will have negligible contribution to this process.

5.7 Impacts on Water Users

There are no registered groundwater bores targeting the alluvium or colluvium within the vicinity of the proposed Modification Area, which is a reflection of the very limited yield potential of this groundwater source in that area. In any case, it has been concluded that the potential for the proposed Modification to impact on the alluvium/colluvium is negligible.

There are a small number of bores which target groundwater in the upper parts of the Branxton Formation (uppermost 100 m or so). The nearest private stock bore registered in the DPI Water database, GW054676, is located just inside the proposed Modification Area (**Figure 4**). However, the owner has backfilled the bore due to its low yield potential and salinity. In any case, the aquifer contributing water to this bore is too shallow to be affected by the subsidence impacts of the proposed Modification.

Lowering of the piezometric surface and changes to quality are considered highly unlikely as discussed in the preceding sections of this report. However, it is possible for lateral dislocation or blockage to occur if horizontal far-field displacements are significant. MSEC (2017) indicate that far-field horizontal displacements may occur, and predict a 99 per cent confidence level that horizontal displacement beyond a distance of 2 km from a single active longwall would be less than 35 mm, and less than 60 mm beyond 1 km from an active longwall.

There is no registered bore within 2 km of the proposed Modification Area, so far-field displacements are not expected to have an adverse impact on any existing water supply bore.

5.8 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) identified in the general region around the proposed Modification Area include Riparian Swamp Oak Open Forest, Riparian Cabbage Gum Forest, and a small soak area (Umwelt, 2015).

As indicated above, the predicted heights of either connected or discontinuous fracturing above the Greta Seam as a result of subsidence are significantly less than the depth of cover above the Greta Seam at the locations of the proposed longwalls. It has been concluded that any impacts on either the shallow surficial groundwater or on stream baseflows will be negligible.

Accordingly, no impacts on any GDEs dependent on the surficial groundwater or on groundwater baseflow are predicted to occur.

There are no known GDEs dependent on groundwater from the Branxton Formation or the Greta Coal Measures within or adjacent to the proposed Modification Area.

6. NSW Aquifer Interference Policy

The predicted groundwater impacts associated with the proposed Modification have been assessed against the NSW Aquifer Interference Policy which requires any mining activity to consider 'Minimal Impact Considerations' with respect to groundwater sources.

The NSW Aquifer Interference Policy considers two categories of groundwater sources, viz 'highly productive' and 'less productive'. Both the alluvial and porous rock groundwater sources within the proposed Modification Area are considered 'less productive' sources as they do not meet the water quality and yield requirements for 'highly productive' groundwater sources.

Key criteria to demonstrate minimal impact for less productive groundwater sources include:

- less than 10% variation in the water table, 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule of the WSPHUAWS;
- a maximum 2 m decline at any water supply work;
- no mining activity to be within 200 m laterally from the top of high bank or 100 m vertically beneath of a highly connected surface water source that is defined as a 'reliable water supply'; and
- any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.

The closest high priority groundwater dependent ecosystem or high priority culturally significant site listed in Schedule 4 of the WSPHUAWS is located more than 30 km away from the proposed Modification Area. The proposed Modification will not impact the water table at that distance.

The closest registered privately owned bore is GW054676 located just inside the proposed Modification Area, which targeted a shallow water bearing zone in the Branxton Formation. However, the landowner has advised that this bore has been decommissioned and backfilled. There are no other registered privately owned bores within the zone of potential impact on groundwater levels or quality from the proposed Modification.

There are no highly connected surface water sources as defined by the NSW Aquifer Interference Policy and Water Management Regulations within 200 m laterally or 100 m vertically of the proposed longwalls. Nor are there any water sources that represent a 'reliable water supply' as defined by the NSW Aquifer Interference Policy and Strategic Regional Land Use Plan – Upper Hunter.

The assessment in the preceding sections of this report has concluded that any impacts on either the surficial groundwater of the alluvium/colluvium/regolith, or the hard rock groundwater in the uppermost 100 m or so of the Branxton Formation, from the proposed Modification, will be negligible, due to a combination of the large cover depth over the Greta Seam and the limited height of either connected or discontinuous fracturing above the goaf (MSEC, 2017). This conclusion is consistent with observations of responses to prior mining of Stages 2 and 3 (Connell Wagner, 2007).

There are no known users of this groundwater resource within or near the proposed Modification Area and, as the impact on the aquifer is predicted to be negligible, any potential future groundwater users are unlikely to be adversely affected.

The quality of water within the alluvium/colluvium aquifer is variable and there is no known current use of the surficial groundwater. This is consistent with our conclusion the surficial aquifer has limited beneficial use potential. The proposed Modification is therefore not expected to further limit potential beneficial uses of this water supply.

Likewise, the generally poor quality of groundwater within the upper parts of the underlying Branxton Formation means that it has limited beneficial use potential. Nevertheless, the predicted negligible impact from the proposed Modification will not inhibit any potential future use of that aquifer system. Groundwater in the deeper parts of the Branxton Formation and the Greta Coal Measures is believed to be saline, and therefore has very low potential for future beneficial use other than for coal mining operations. Accordingly, the proposed Modification is not predicted to unduly restrict future use.

In summary, the alluvial/colluvial aquifer associated with Quorrobolong Creek and its tributaries within the proposed Modification Area is not characterised as a 'highly productive' groundwater source or a highly connected surface water source, as defined by the NSW Aquifer Interference Policy. The lack of registered bores within the area also indicates that the alluvial aquifer in the vicinity of the proposed Modification has limited use as a water supply for stock, domestic or other consumptive purpose.

On this basis, it is considered that the proposed Modification adequately satisfies the minimal impact considerations for less productive groundwater sources defined by the NSW Aquifer Interference Policy.

7. Groundwater Licensing Requirements

Groundwater impacts associated with the Austar Coal Mine involve a water take from the 'Porous Rock' groundwater source which is regulated by the *Water Management Act 2000*.

The water takes from the 'porous rock' water source for the currently approved mine plan are estimated by mine site Technical Services personnel to be less than 2 ML/d during the period from June 2016 to present, which equates to approximately 730 ML/y. This is based on a maximum rate of water removal from the mine of around 5 ML/d, of which approximately 3 ML/d is imported water. The proposed Modification is predicted to result in a minimal change to the total water take from this source.

The current water takes are authorised under access licences 20BL171481, 20BL173349, and 20BL173350, which have a combined capacity of 770 ML/y.

It is concluded therefore that current water take from the hard rock water source is below the current licence capacity, and an increase in the licence allocation will not be required for the proposed Modification.

8. Groundwater Management and Monitoring

The current groundwater monitoring program includes:

- Water production volumes from underground and through the water management system;
- Water levels in shafts or bores into the former workings, including Bellbird boreholes BB1 and BB2, Ellalong No 2 Shaft, and old mine shafts into Kalingo, Aberdare Central, Hepburn No 2 and Elrington (for locations see **Figure 1**), to monitor the accumulation of water in the former mine workings;
- Monitoring of groundwater levels and quality in 5 shallow bores in alluvium/colluvium or weathered bedrock, and 1 shallow Branxton Formation bore, in the Stage 2 mining area, to the north of the proposed Modification (for locations see **Figure 4**);
- Monitoring of groundwater levels and quality in 2 deeper bores in the Branxton Formation above the Stage 3 mining area (for locations see **Figure 4**); and
- Monitoring of hydrostatic pressures at multi-level vibrating wire piezometer bore AQD 1121 located between the Stage 2 and Stage 3 mining areas (for location see **Figure 4**).

This monitoring program has shown no impacts from mining on the surficial groundwater in the alluvium/colluvium aquifer or the upper parts of the Branxton Formation within the Stage 2 mining area to date.

It is recommended that water levels and water quality will continue to be monitored in the 6 shallow piezometers in this area on a regular basis, in accordance with the existing Site Water Management Plan (Austar, 2013), and EL6598 Groundwater Monitoring and Modelling Plan (RPS, 2014). These measures will be reflected in the Extraction Plan for LWB4-B7 following approval of the proposed Modification.

The following additional monitoring and management measures are recommended for incorporation into the Extraction Plan for LWB4-B7 and are consistent with the requirements of the existing approved Austar Site Water Management Plan (Austar, 2013):

- Establish one shallow groundwater monitoring bore in the alluvial area of the Quorrobolong Creek floodplain at a location above LWB6 or LWB7 (preferably LWB6 if possible), and monitor the groundwater levels on a regular basis to give an indication of the impact of longwall mining on the groundwater in the alluvium. EC readings should be measured on samples taken in this bore and the 6 existing monitoring bores in the Stage 2 area every three months. The installation and final location of the groundwater monitoring bore would be subject to landholder agreement, but should be located centrally within the predicted subsidence zone across the alluvium if possible.
- Review local daily rainfall record when undertaking groundwater monitoring reviews so that the timing of any groundwater level fluctuations can be compared with the occurrence of rainfall events, consistent with the requirements of the current approved Austar Site Water Management Plan (Austar, 2013).
- Review the results of the above monitoring at three monthly intervals and report results annually in accordance with Annual Review Report requirements, consistent with the requirements of the current approved Austar Site Water Management Plan (Austar, 2013).

9. Conclusions

This letter report details the expected incremental impacts of the proposed Modification which was described in **Section 2**.

The key findings of this assessment are:

- There are essentially two aquifer systems in the vicinity of the proposed Modification, namely a surficial aquifer system comprising unconsolidated material including alluvium ('alluvial' aquifer), colluvium/eluvium and/or highly weathered bedrock, and a 'hard rock' aquifer system that includes fractured zones in the Permian Branxton Formation and the Greta Coal Measures.
- Both aquifer systems are assessed to be 'less productive' groundwater sources in terms of the requirements of the NSW Aquifer Interference Policy, on the basis of low yield potential, as well as marginal and variable salinity.
- A third potential source of water inflow to the Austar Coal Mine is water stored in nearby abandoned mine workings. This water source is saline to highly saline, and is not subject to any beneficial use.
- The depth of cover above the Greta Seam in the proposed longwalls is much greater than the predicted maximum extent of either connected or discontinuous fracturing above the goaf. Consequently, surficial groundwater in the unconsolidated material comprising alluvium, colluvium and weathered rock within the floodplain of Quorrobolong Valley overlying the longwall panels will not be impacted by the proposal.
- Based on worst case predictions of subsidence fracturing impacts, groundwater in fracture zones in the uppermost 100 m or so of the Branxton Formation could theoretically experience temporary impacts within part of the Modification Area, as discontinuous fracturing within the 'constrained zone' could extend to within 100 m of the ground surface within all of LWB7 and parts of LWB6 and LWB5. Nevertheless, based on prior experience above nearby longwalls LWA1 and LWA2, groundwater within the Branxton Formation is expected to be at most only minimally impacted by the proposed Modification.
- The Greta Seam and the roof and floor sediments of the Greta Coal Measures are already

substantially depressurised as a result of prior mining. They are expected to undergo only marginal additional depressurisation as a result of the proposed Modification.

- No changes to groundwater quality are predicted to occur as a result of the proposed Modification.
- No adverse impacts on either baseflow of stream leakage are predicted to occur as a result of the proposed Modification.
- No increase in groundwater inflow to the mine is predicted to occur as a result of the proposed Modification, consistent with the historical observation that increases in inflow rates are associated with the mine progressing further downdip over time. The proposed longwall panels are located up-dip from the current mining of the approved LWB1-B3 panels to the south in Stage 2, and the coal measures have already experienced significant depressurisation or dewatering in the vicinity of the proposed longwalls, and the proposed Modification therefore does not involve any real downdip extension of mining.
- Any increased groundwater inflow that might occur to the proposed longwalls will not result in the current licensed entitlement being exceeded, and no new licence will be required.
- There are no high priority GDEs listed in the WSPHUAWS within the region potentially impacted by the Austar Coal Mine. Accordingly, the proposed Modification will have no impact on any high priority GDEs. In any case, the surficial groundwater of the alluvium/colluvium/regolith is predicted to be un-impacted by the proposed Modification, by virtue of the very large depth of cover relative to the maximum predicted extent of both connected and discontinuous subsidence-induced fracturing above the goaf.
- Likewise, no existing groundwater user is expected to be impacted by the proposed Modification. No drawdown impacts are predicted to occur in the alluvial aquifer system, which in any case is not utilised by other users in the vicinity of the proposed Modification. The limited potential use of the upper 50 to 100 m of the Branxton Formation as a stock water supply is also predicted to be not adversely impacted by the proposed Modification, due to the large depth of cover relative to the predicted maximum heights of subsidence-induced fracturing.
- The current monitoring program should be continued, with the addition of a further shallow standpipe piezometer in the Quorrobolong Valley alluvium above LWB6 or LWB7, which should be monitored for both water level and water quality, in conjunction with the current monitoring regime. The installation and final location of the groundwater monitoring bore would be subject to landholder agreement.

In summary, the proposed Modification is predicted to not have a significant additional impact above the impacts associated with the approved mining at the Austar Coal Mine.

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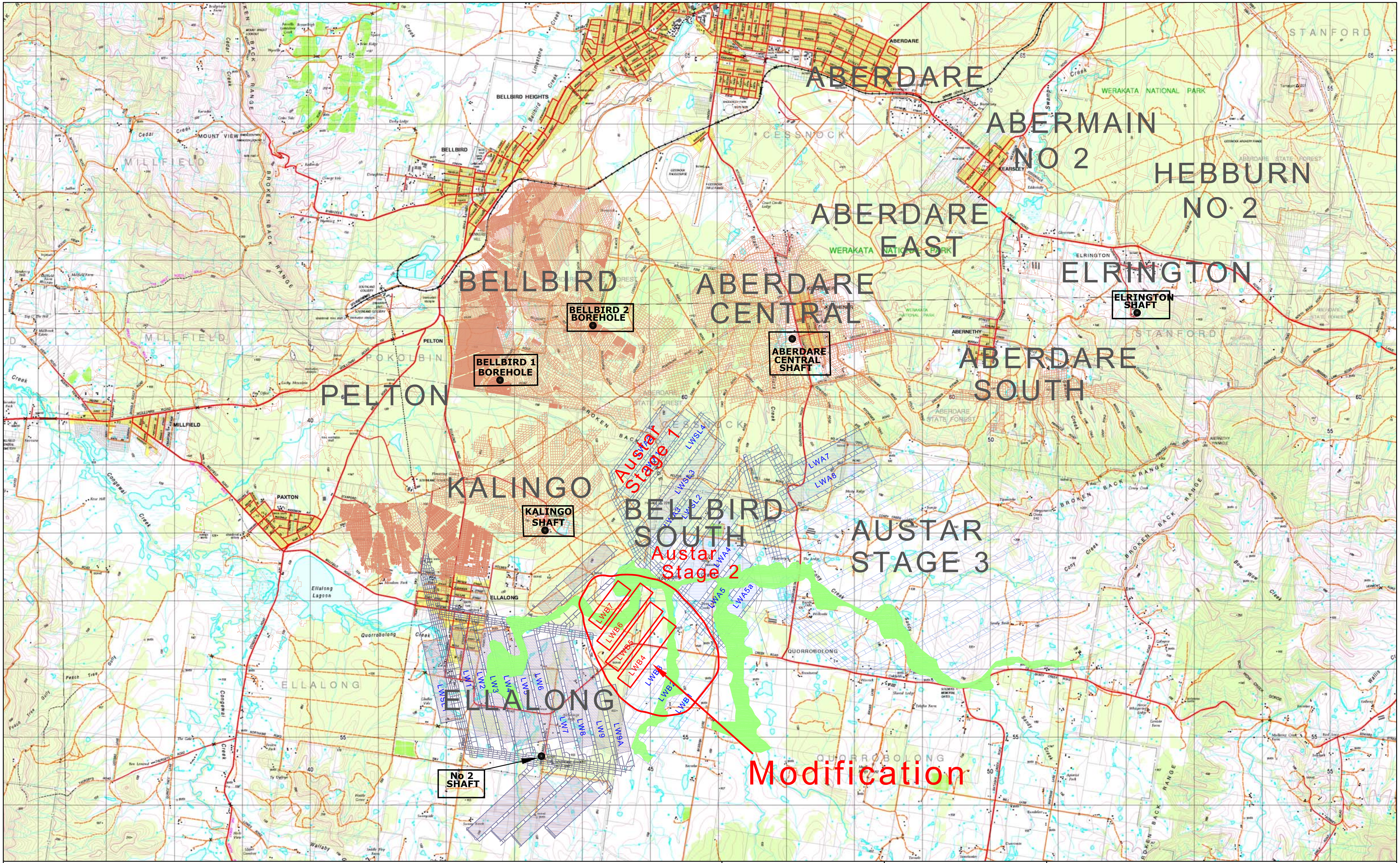
Tables

Figures

Yours faithfully,

Peter Dundon



Legend

BELLBIRD 1 BOREHOLE ●	Shafts/Boreholes into Old Workings
	Former Mine Workings
	Ellalong / Bellbird South / Austar Stage 3
	Stage 3 / Bellbird South Modification First Workings
	Modification Longwall Panels
	Predicted 20mm subsidence line
	Alluvial floodplain

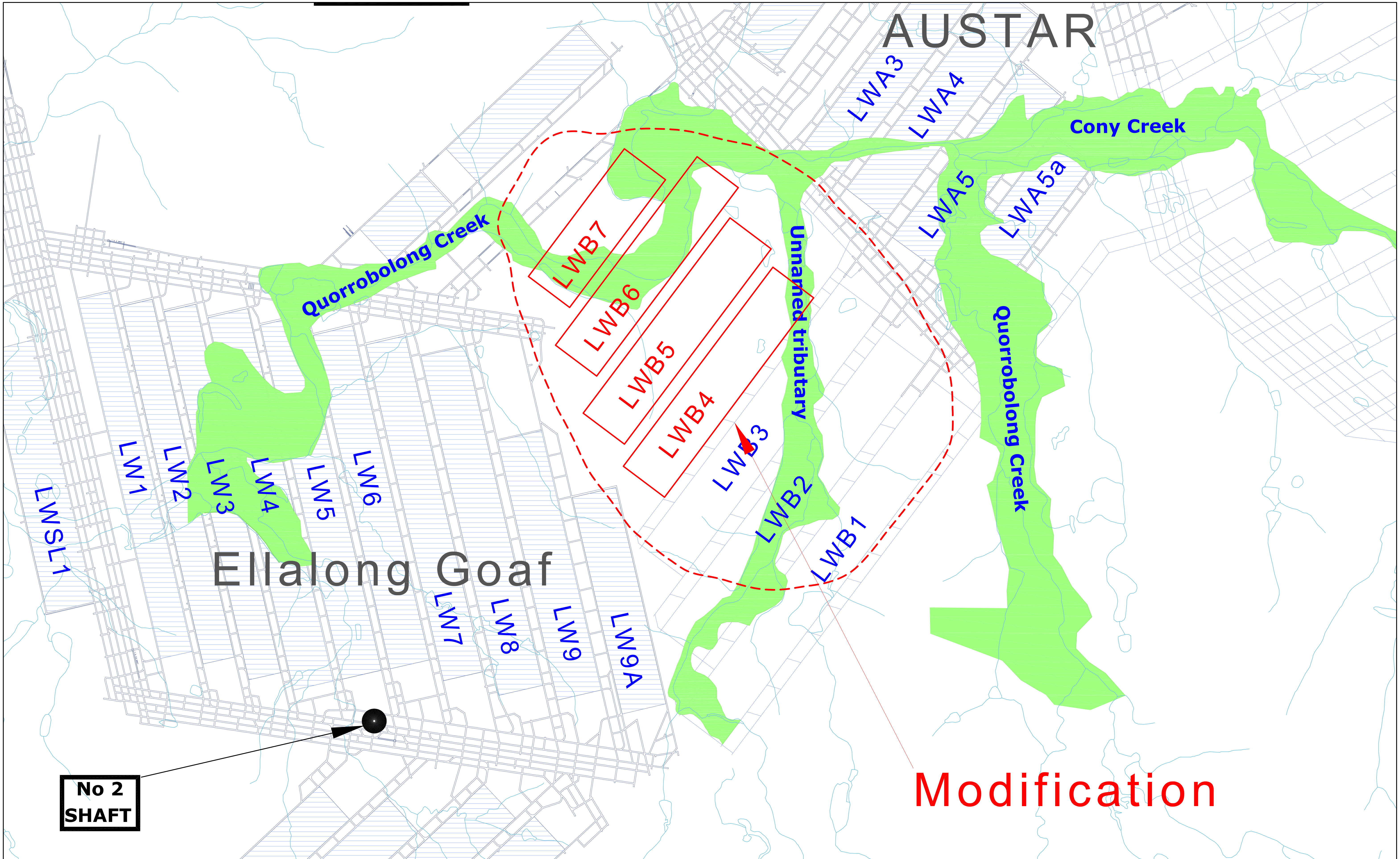
Date: 19 March 2017	Scale: As shown		
Initials: PJD	Job No: 16-0319		
Drawing No: 0319-001	Rev:		

Dundon Consulting Pty Limited

Austar Coal Mine Pty Ltd

BELLBIRD SOUTH MODIFICATION LWB4-B7
REGIONAL LOCATION

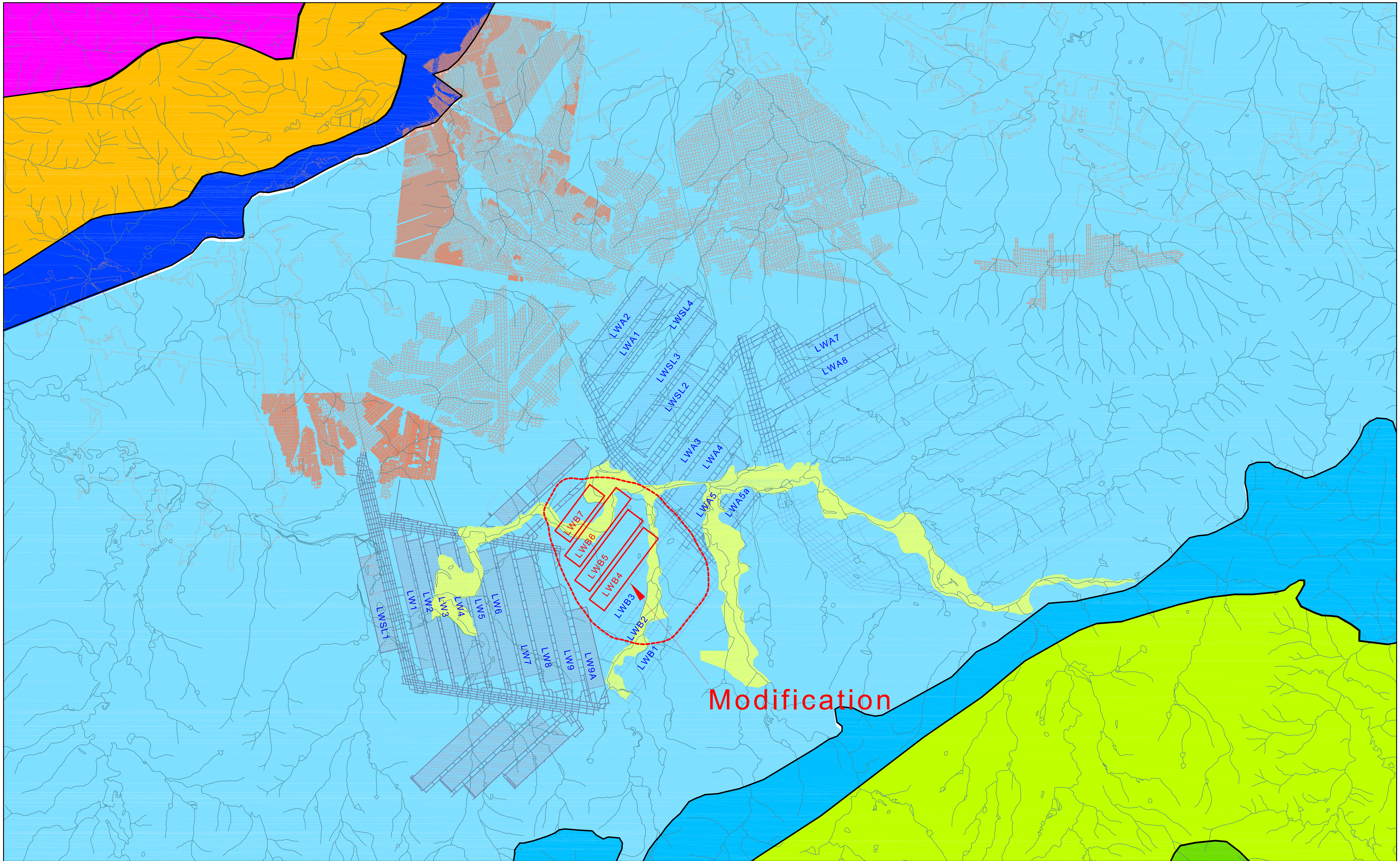
Figure 1



Legend

- Ellalong / Bellbird South / Austar Stage 3
- Stage 3 / Bellbird South Modification First Workings
- Alluvial floodplain
- MOD LWB4-LWB7 Longwall Panels
- Predicted 20mm subsidence line

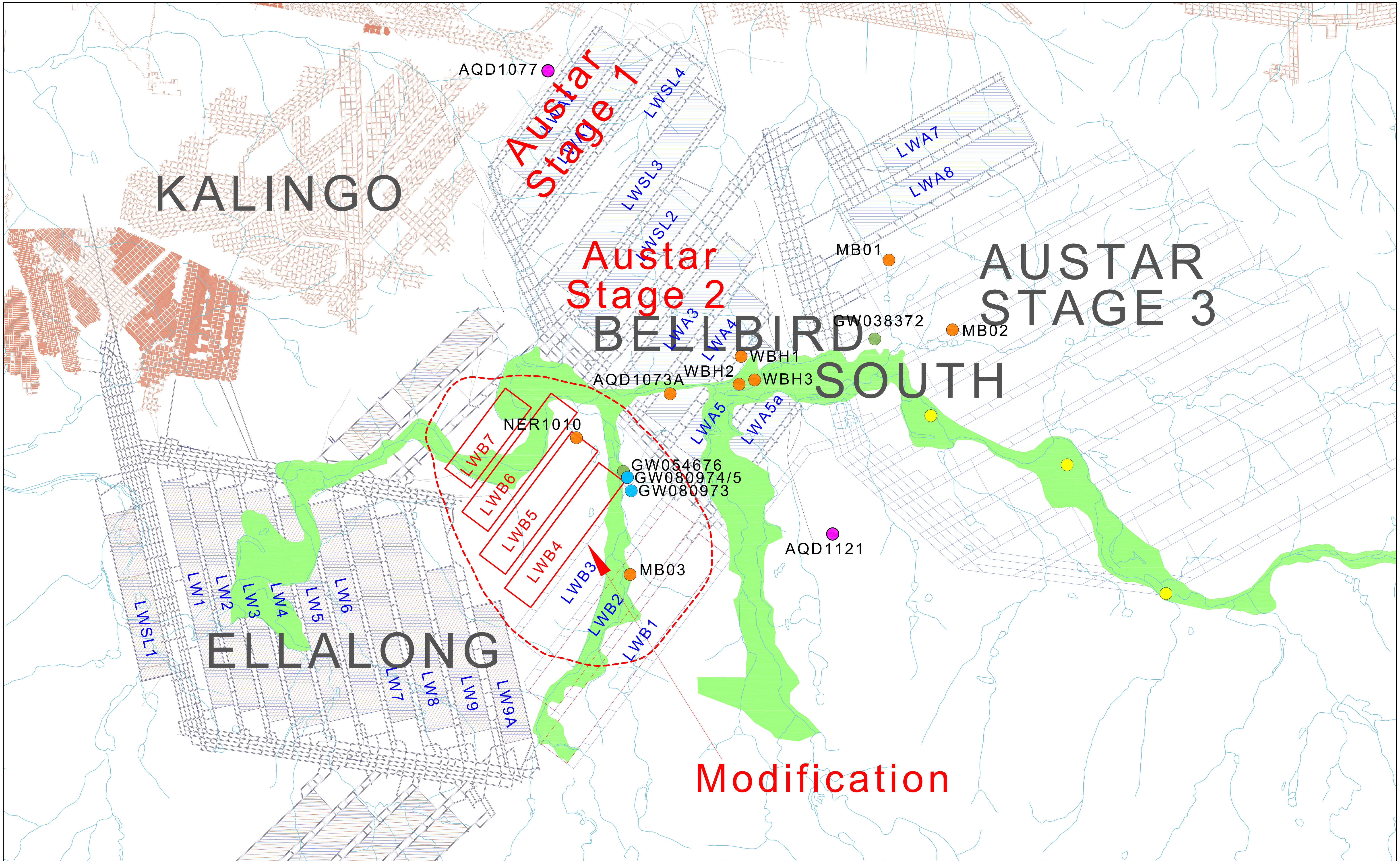
Date: 9 March 2017	Scale: As shown	**Austar Coal Mine Pty Ltd**
Initials: PJD	Job No: 16-0319	**AUSTAR - LOCATION OF PROPOSED MODIFICATION**
Drawing No: 0319-002	Rev:	
Dundon Consulting Pty Limited		**Figure 2**



Legend

- Alluvium
- Narrabeen Group
- Mulbring Siltstone
- Muree Sandstone
- Branxton Formation
- Greta Coal Measures
- Farley Formation
- Rutherford Formation
- Predicted 20mm subsidence line
- MOD LWB4-B7 Longwall Panels

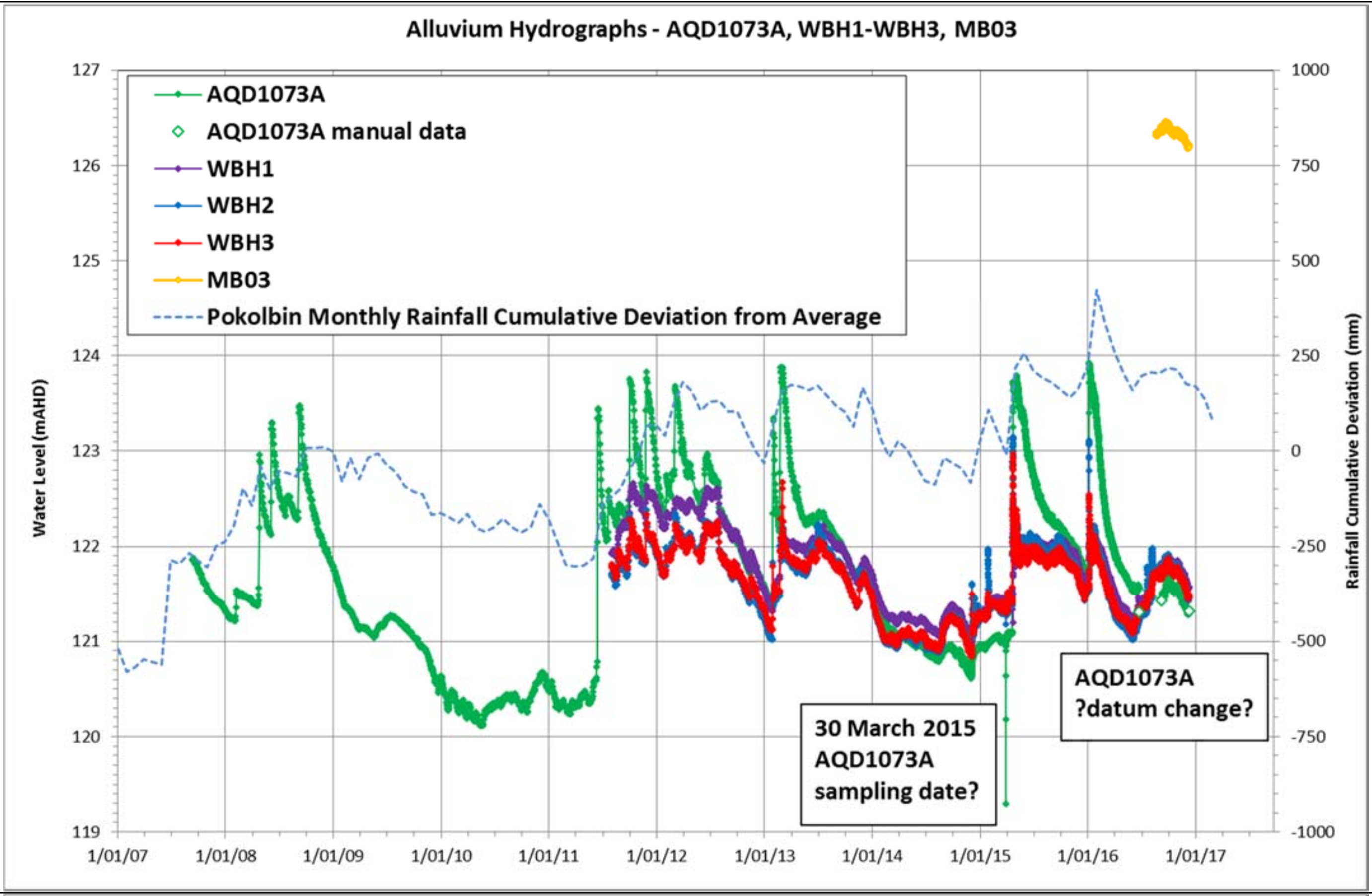
Date: 19 March 2017	Scale: As shown	**Austar Coal Mine Pty Ltd**	
Initials: PJD	Job No: 16-0319	**BELLBIRD SOUTH MODIFICATION LWB4-B7 SURFACE GEOLOGY**	
Drawing No: 0319-003	Rev: 0		
Dundon Consulting Pty Limited			**Figure 3**

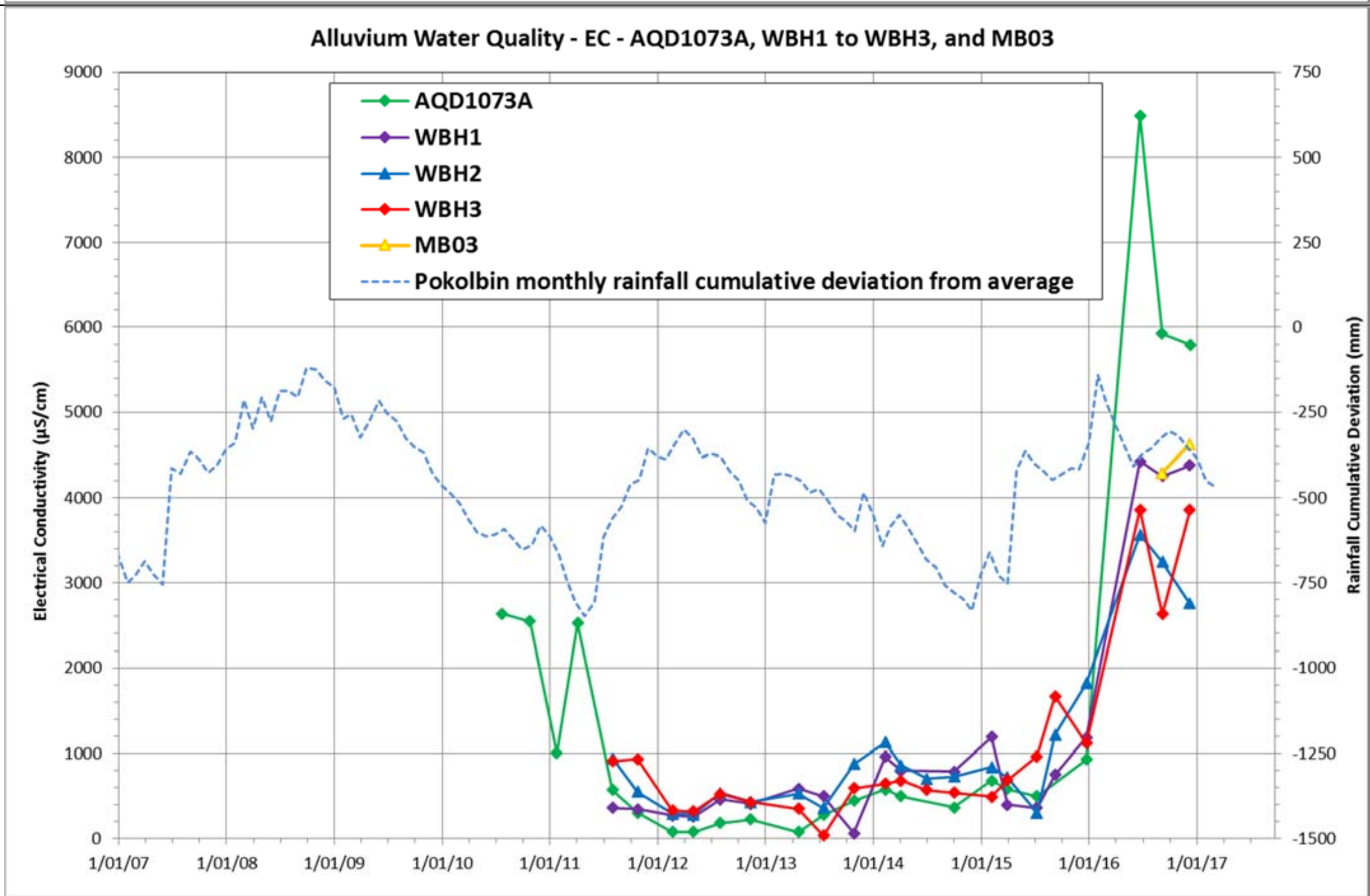


Legend

- Ellalong / Bellbird South / Austar Stage 3
- MOD LWB4-LWB7 Longwall Panels
- Predicted 20mm subsidence line
- Alluvial floodplain
- Austar Monitoring Bore
- Austar Proposed Shallow Monitoring Bore
- Austar Vibrating Wire Piezometer Bore
- DPI Water Monitoring Bore
- Registered Private Bore

Date: 9 March 2017	Scale: As shown	Austar Coal Mine Pty Ltd	
Initials: PJD	Job No: 16-0319	BELLBIRD SOUTH MODIFICATION LWB4-B7 ALLUVIAL FLOODPLAIN and BORE LOCATIONS	
Drawing No: 0319-004	Rev: B		Figure 4
Dundon Consulting Pty Limited			





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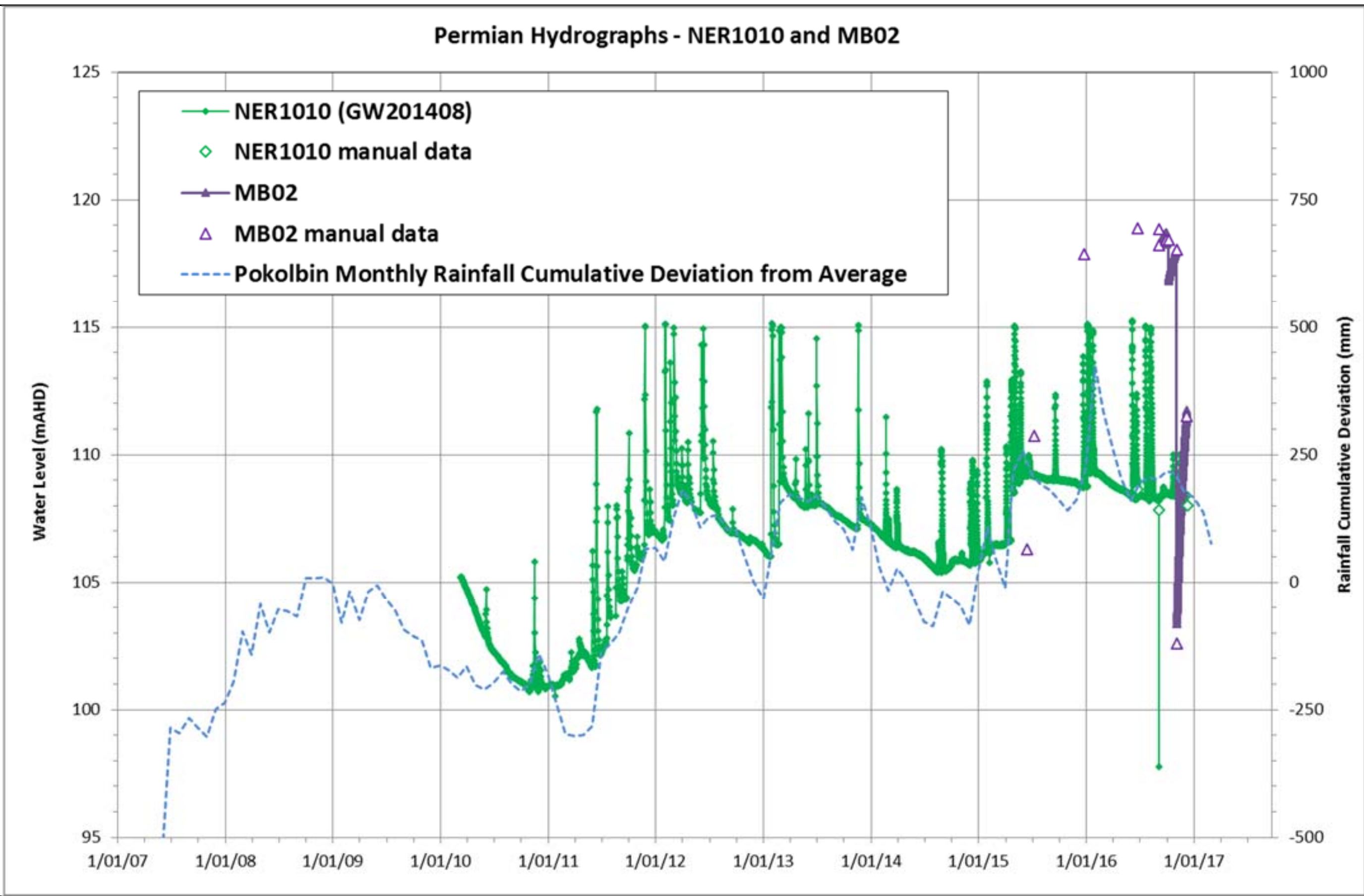
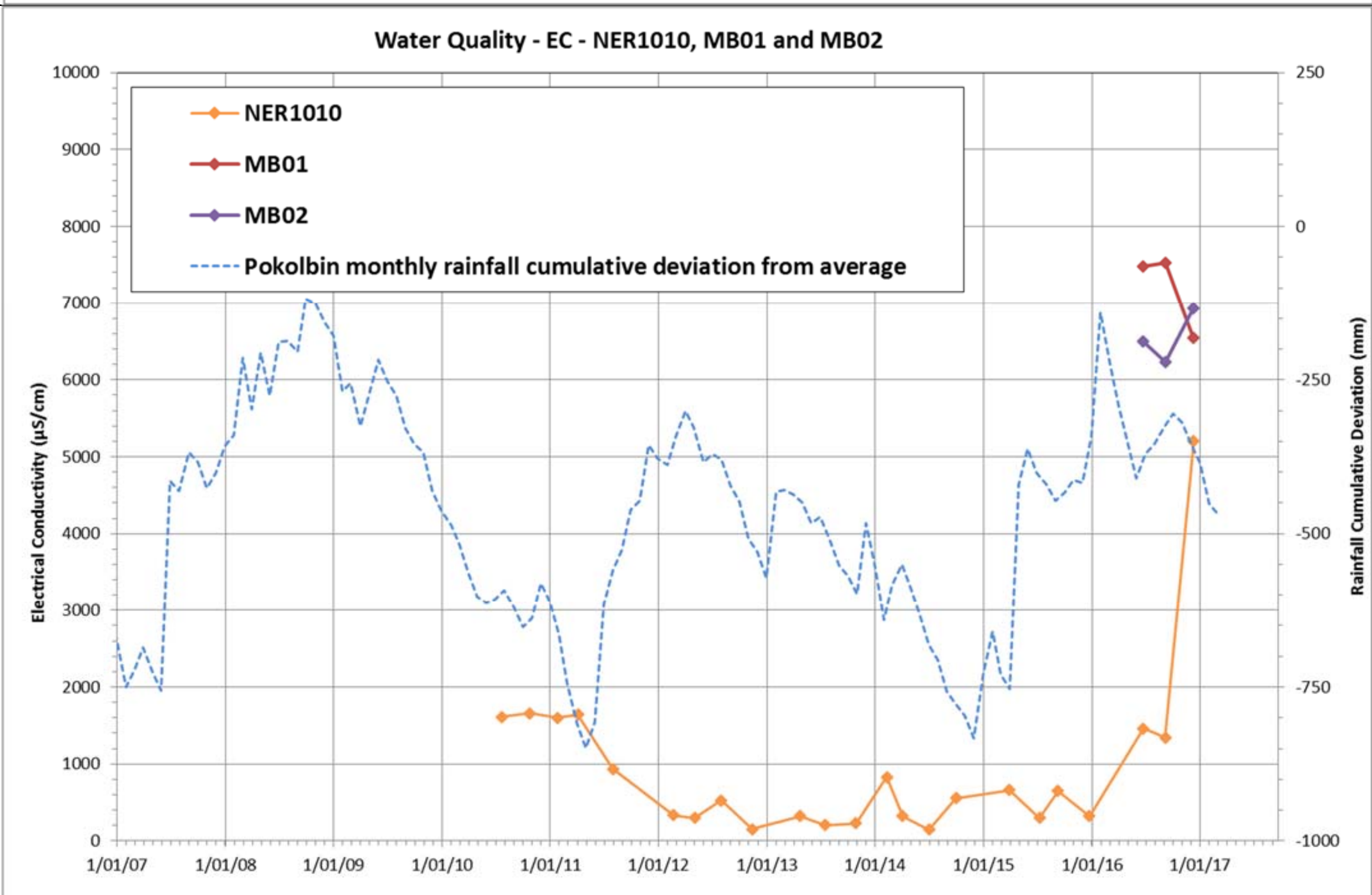
Dwg No: 0319-005		Revision:	
Dundon Consulting Pty Ltd			**Figure 5**





Date: 13 Mar 2017		Scale: as shown	**Austar Coal Mine Pty Limited**
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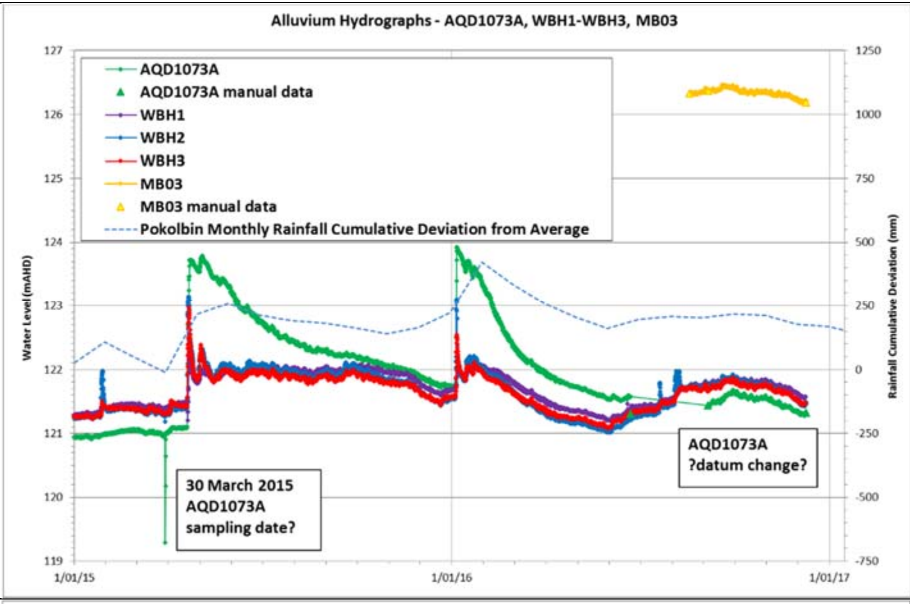
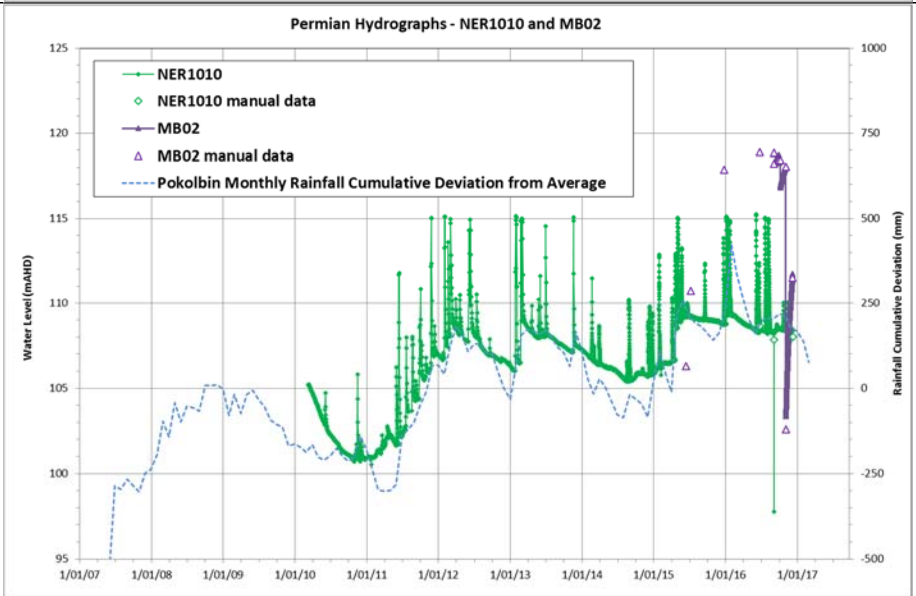
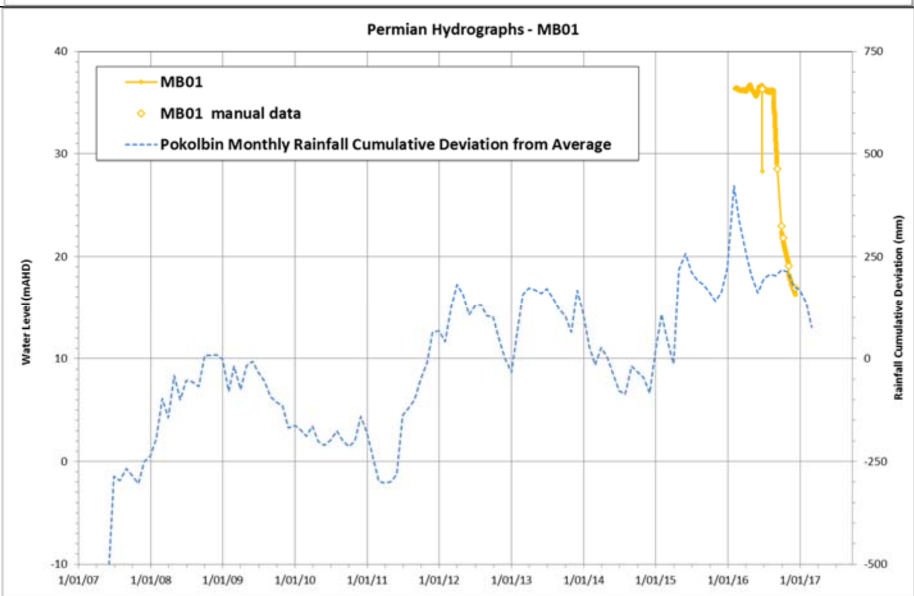
Dwg No: 0319-006		Revision:	
Dundon Consulting Pty Ltd			**PERMIAN GROUNDWATER** — **Figure 6**







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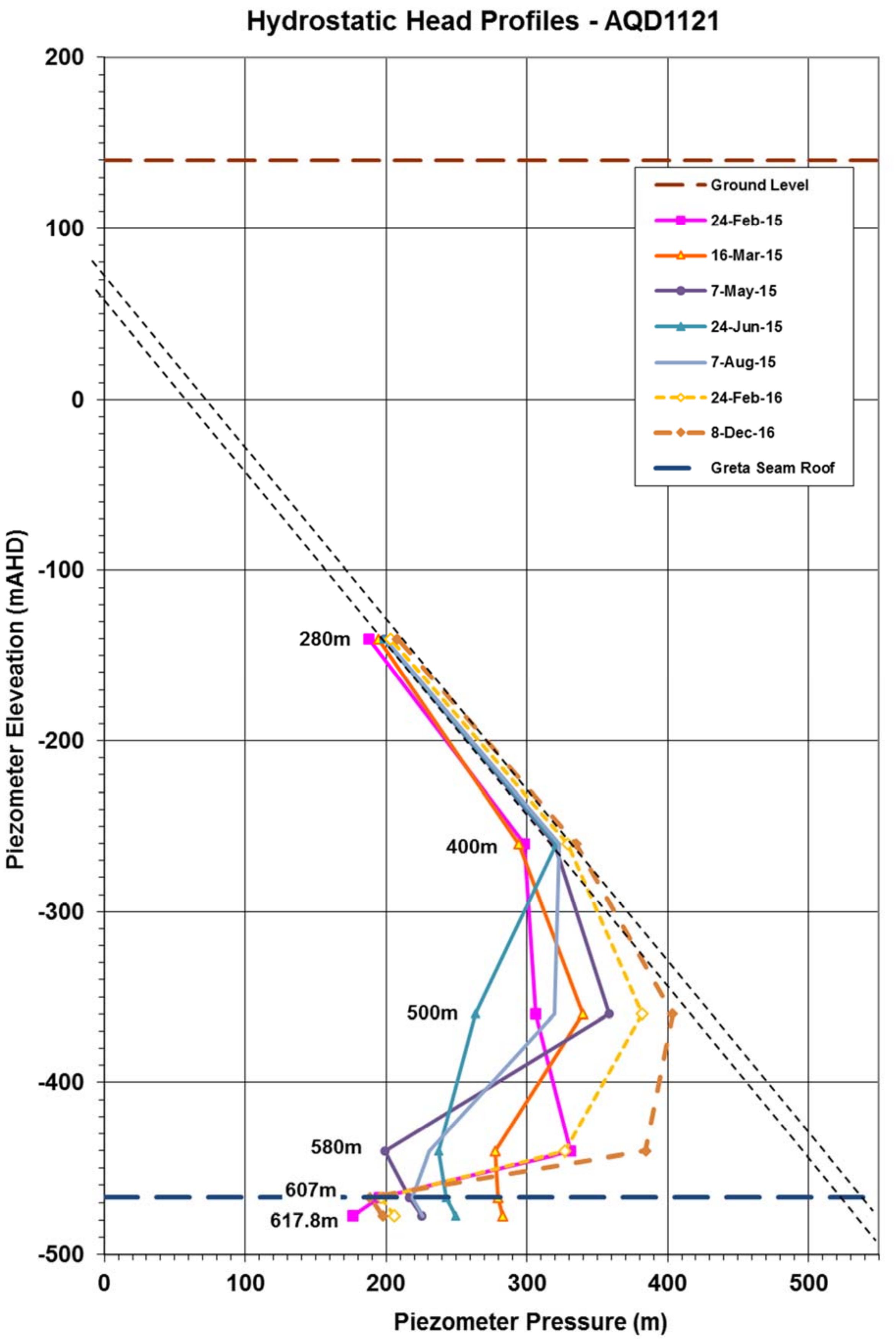
Author: PD	Checked: PD	Project No: 16-0319	**BELLBIRD SOUTH MODIFICATION LWB4-LWB7 WATER LEVEL AND EC 2015 – 2017 DATA**
Dwg No: 0319-007		Revision:	
Dundon Consulting Pty Ltd			**Figure 7**



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Dwg No: 0319-008		Revision:	
Dundon Consulting Pty Ltd			**AQD1121** / **Figure 8**

APPENDIX 5

Ecological Assessment

Inspired people | Dedicated team
Quality outcomes

AUSTAR COAL MINE

LWB4-B7 MODIFICATION ECOLOGICAL ASSESSMENT

Austar Coal Mine

FINAL

May 2017

LWB4-B7 MODIFICATION ECOLOGICAL ASSESSMENT

Austar Coal Mine

FINAL

Prepared by

Umwelt (Australia) Pty Limited

on behalf of

Austar Coal Mine

Project Director:	Barbara Crossley
Project Manager:	Gabrielle Allan
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Report No.	3900/R02/Final
Date:	May 2017

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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	**Date**	**Name**	**Date**
Final	Gabrielle Allan	24/05/2017	Barbara Crossley	24/05/2017

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Appendices

1.0 Introduction

Austar Coal Mine Pty Ltd (Austar), a subsidiary of Yancoal Australia Limited (Yancoal), operates the Austar Coal Mine, an underground coal mine located approximately 10 kilometres south of Cessnock in the Lower Hunter Valley in NSW (refer to **Figure 1.1**). The Austar Coal Mine incorporates the former Pelton, Ellalong, Cessnock No. 1 (Kalingo) and Bellbird South Collieries and includes coal extraction, handling, processing and rail and road transport facilities (refer to **Figure 1.2**).

Extensive mining has been undertaken within the Austar Coal Mine since 1916. Historical mining was predominantly via bord and pillar mining and more recently via conventional longwall mining and longwall top coal caving (LTCC) methods. Mining within the Bellbird South areas (Southland, Stage 1 and Stage 2, refer to **Figure 1.2**) was approved by the Minister for Urban Affairs and Planning in 1996 under DA 29/95, while mining of Stage 3 was approved by the Minister for Planning in 2009 under Project Approval 08_0111. Longwall mining commenced in the Ellalong Colliery area in 1983 and has subsequently progressed into the Bellbird South and the Stage 3 areas.

Mining is currently proceeding in the LWB1-B3 mining area in accordance with DA 29/95 (as modified).

A review of accessible coal resources within the Bellbird South / Ellalong Colliery areas has identified the potential for four additional longwall panels (LWB4-B7) adjacent to LWB3 that can be accessed from the Bellbird mains (refer to **Figure 1.3**). This additional longwall resource would provide continuity of mining following the completion of LWB3, and with minimal additional mine development would provide a further approximately 3.65 million tonnes (Mt) of run-of-mine (ROM) coal.

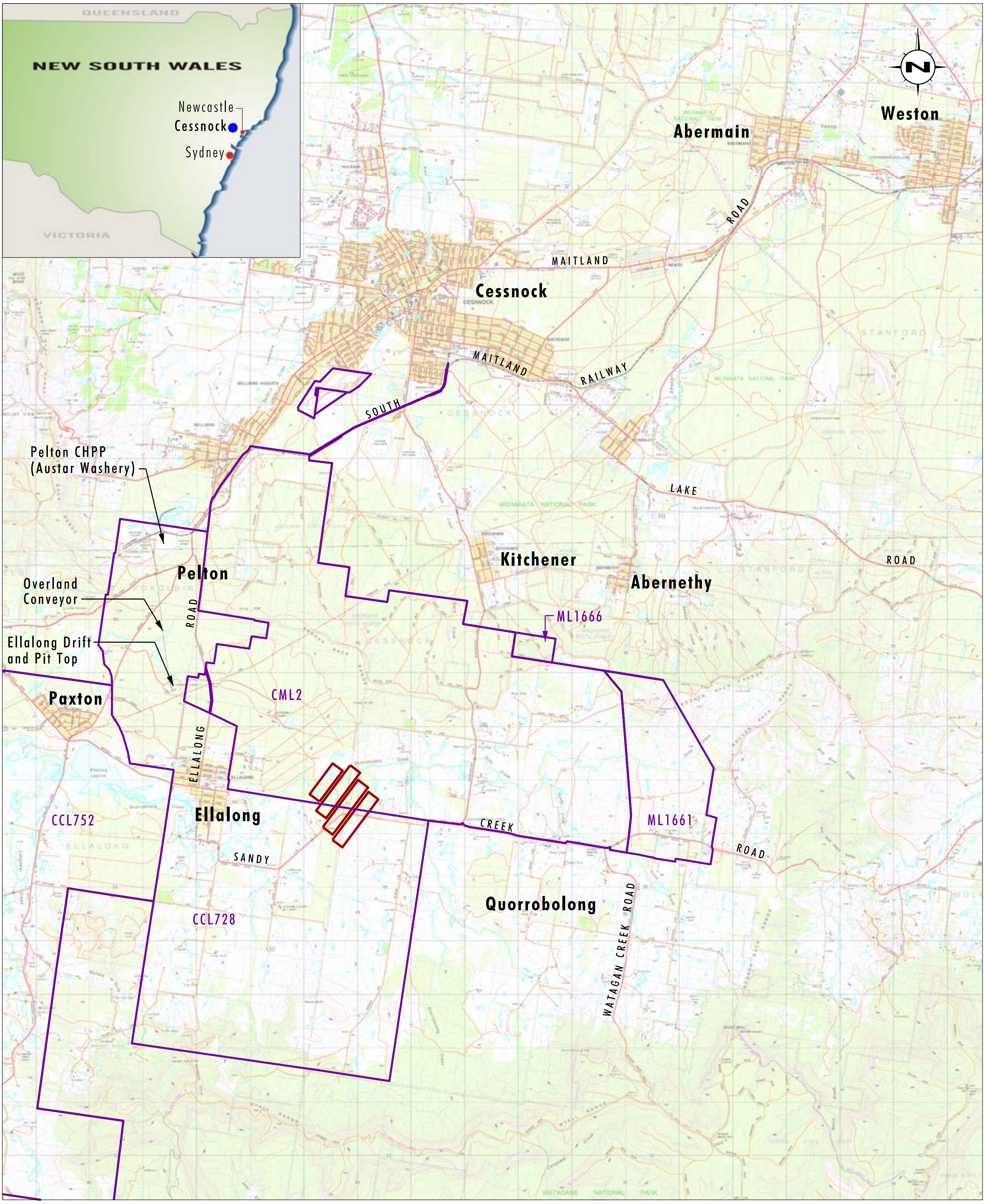

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

0 1.0 2.5 5.0km
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Legend

- Proposed LWB4-B7 Longwall Panels
- Mining Lease Boundary

FIGURE 1.1

Locality Plan

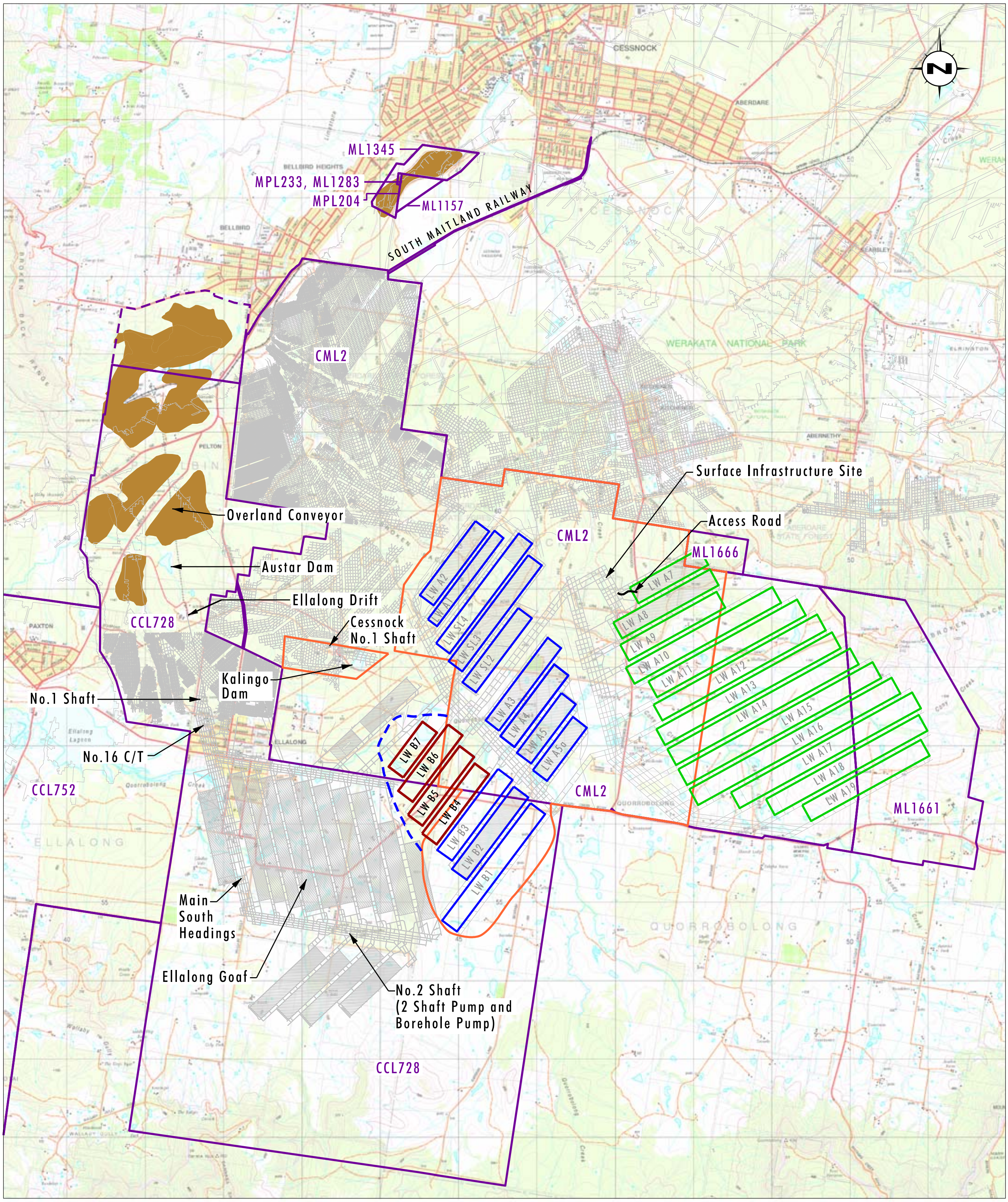

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

Legend

- Bellbird South Stage 1, Stage 2, Southland and LWB1-B3 Longwall Panels (DA 29/95)
- Proposed LWB4-B7 Longwall Panels (DA 29/95)
- Stage 3 Longwall Panels (PA08_0111)
- DA 29/95 Bellbird South Consent Area (Subsurface) - As Approved
- DA 29/95 Bellbird South Consent Area (Subsurface) - Proposed Extension
- Approved Reject Emplacement Areas
- Completed Underground Workings
- Mining Lease Boundary
- Austar owned CHPP Land

FIGURE 1.2

Austar Coal Mine and Proposed LWB4-B7

File Name (A4): R02/3900_020.dgn
20170216 10.49

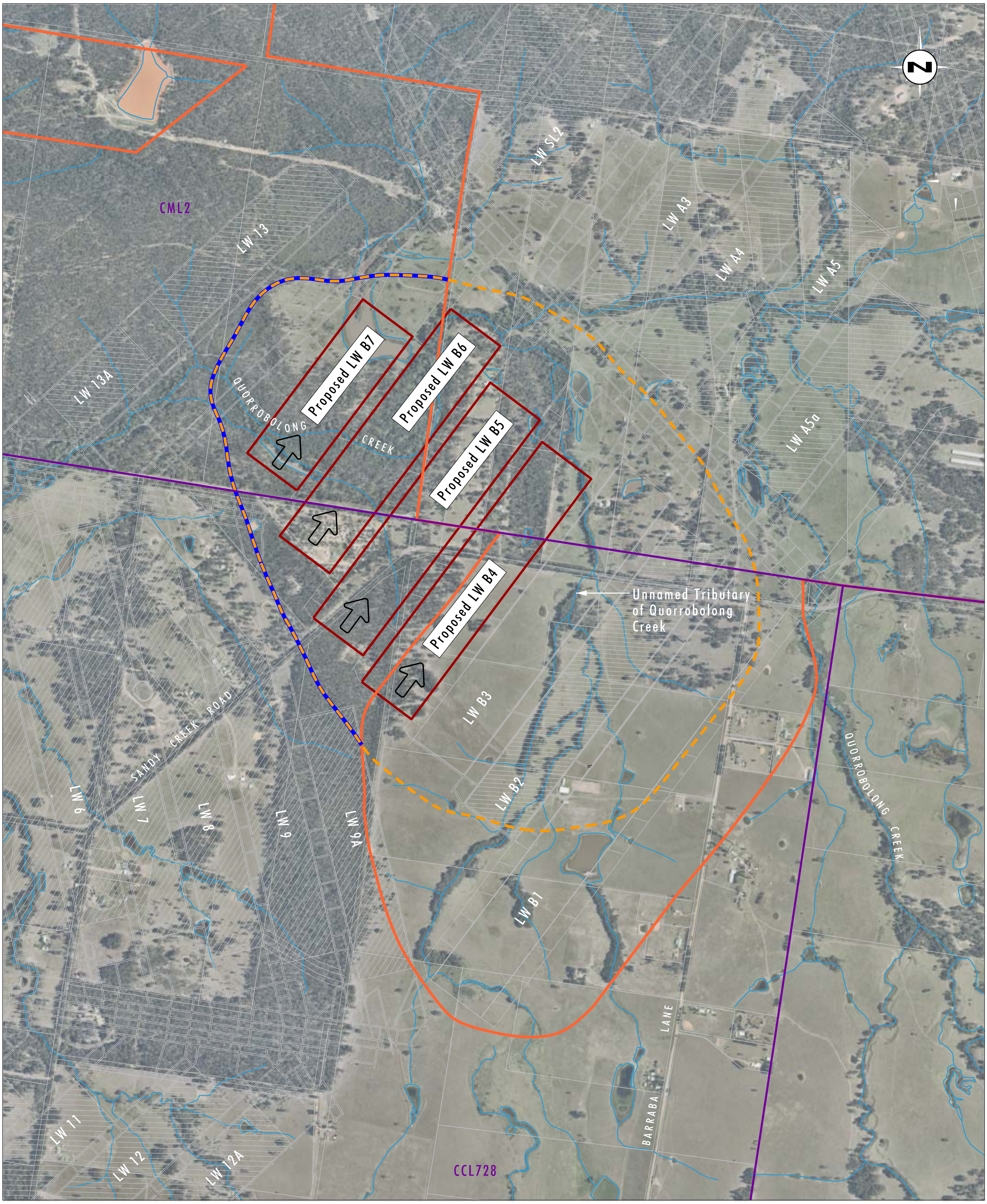

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- DA 29/95 Bellbird South Consent Area (Subsurface) - As Approved
- DA 29/95 Bellbird South Consent Area (Subsurface) - Proposed Extension
- Mining Lease Boundary
- Completed Underground Workings
- Direction of Mining
- Drainage Line

FIGURE 1.3

Proposed LWB4-B7 Modification

File Name (A4): R02/3900_021.dgn
20170516 11.54

1.1 Overview of Proposed LWB4-B7 Modification

Austar proposes to modify the Bellbird South Consent to permit the transfer and processing of coal from four proposed longwall panels (LWB4-B7) via the existing Bellbird mains and to extend the development consent area to cover the four longwall panels (refer to **Figure 1.3**).

No other changes to the approved mining operations associated surface facilities or production rates are proposed as part of the modification.

1.2 Proposed Modification Area

The environmental impacts of the proposed LWB4-B7 Modification have been assessed within the 20 millimetre subsidence contour for LWB4-B7. This area is referred to as the 'LWB4-B7 Modification Area' and is shown on **Figure 1.3.** The 20 millimetre subsidence contour is considered the vertical limit of subsidence.

1.3 Environmental Context and Land Use

The LWB4-B7 Modification Area is located in Quorrobolong, approximately two kilometres east of the township of Ellalong in the lower Hunter Valley of NSW (refer to **Figure 1.1**). The environmental context of the LWB4-B7 Modification Area is shown on **Figure 1.4**.

The topography of the LWB4-B7 Modification Area is generally characterised by low undulating hills and creek flats associated with Quorrobolong Creek and its unnamed tributary (refer to **Figure 1.4**). Elevations within the LWB4-B7 Modification Area range from approximately 120 metres to 150 metres Australian Height Datum (AHD). Steeper slopes associated with the Broken Back Range are located approximately one kilometre to the north of the LWB4-B7 Modification Area within the Werakata State Conservation Area.

The LWB4-B7 Modification Area is situated within the Quorrobolong Creek Catchment, a sub-catchment to the larger Wollombi Brook and ultimately the Hunter River catchment. Quorrobolong Creek forms part of the Congewai Creek Management Zone of the Upper Wollombi Water Source within the Hunter Unregulated and Alluvial Water Sources Water Sharing Plan area. Quorrobolong Creek crosses the northern portion of the LWB4-B7 Modification Area (refer to **Figure 1.4**) and flows west into Ellalong Lagoon approximately 2.5 kilometres to the west. An un-named tributary of Quorrobolong Creek runs from south to north across the proposed LWB4-B7 Modification Area prior to joining Quorrobolong Creek (refer to **Figure 1.4**).

One soil landscape type is found within the LWB4-B7 Modification Area, being the Quorrobolong soil landscape (Kovac and Lawrie 1991) (refer to **Figure 1.4**). The main soils within this landscape are prairie soils which form in alluvium and occur in drainage depressions and on lower slopes. They are generally poorly drained, have moderate permeability and the upper horizon has moderate erodibility (Kovac and Lawrie 1991). The soils are moderately fertile and the main land use is generally grazing on unimproved pasture.

Land use surrounding the LWB4-B7 Modification Area is primarily rural to the northeast, east, south and west and is dominated by cleared grazing land. Land to the north is owned by Austar Coal Mine and is used for surface mining infrastructure and includes undeveloped native vegetation areas. The Watagans National Park is located approximately four kilometres south of the LWB4-B7 Modification Area, the Werakata State Conservation Area is located approximately one kilometre to the north and Werakata National Park is located approximately five kilometres to the north-east.

umwelt

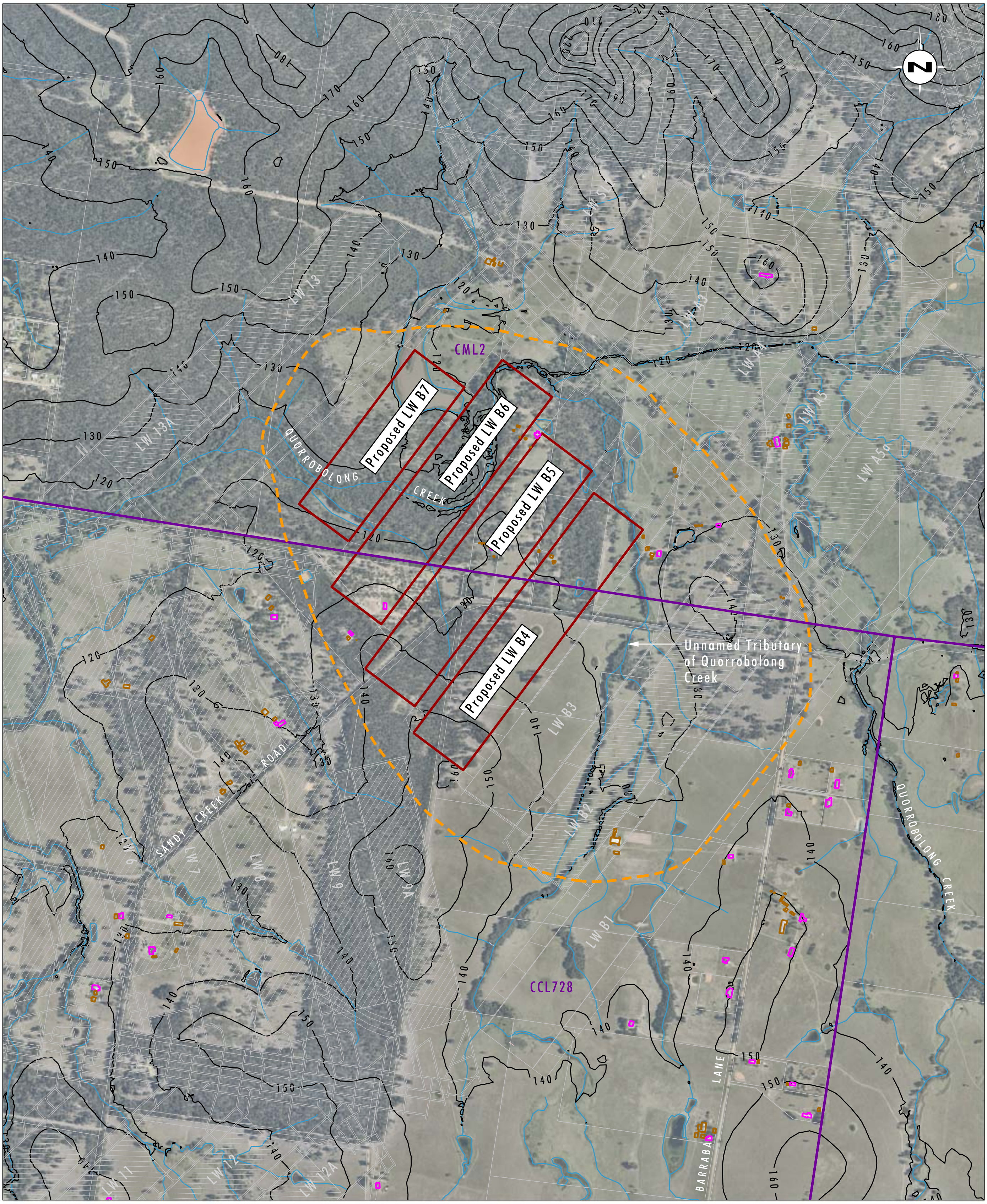

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2015)
Note: Contour Interval 10m

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Drainage Line
- Contour
- Dwelling
- Other Structure

FIGURE 1.4

Topography and Land Use Context

File Name (A4): R02/3900_022.dgn
20170516 12.40

1.4 Objectives of Ecological Assessment

The objectives of this Ecological Assessment are to:

- record the flora and fauna species diversity, vegetation communities and fauna habitats occurring within the LWB4-B7 Modification Area
- identify any threatened species, migratory species, endangered populations or threatened ecological communities (TECs) (or their habitats), listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act), Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act), and the *NSW Fisheries Management Act 1995* (FM Act)
- assess the potential impacts of the proposed modification on threatened species, migratory species, endangered populations and TECs in accordance with the requirements of the NSW *Environmental Planning and Assessment Act* 1979 (EP&A Act) and the EPBC Act
- address the requirements of the State Environmental Planning Policy 44 – Koala Habitat (SEPP 44)
- propose reasonable measures (where required) to mitigate impacts associated with the proposed modification.

2.0 Methods

2.1 Context of Other Recent Impact Assessments

Umwelt was commissioned by Austar in 2015 to undertake an ecological impact assessment for a proposed modification to the Bellbird South Consent to permit the transfer and processing of coal from proposed LWB1-B3. This assessment area for the LWB1-B3 Modification Ecological Assessment (Umwelt 2015), referred to as the LWB1-B3 Modification Area, is located immediately south-east of the current LWB4-LWB7 Modification Area and overlaps the LWB4-B7 Modification Area in part.

Given that the LWB4-B7 Modification Area is immediately adjacent to and overlaps the former LWB1-B3 Modification Area, the ecological information collected during this survey is still relevant and where necessary has been referred to throughout this document.

2.1 Ecological Database Searches

In order to identify potential threatened and migratory species, endangered populations and TECs with potential to occur in the LWB4-B7 Modification Area, a search of relevant ecological databases was completed during December 2016. These database sources comprised:

- a 10 kilometre radius search from the centre of the LWB4-B7 Modification Area of the Office of Environment and Heritage (OEH) Atlas of NSW Wildlife (December 2016)
- a 10 kilometre radius search from the centre of the LWB4-B7 Modification Area of the Department of the Environment and Energy (DoEE) Protected Matters Database (December 2016)
- a review of the NSW Department of Primary Industries (DPI) *Fish communities and threatened species distributions of NSW* (NSW DPI 2016).

Records from these database searches were combined with records derived through literature reviews and professional opinion to identify the range of potentially occurring threatened and migratory species, endangered populations and TECs for the area. The results of the database searches are compiled in **Appendix A**.

Current lists of threatened species and key threatening processes were sourced from the OEH, DoEE and the Department of Primary Industries websites.

2.2 Literature Review

A review of relevant and available literature was undertaken in order to gain a greater understanding of the ecological values of the LWB4-B7 Modification Area and its locality. Documents reviewed included previous ecological studies relating to sites in proximity to the LWB4-B7 Modification Area, regional vegetation mapping, relevant papers in scientific journals and threatened species information resources such as the OEH internet resources. A full list of references cited within this report is provided in **Section 6**.

A summary of the ecological findings of the key literature is provided in the following section.

2.2.1 Floristic Species List of Duckworth Property (Elliot 2014)

Although not a formal report, local horticulturalist and native plant specialist Max Elliot compiled a flora species list of Lot 201 DP 1136015 and Lot 31 DP 849031 (1364 Sandy Creek Road and 1392 Sandy Creek Road Quorrobolong) (within the LWB4-B7 Modification Area) on behalf of the landholder. As access to this property was limited during the time of survey, this species list was utilised to inform floristic composition and to inform vegetation community mapping for this area.

2.2.2 Austar Stage 2 Subsidence Management Plan – Appendix 1 Ecological Assessment (Umwelt 2007)

Umwelt prepared an Ecological Assessment for the mining of three longwalls (A3-A5) within the Bellbird South - Stage 2 area (Stage 2 area) located within 1 kilometre of the current LWB4-B7 Modification Area (Umwelt 2007). Field surveys for this project were undertaken to identify threatened and migratory species, endangered populations and TECs occurring or with potential to occur in the Stage 2 area, as well as to map the vegetation communities present and to describe the fauna habitats.

Two TSC Act listed endangered ecological communities (EECs) where recorded in the Stage 2 area, being the River Flat Eucalypt Forest and the Lower Hunter Spotted Gum – Ironbark Forest. Two threatened fauna species were recorded: the grey-crowned babbler (*Pomatostomus temporalis temporalis*) and the speckled warbler (*Chthonicola sagittata*). Two EPBC Act listed migratory species were also recorded: the great egret (*Ardea alba*) and the white-bellied sea-eagle (*Haliaeetus leucogaster*). A number of other threatened flora and fauna species were found to have potential to occur in the Stage 2 area; however none were identified during targeted surveys.

Analysis of changes to surface terrain, creek bed profiles and surface and groundwater regimes as a result of the predicted and upper bound subsidence for Stage 2 indicated that:

- there would be no significant changes to catchment boundaries
- there would be no significant change to channel alignment or bank stability
- there would be no significant change to in channel or out of channel ponding
- groundwater availability to riparian vegetation would not be likely to substantially change as a result of mining.

To ensure the continued protection of significant ecological values of the Stage 2 area, regular monitoring of the predicted subsidence area was recommended to identify unforeseen impacts of the underground mining, and to enable appropriate mitigation measures to be implemented to ameliorate these impacts. The monitoring program was specifically targeted towards identifying changes to River-flat Eucalypt Forest EEC, outcomes of this targeted monitoring indicate no impacts to ecological values as a result of subsidence (as provided in **Section 2.2.6**).

2.2.3 Austar Ecological Assessment, Stage 3 Mine Area (Longwalls A6 to A17) and Surface Infrastructure Site (Umwelt 2008)

The Stage 3 project documented in Umwelt (2008) involved two components, the first being the addition of 12 longwall panels (expanding from Stage 2), and the second being the development of associated surface infrastructure. This project is located less than 2 kilometres from the LWB4-B7 Modification Area. A detailed ecological survey and assessment was undertaken by Umwelt to identify the impacts of the proposed longwall mining and surface infrastructure developments on any ecological values and to integrate into the development any measures to avoid or minimise these impacts.

Extensive multi-season ecological surveys were conducted, a summary of the methods employed is provided in Section 3.1 of this document. The following threatened species, endangered populations and TECs were recorded:

- heath wrinklewort (*Rutidosis heterogama*)
- small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*)
- Lower Hunter Spotted Gum – Ironbark Forest EEC
- River-flat Eucalypt Forest EEC
- Hunter Lowland Red Gum Forest EEC
- Quorrobolong Scribbly Gum Woodland EEC
- gang-gang cockatoo (*Callocephalon fimbriatum*)
- grey-crowned babbler (*Pomatostomus temporalis temporalis*)
- speckled warbler (*Chthonicola sagittata*)
- powerful owl (*Ninox strenua*)
- squirrel glider (*Petaurus norfolcensis*)
- little bentwing-bat (*Miniopterus australis*)
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*)
- large-footed myotis (*Myotis macropus*)
- eastern freetail-bat (*Mormopterus norfolcensis*).

The construction of the Surface Infrastructure Site (SIS) required the clearing of an 8-10 hectare area of vegetation which included habitat for two EECs and a number of threatened species. A 17 hectare parcel of land nearby to the SIS, and with similar ecological characteristics to the SIS, was nominated as a biodiversity offset for the SIS development. In addition to the biodiversity offsets, a detailed tree-clearing procedure was developed to minimise the impacts on any hollow-bearing fauna during the construction of the SIS facilities.

Based on the subsidence predictions and modelling, it was determined that the Stage 3 project would not have a significant impact on any threatened species, migratory species, endangered populations or TECs.

2.2.4 Ecological Assessment for Austar Proposed Stage 3 Modification (Umwelt 2011a)

The subject of this ecological assessment was the reorientation of the approved Stage 3 longwall panel alignment. This project was located within 2 kilometres of the LWB4-B7 Modification Area.

Although much of the area had already been subject to ecological survey as part of Umwelt (2008), additional surveys were undertaken by Umwelt to examine previously un-surveyed vegetation to identify threatened species and delineate/clarify existing vegetation mapping.

This project identified:

- eight vegetation communities, of which two (River-flat Eucalypt Forest EEC and Lower Hunter Spotted Gum – Ironbark Forest EEC) were TECs
- three threatened flora species, being heath wrinklewort (*Rutidosis heterogama*), small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) and netted bottle-brush (*Callistemon linearifolius*)
- four further threatened flora species with potential to occur, being Bynoes wattle (*Acacia bynoeana*), leafless tongue orchid (*Cryptostylis hunteriana*), Illawarra greenhood (*Pterostylis gibbosa*) and Groves paperbark (*Melaleuca groveana*)
- twelve threatened fauna species: gang-gang cockatoo (*Callocephalon fimbriatum*), grey-crowned babbler (*Pomatostomus temporalis temporalis*), speckled warbler (*Chthonicola sagittata*), powerful owl (*Ninox strenua*), little lorikeet (*Glossopsitta pusilla*), scarlet robin (Petroica boodang), squirrel glider (*Petaurus norfolcensis*), little bentwing-bat (*Miniopterus australis*), eastern bentwing-bat (*Miniopterus schreibersii oceanensis*), southern myotis (*Myotis macropus*), eastern false pipistrelle (*Falsistrellus tasmaniensis*) and east-coast freetail-bat (*Mormopterus norfolkensis*)
- 18 additional threatened fauna species with potential to occur.

Based on the subsidence predictions and modelling, it was determined that the revised Stage 3 longwall panel alignment would not have a significant impact on any threatened species, migratory species, endangered populations or TECs.

2.2.5 Ecological Assessment for Austar LWB1-B3 Modification Area (Umwelt 2015)

The subject of this ecological assessment was the addition of three longwall (LW) panels in the Bellbird South mining area. The project was located directly adjacent to and, in part, overlapping the LWB4-B7 Modification Area.

The project identified:

- six vegetation communities of which two (River Flat Eucalypt Forest EEC and Lower Hunter Spotted Gum – Ironbark EEC) were TECs and one potential TEC (Quorrobolong Scribbly Gum Woodland EEC)
- three threatened flora species being heath wrinklewort (*Rutidosis heterogama*), small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) and netted bottle-brush (*Callistemon linearifolius*)
- six threatened fauna species being squirrel glider (*Petaurus norfolcensis*), large-eared pied bat (*Chalinolobus dwyeri*), greater broad-nosed bat (*Scoteanax rueppellii*), koala (*Phascolarctos cinereus*) (OEH database record), grey-crowned babbler (*Pomatostomus temporalis temporalis*), and varied sittella (*Daphoenositta chrysoptera*). One migratory species listed under the EPBC Act was also identified, being the cattle egret (*Ardea ibis*) and
- seven additional threatened species with potential to occur.

Based on the subsidence predictions and modelling, it was determined that the LWB1-B3 Modification would not have a significant impact on any threatened species, migratory species, endangered populations or TECs.

2.2.6 Stage 2, Stage 3 and LWB1-B3 Ecological Monitoring (Umwelt 2009, , Umwelt 2011b, Umwelt 2013, Umwelt 2014a, Umwelt 2014c, Umwelt 2016a, 2016b and 2016c)

Austar established an ecological monitoring program for the Stage 2, Stage 3 and LWB1-B3 areas in order to detect any impacts that may be associated with the longwall mining on the ecological values identified. Monitoring has been undertaken on a biannual basis at both Stage 2 and Stage 3 monitoring sites and on an annual basis for LWB1-B3 monitoring sites.

Monitoring of Stage 2 areas commenced in 2008 and is focused on monitoring riparian vegetation, particularly River-flat Eucalypt Forest EEC. There are six Stage 2 monitoring sites and monitoring consists of a combination of vegetation plot monitoring, condition assessment and photo monitoring.

Monitoring of Stage 3 areas commenced in 2012 and is focused on monitoring values of Lower Hunter Spotted Gum - Ironbark Forest EEC, heath wrinklewort (*Rutidosis heterogama*), small flower grevillea (*Grevillea parviflora* subsp. *parviflora*) and netted bottle brush (*Callistemon linearifolius*). There are nine Stage 3 monitoring sites at which a combination of vegetation plot monitoring, condition assessment, habitat assessment, targeted threatened species monitoring and photo monitoring are undertaken.

Baseline monitoring for the LWB1-B3 sites commenced in spring 2016 and is focused on monitoring values of Lower Hunter Spotted Gum – Ironbark Forest EEC as well as River-flat Eucalypt Forest EEC. There are two monitoring sites in this area at which vegetation plot monitoring, condition assessment, habitat assessment and photo monitoring are undertaken.

To date, there have been no observable impacts of longwall mining on ecological values or channel geomorphology in the Stage 2 area, with mining of all of the Stage 2 longwall panels completed in 2013. There have also been no observed changes to any of the ecological values in the Stage 3 area, with the completion of mining of LWA7 and LWA8 to date. As only baseline ecological monitoring has been completed for the LWB1-B3 Modification Area no observation of post-mining data can be made. The first post mining ecological monitoring event is scheduled to commence in the LWB1-B3 Modification Area in spring 2017.

2.2.7 Longwall Panels A1 and A2 Flora and Fauna Assessment, Austar Coal Mine (ERM 2006)

ERM undertook an ecological survey and assessment for the proposed mining of LWA1 and LWA2 and associated infrastructure, on behalf of Austar Coal Mine (ERM 2006). The ecological survey comprised random meander and vehicle based vegetation transects, habitat assessment and opportunistic fauna observations (including observations for secondary traces of fauna such as scats, tracks, scratches and diggings). This project was located approximately 1 kilometre north of the LWB4-B7 Modification Area.

Three vegetation communities were recorded within the survey area, including the Lower Hunter Spotted Gum – Ironbark Forest and the Hunter Lowland Red Gum Forest, both TSC Act listed EECs. The third community was described as mostly cleared and is unlikely to conform to any TEC listings.

No threatened flora or fauna species were recorded within the survey area during the study, however several species were described as having potential to occur. Two ROTAP species were recorded, being *Grevillea montana* and *Macrozamia flexuosa*.

A 7 Part Test of Significance in accordance with the requirements of the EP&A Act was undertaken for the two EECs recorded and all threatened flora and fauna species found to have potential to occur within the Study Area. This assessment concluded that the proposed longwall mining development and clearing for associated surface infrastructure would not have a significant impact on any threatened species, migratory species, populations or EECs.

2.2.8 Vegetation of Werakata National Park, Hunter Valley, New South Wales. Cunninghamia 8(3): 331-347 (Bell 2004)

Werakata National Park lies within the largest patch of vegetation of the Hunter Valley floor and protects a number of vegetation communities considered to be poorly conserved within the region, as well as populations of a number of threatened flora species. Werakata National Park is located approximately 5 kilometres north-east of the LWB4-B7 Modification Area.

Six vegetation communities were delineated within the Park, which included Lower Hunter Spotted Gum – Ironbark Forest, Central Hunter Riparian Forest, Hunter Lowlands Red Gum Forest, Kurri Sand Swamp Woodland, Kurri Sand Melaleuca Scrub Forest and Riparian Melaleuca Thicket. Each of these communities corresponds with a TSC Act listed EEC, aside from Kurri Sand Melaleuca Scrub Forest and Riparian Melaleuca Thicket.

A total of 190 flora species were recorded within the Park; threatened species recorded included *Callistemon linearifolius, Grevillea parviflora* subsp. *parviflora, Eucalyptus glaucina* and *Eucalyptus parramattensis* subsp. *decadens.* Two ROTAP species were also recorded, being *Grevillea montana* and *Macrozamia flexuosa*.

Callistemon linearifolius was found in two locations within Werakata National Park, which may represent the known northern limit of the species. *Grevillea parviflora* subsp. *parviflora* was found to be common in the southern portion of Werakata National Park near Kitchener. A small population of *Eucalyptus glaucina* was found in the north-west corner of the Bishops Hill portion of Werakata National Park, where it occurs in the Hunter Lowlands Red Gum Forest. In Werakata National Park, *Eucalyptus parramattensis* subsp. *decadens* was found to have a limited distribution, mainly in association with the Neath Soil landscape and the Kurri Sand Swamp Woodland.

2.2.9 Vertebrate Fauna of Werakata National Park (DEC 2005)

A study on the vertebrate fauna of the former Aberdare State Forest (now Werakata State Conservation Area and Werakata National Park) was undertaken to inform the conservation and management of ecological values contained within the Park. The study drew on the findings of a number of previous surveys in the locality, including Ecotone (1995), Hoye (1995), Webster (1995) and Wellington and Wells (1995). This study area is approximately 5 kilometres north-east of the LWB4-B7 Modification Area.

In addition to the literature review, a wide range of systematic site-based fauna survey methods were employed for the project. This included diurnal bird and herpetofauna searches, nocturnal spotlighting, harp trapping, Anabat echolocation recording, call playback, Elliott trapping, hair tube sampling, habitat assessment and opportunistic observations.

The compilation of all data from previous and current surveys found that a total of 210 species of vertebrate fauna were found to be present within Werakata National Park, including 18 which are now listed under the NSW TSC Act (four of which are also now listed under the Commonwealth EPBC Act). The following lists all the threatened fauna species that were recorded within Werakata National Park:

- Stephens banded snake (*Hoplocephalus bungaroides*)
- black bittern (*Ixobrychus flavicollis*)
- glossy black-cockatoo (*Calyptorhynchus lathami*)
- swift parrot (*Lathamus discolor*)
- turquoise parrot (*Neophema pulchella*)
- barking owl (*Ninox connivens*)
- powerful owl (*Ninox strenua*)
- masked owl (*Tyto novaehollandiae*)
- brown treecreeper (eastern subsp.) (*Climacteris picumnus victoriae*)
- speckled warbler (*Chthonicola sagittatus*)
- black-chinned honeyeater (eastern subsp.) (*Melithreptus gularis gularis*)
- regent honeyeater (*Anthochaera phrygia*)
- hooded robin (*Melanodryas cucullata*)
- grey-crowned babbler (eastern subsp.) (*Pomatostomus temporalis temporalis*)
- koala (*Phascolarctos cinereus*)
- yellow-bellied glider (*Petaurus australis*)
- squirrel glider (*Petaurus norfolcensis*)
- grey-headed flying-fox (*Pteropus poliocephalus*)
- east-coast freetail-bat (*Mormopterus norfolkensis*)
- eastern false pipistrelle (*Falsistrellus tasmaniensis*)
- little bentwing-bat (*Miniopterus australis*)
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*).

Ten introduced fauna species have been recorded in Werakata National Park, the most common being wild/domestic dog (*Canis lupus familiaris*) and European red fox (*Vulpes vulpes*).

The report identifies two areas of high conservation significance, the Tomalpin Arboreal Zone and the known Swift Parrot Locations. In the Tomalpin Arboreal Zone, the highest density of hollow-bearing trees was recorded. Hollow-bearing trees are an important habitat component for a number of threatened fauna species recorded in the park including the squirrel glider, yellow-bellied glider, masked owl, powerful owl and micro-bat species. There were a number of locations at which the swift parrots have been recorded, in which important foraging resources were present such as spotted gum (*Corymbia maculata*) blossom and nectar; and grey box (*Eucalyptus moluccana*) lerp.

Several recovery plan actions were outlined in the document, primarily focusing on the protection of the swift parrot (*Lathamus discolor*), regent honeyeater (*Anthochaera phrygia*), large forest owls, barking owl (*Ninox connivens*), koala (*Phascolarctos cinereus*) and the yellow-bellied glider (*Petaurus australis*). A number of general recovery actions were outlined, including fire and pest species management and other habitat management practices.

2.2.10 Vertebrate Fauna of Werakata National Park and Werakata State Conservation Area (DECC 2008a)

This report was a study into the vertebrate fauna present in Werakata NP and Werakata SCA and built upon the content of DEC 2005. Data that went into the report comprised 72 DECC systematic survey sites that sampled for frogs, reptiles, birds and mammals as well as a compilation of past records from the Atlas of NSW Wildlife.

This study identified a total of 236 native terrestrial vertebrate fauna across both areas (totalling 6,300 hectares), comprised of 15 frogs, 27 reptiles, 159 birds and 35 mammals. It additionally identified 11 feral mammal species and five introduced birds.

Diversity of these areas was identified as being particularly high in comparison to other reserves of a similar size, likely as a result of the following:

- The study area lies within a corridor of contiguous vegetation (the largest patch of remnant vegetation on the Hunter Valley floor) that links Cessnock to the surrounding Hunter Ranges
- Dominance by spotted gum (*Corymbia macualta*), one of the few trees near the coast that are winter flowering.
- The ecological linkage for the movement of many species between the dry western environments and those along the coast.

Threatened species identified were the:

- Stephens banded snake (*Hoplocephalus bungaroides*)
- black bittern (*Ixobrychus flavicollis*)
- regent honeyeater (*Anthocahera phrygia*)
- swift parrot (*Lathamus discolor*)
- white-bellied sea eagle (*Haliaeetus leucogaster*)
- square-tailed kite (*Lophoictinia isura*)

- little eagle (*Hieraatus morphnoides*)
- barking owl (*Ninox connivens*)
- powerful owl (*Ninox strenua*)
- masked owl (*Tyto novaehollandiae*)
- brown treecreeper (*Climacteris picumnus*)
- speckled warbler (*Chthonicola sagittata*)
- black-chinned honeyeater (*Melithreptus gularis*)
- grey-crowned babbler (*Pomatostomus temporalis*)
- glossy-black cockatoo (*Calyptorhychus lathami*)
- gang gang cockatoo (*Callocephalon fimbriatum*)
- turquoise parrot (Neophema pulchella)
- little lorikeet (*Glossopsitta pusilla*)
- hooded robin (*Melanodryas cucullata*)
- scarlet robin (*Petroica boodang*)
- varied sittella (*Daphoenositta chrysoptera*)
- dusky woodswallow (*Artamus cyanopterus*)
- koala (*Phascolarctos cinereus*)
- squirrel glider (*Petaurus norfolcencis*)
- yellow-bellied glider (*Petaurus australis*)
- eastern freetail-bat (*Mormopterus norfolkensis*)
- little bentwing-bat (*Miniopterus australis*)
- eastern betwing-bat (*Miniopterus schreibersii oceanensis*)
- grey-headed flying fox (*Pteropus poliocephalus*)
- false pipistrelle (*Falsistrellus tasmaniensis*)
- New Holland Mouse (*Pseudomys novaehollndiae*).

2.2.11 Watagans National Park and Jilliby State Conservation Area Plan of Management (DECCW 2010)

The Watagans NP and Jilliby SCA cover areas of 7,798 hectares and 12,159 hectares respectively. Both are located in an area where the ecologically rich and productive moist forests of the mid north coast's give way to the drier forests of the Sydney sandstone country. This plan was designed to protect native vegetation, biodiversity, land, rivers and coastal waterways.

This plan identifies the key ecological values being protected. Key ecological features identified within the Watagas NP were:

- Hunter Lowland Redgum Forest EEC (TSC Act)
- Lowland Rainforest EEC (TSC Act) and CEEC (EPBC Act)
- yellow satinheart (*Bosistoa transversa*)
- giant barred frog (*Mixophyes iteratus*)
- stuttering frog (*Mixophyes balbus*)
- barking owl (*Ninox connivens*)
- glossy black cockatoo (*Calyptorhynchus lathami*)
- masked owl (*Tyto novaehollandiae*)
- sooty owl (*Tyto tenebricosa*)
- brush-tailed rock wallaby (*Petrogale penicillata*)
- yellow-bellied glider (*Petarurus australis*)
- koala (*Phascolarctos cinereus*)
- large-eared pied bat (*Chalinolobus dwyeri*)
- spotted-tailed quoll (*Dasyurus maculatus*).

2.2.12 Vegetation of the Cessnock-Kurri Kurri Region, Cessnock LGA, New South Wales: Survey, Classification & Mapping (Bell and Driscoll 2008)

A vegetation survey, classification and mapping project was undertaken for the Cessnock-Kurri region (Bell & Driscoll 2008) on behalf of OEH, (formerly DECC). The area covered by the project included 70,000 hectares of land between the foothills of the Watagan Range in the south, the Corrabare and Broken Back Ranges in the west, North Rothbury in the north and the Wallis Creek floodplain in the east. The principal driver for the project was to clarify the composition and distribution of EECs within the project area, while also providing vegetation community maps and descriptions of extant and pre-1750 vegetation. The conservation significance of each vegetation community described was determined, assisted by comparisons with other proximate regional vegetation classification projects. Recommendations for which communities might meet the criteria for nomination as EECs under the TSC Act were also made.

Within the project area close to 800 native plant taxa and 37 vegetation communities were recorded, including 10 threatened flora species and three undiscovered or previously undescribed flora taxa. Seven EECs were found to be present within the Study Area, including Lower Hunter Spotted Gum-Ironbark Forest EEC (TSC Act), Hunter Lowlands Red Gum Forest EEC (TSC Act) and Kurri Sand Swamp Woodland EEC (TSC Act).

2.3 Flora and Vegetation Community Surveys

Targeted field surveys were completed in the LWB4–B7 Modification Area in order to classify and map vegetation communities and fauna habitats and included targeted threatened flora and fauna species searches. Field surveys were designed with consideration of the *Threatened Species Surveys and Assessment: Guidelines for developments and activities* (working draft) (DEC 2004) and Cessnock Council *Flora and Fauna Survey Guidelines – Lower Hunter and Central Coast Region 2002* (Murray, Bell and Hoye 2002).

Surveys were undertaken on 23 March 2017, between 20 and 22 December 2016, 4 to 6 August 2015 and on 16 September 2015. The temperature during the 2017 survey was approximately 25 degrees Celsius and the weather was clear. Weather during the 2016 survey ranged between 11 and 34 degrees Celsius. Wind speeds were between 20 and 48 kilometres an hour and no rain was recorded. During 2015 surveys, temperatures ranged between 12 and 22 degrees Celsius and temperatures at night ranged between 1 and 15 degrees Celsius. Wind averaged 12 kilometres an hour and no rain was recorded.

2.3.1 Flora Surveys

Flora surveys comprised plot-based surveys, rapid assessments, and transect-based surveys. The locations of each of the flora surveys methods are shown on **Figure 2.1**. The aims of floristic surveys were to:

- record floristic diversity
- map vegetation communities
- describe the condition of vegetation
- determine the occurrence and extent of any threatened species, endangered populations or TECs within the LWB4-B7 Modification Area.

The extent of flora survey effort undertaken is provided in **Table 2.1** below.

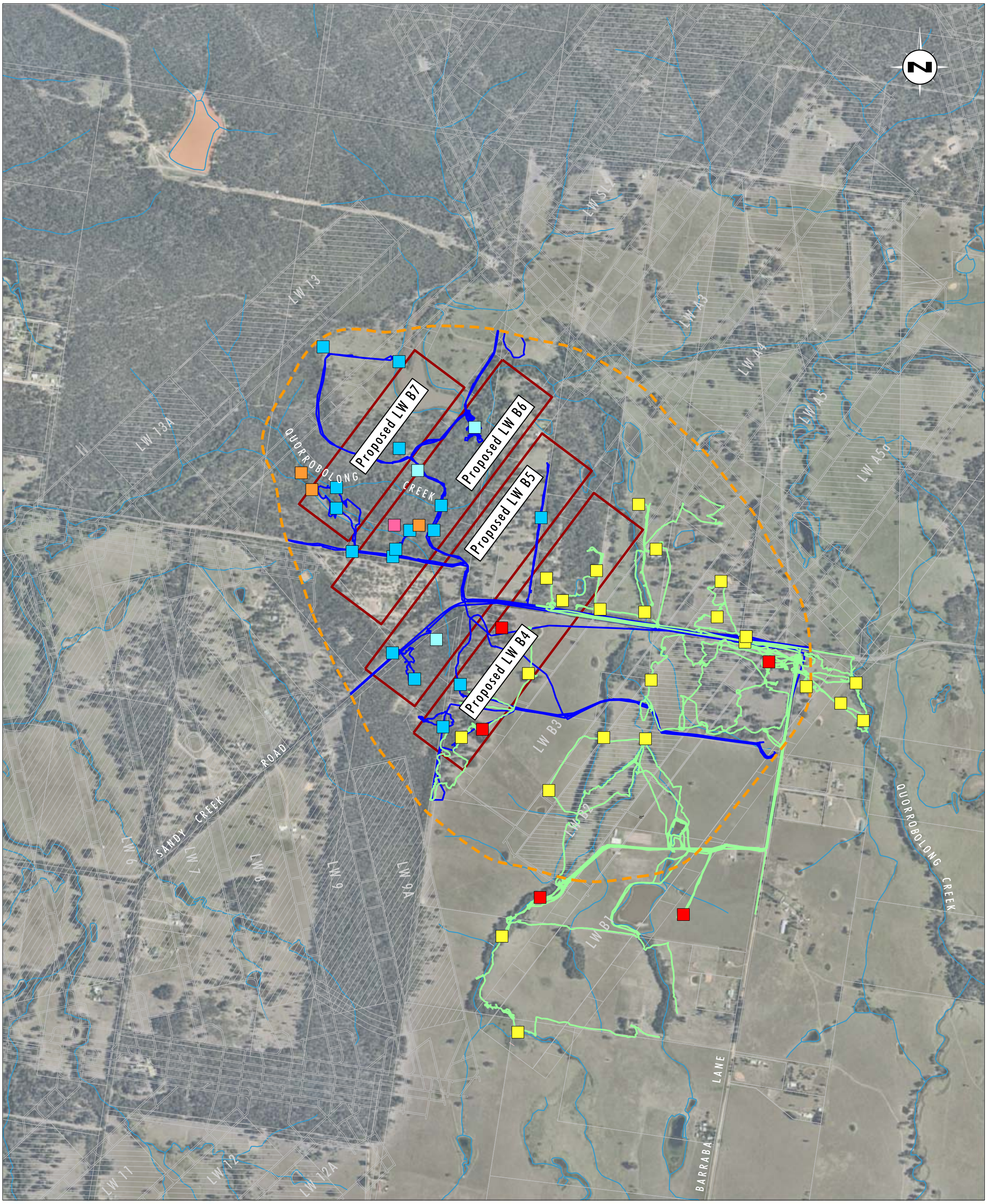

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- 2015 Meander Transect
- 2016 Meander Transect
- 2015 Plot-based Assessment
- 2015 Rapid Assessment
- 2016 Plot-based Assessment
- 2016 Rapid Assessment
- 2017 Plot-based Assessment
- 2017 Rapid Assessment

FIGURE 2.1

Flora Survey Methods

File Name (A4): R02/3900_023.dgn
20170516 12.41

Table 2.1 Extent and Adequacy of Flora Surveys Undertaken in the LWB4-B7 Modification Area

Survey Technique	Extent Required in Accordance with OEH Draft Guidelines (DEC 2004)	Extent Undertaken in LWB4-B7 Modification Area (Vegetation Community) 2015 and 2016	Adequacy
Floristic Plots	1 quadrat per stratification unit <2 hectares 2 quadrats per 2-50 hectares of stratification unit 3 quadrats per 51-250 hectares of stratification unit	1 (Riparian Swamp Oak Open Forest) 2 (Riparian Cabbage Gum Open Forest) 0 (Coastal Foothills Transition Forest) 0 (Melaleuca Scrubland with Emergent Eucalypts) 4 (Lower Hunter Spotted Gum Ironbark Forest (including variants)) 0 (Planted Vegetation) 0 (Grassland)	Considered sufficient given modified nature of vegetation (large amounts of grazing land), level of fragmentation, extent of mapping undertaken in region (see **Section 2.2**), and level of supplementary rapid assessments undertaken.

Survey Technique	Extent Required in Accordance with OEH Draft Guidelines (DEC 2004)	Extent Undertaken in LWB4-B7 Modification Area (Vegetation Community) 2015 and 2016	Adequacy
Rapid Assessments	Not required	5 (Riparian Swamp Oak Open Forest) 7 (Riparian Cabbage Gum Open Forest) 6 (Coastal Foothills Transition Forest (including variants)) 13 (Lower Hunter Spotted Gum Ironbark Forest (including variants)) 1 (Melaleuca Scrubland with Emergent Eucalypts) 1 (planted vegetation) 2 (Grassland) 2 (water body)	Sufficient to provide supplementary information regarding floristic composition and extent of community.

Survey Technique	Extent Required in Accordance with OEH Draft Guidelines (DEC 2004)	Extent Undertaken in LWB4-B7 Modification Area (Vegetation Community) 2015 and 2016	Adequacy
Transects	1x100m traverse per stratification unit <2 hectares 2x100m traverses per 2-50 hectares of stratification unit 3x100m traverses per 51-250 hectares of stratification unit and 30 minutes of random meanders for each quadrat sampled within the same stratification unit	2.0 km (Riparian Swamp Oak Open Forest) 2.1 km (Riparian Cabbage Gum Open Forest) 1.9 km (Coastal Foothills Transition Forest (including variants)) 0.4 km(Melaleuca Scrubland with Emergent Eucalypts) 12.8 km (Lower Hunter Spotted Gum Ironbark Forest (including variants)) 0.2 km (Planted Vegetation) 8.4 km (Grassland) 0.22 (Water Body))	Sufficient to provide supplementary information regarding floristic composition and extent of community.

2.3.2 Plot-based Surveys

A total of nine (five in 2015, three in 2016 and 1 during 2017) plot-based assessments were undertaken in the LWB4-LWB7 Modification Area, locations are provided on **Figure 2.1**.

The plot-based systematic vegetation surveys were undertaken using methods that were standard with the 2015 surveys. This ensured that data collected by other surveys could be incorporated into the current work, and that the data from the current study could be analysed in an equivalent way to that collected by other recognised studies.

When undertaking systematic sampling to assist vegetation community mapping and description, plot-based (or quadrat) surveys have several distinct advantages over non-quantitative transects, including:

- providing a quantitative examination of species distribution and abundance
- being likely to detect inconspicuous or rare species (especially forbs and grasses) within the given sampling area, as a smaller area is surveyed in a concentrated search
- providing a basis for any subsequent monitoring required.

Systematic 400 m^2 plots were used to undertake semi-quantitative sampling of vegetation. The typical dimensions of the plots are 20 x 20 metres. This plot size is used widely, including by the Royal Botanic Gardens Sydney and OEH.

At each plot, roughly 45 to 60 minutes were spent searching for all vascular flora species present within the plot. Searches of each plot were generally undertaken through parallel transects from one side of the plot to another. Most effort was spent on examining the groundcover, which usually supported well over half of the species present, however the composition of the shrub, mid-understorey, canopy and emergent layers were also thoroughly examined. Effort was made to search the canopy and tree trunks for mistletoes, vines and epiphytes.

Species within the plot were assigned a cover-abundance value to reflect their relative cover and abundance in the plot. Species located outside the plot were marked as present but were not assigned a cover-abundance value. A modified Braun-Blanquet 6-point scale (Braun-Blanquet 1927, with selected modifications sourced from Poore 1955 and Austin *et al*. 2000) was used to estimate cover-abundances of all plant species within each plot. **Table 2.2** shows the cover-abundance categories used.

Table 2.2 Modified Braun-Blanquet Crown Cover-abundance Scale

Class	Cover-abundance*	Notes
1	Few individuals (less than 5% cover)	Herbs, sedges and grasses: <5 individuals Shrubs and small trees: <5 individuals
2	Many individuals (less than 5% cover)	Herbs, sedges and grasses: 5 or more individuals Shrubs and small trees: 5 or more individuals Medium-large overhanging tree
3	5 – less than 20% cover	-
4	20 – less than 50% cover	-
5	50 – less than 75% cover	-
6	75 – 100% cover	-

Note: * Modified Braun-Blanquet scale (Poore 1955; Austin *et al*. 2000).

All flora species that were readily identified in the field were recorded on pro forma field survey datasheets. All flora species that could not be immediately identified and samples of all threatened flora species were collected, dried and identified or sent to the National Herbarium of NSW for identification.

In addition, information was gathered on the condition of the vegetation at each of the survey sites, including fire history and the density of weeds and evidence of disturbance such as feral animals.

2.3.3 Rapid Assessments

A total of 42 (23 during 2015, 16 during 2016 and three during 2017) rapid vegetation assessments were completed, primarily to assist in the delineation and refinement of vegetation mapping. These assessment sites were located within each broadly mapped vegetation community to allow data collection for each community without confounding effects from adjacent communities. Dominant, common and some uncommon plant taxa were recorded within each vegetation community along meandering transects, carried out on foot, at each location.

The rapid vegetation assessments did not utilise a quantitative sampling approach as this method was designed to allow rapid collection of non-quantitative species dominance data within limited timeframes. This technique involved walking a transect and recording species found at points along the transect. Rapid vegetation assessments were selected instead of the plot-based method because it increased the amount of data that could be collected within the available survey time, thereby maximising the quality and coverage of vegetation description and mapping. This technique also facilitates the recording of general species richness, assists in the delineation of vegetation community boundaries and targets the presence of threatened and significant flora species, endangered populations and TECs.

2.3.4 Meander Transect Surveys

Meander transects and field reconnaissance was undertaken across the LWB4-B7 Modification Area while both walking and driving. This form of survey is an alternative method of flora data collection that enables the surveyor to sample flora across a much larger area than that sampled in systematic plots. However, the data collected are usually in the form of presence records, rather than semi-quantitative values, and therefore do not contribute as much to the delineation of vegetation communities. Notwithstanding this, meander transects and field reconnaissance are valuable in that they enable a wide coverage of the area under investigation, and also facilitate the discovery of widely dispersed rare plant species and the identification of vegetation community boundaries.

Specific threatened species searched for during these surveys were:

- heath wrinklewort (*Rutidosis heterogama*) – vulnerable under the TSC Act and the EPBC Act
- Bynoes wattle (*Acacia bynoeana*) – endangered under the TSC Act and vulnerable under the EPBC Act
- black-eyed Susan (*Tetratheca juncea*) – vulnerable under the TSC Act and the EPBC Act
- netted bottle brush (*Callistemon linearifolius*) – vulnerable under the TSC Act
- *Eucalyptus parramattensis* subsp. *decadens* – vulnerable under the TSC Act and the EPBC Act
- slaty red-gum (*Eucalyptus glaucina*) – listed as vulnerable under the TSC Act and EPBC Act
- Craven grey box (*Eucalyptus largeana*) – listed as vulnerable under the TSC Act

- Pokolbin mallee (*Eucalyptus pumila*) - listed as vulnerable under the TSC Act and EPBC Act
- small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) – vulnerable under the TSC Act and the EPBC Act
- *Spyridium burragorang* – endangered population in the Cessnock local government area under the TSC Act.

2.3.5 Plant Identification and Nomenclature Standards

All vascular plants recorded or collected within quadrats, at rapid assessment points and along transects were identified using keys and nomenclature in Harden (1992, 1993, 2000 and 2002) and Wheeler *et al*. (2002). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from *PlantNET* (Botanic Gardens Trust 2016), the online plant name database maintained by the National Herbarium of New South Wales.

Common names used follow Harden (1992, 1993, 2000 and 2002) where available, and draw on other sources such as local names where these references do not provide a common name. Where the identity of a specimen was unknown or uncertain, it was lodged with the National Herbarium of New South Wales at the Royal Botanic Gardens Sydney.

2.3.6 Vegetation Mapping

Vegetation mapping involved the following steps to delineate community boundaries:

- review of aerial photography
- review of previous mapping undertaken (particularly Bell and Driscoll 2008)
- revision of existing vegetation mapping based upon ground-truthing.

Vegetation communities were delineated through the identification of repeating patterns of plant species assemblages in each of the identified strata. Communities were then compared to those vegetation communities identified in the *Vegetation of the Cessnock-Kurri Region* (Bell and Driscoll 2008).

Vegetation communities were grouped into three vegetation formations, which were based solely on structural characteristics rather than floristic components. These comprised:

- woodland (dominated by trees of 10 to 40 per cent cover and typically 6 to 20 metres height, with or without a mid-understorey or understorey)
- riparian and floodplain forest (dominated by trees of 10 to 80 per cent cover and typically 6 to 20 metres height, in a linear strip along waterways, or restricted to floodplains, with or without a mid-understorey or understorey) and
- grassland (dominated by grasses, sedges and forbs, with trees and shrubs very sparse or absent).

2.4 Fauna Surveys

Given that the proposed modification will not cause direct surface disturbance (i.e. tree-clearing), minimal disturbance to fauna habitat is considered likely to occur. As such, the fauna component of the field surveys focussed on potentially occurring threatened fauna with low mobility, or with potential to be impacted by disruptions to surface water (i.e. creek lines and dams). Fauna species surveys were designed with consideration of the *Threatened Species Surveys and Assessment: Guidelines for developments and activities* (working draft) (DEC 2004) and locations are provided on **Figure 2.2**.

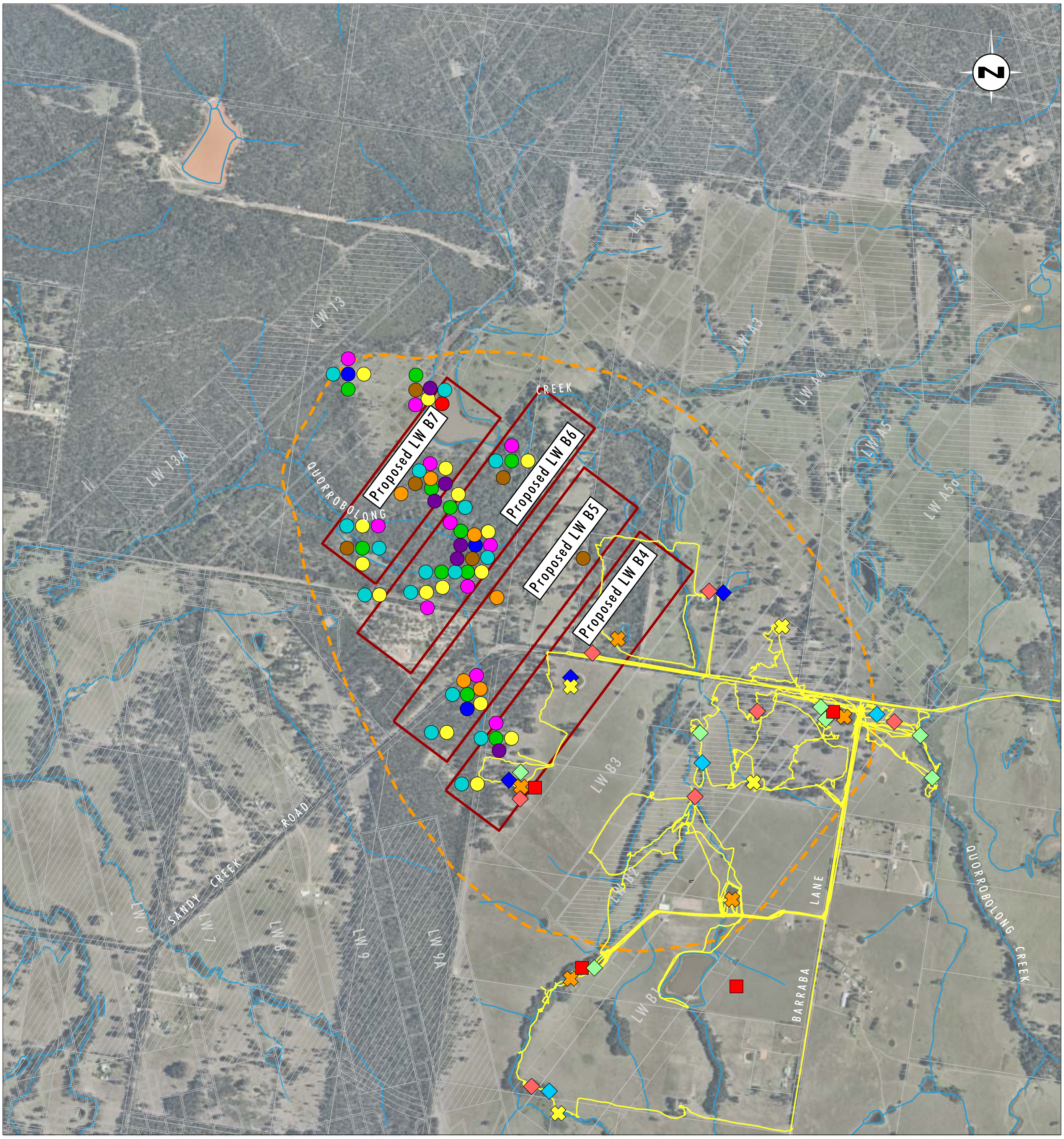

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

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Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- Drainage Line
- Cadastral Boundary
- 2015 Habitat Assessment Location
- 2015 Diurnal Bird Survey
- 2015 Green and Golden Bell Frog Call Playback and Search
- 2015 Herpetofauna Search
- 2015 SEPP 44 Assessment
- 2015 Threatened Mammal and Bird Call Playback
- 2015 Anabat Echolocation Survey
- 2015 Spotlighting Track
- 2016 Anabat Echolocation Surveys
- 2016 Diurnal Bird Surveys
- 2016 Green and Golden Bell Forg Call Playback and Search
- 2016 Habitat Assessment
- 2016 Herpetofauna
- 2016 Remote Camera
- 2016 SEPP 44 Assessment
- 2016 Spotlighting
- 2016 Threatened Mammal and Bird Call Playback

FIGURE 2.2

Fauna Survey Methods

2.4.1 Diurnal Bird Surveys

Bird searches were each undertaken for approximately half an hour (by one or two observers); however were sometimes reduced to 15 minutes in the event of low/no bird activity (particularly during strong winds). Bird species were identified from characteristic calls and by observation using 10 by 42 binoculars. Bird surveys included opportunistic observation of dams for waterbirds.

Opportunistic observations were recorded during all other aspects of the field survey, particularly when travelling between survey sites.

A total of 18 (6 in 2015 and 12 during 2016) bird surveys were undertaken across the LWB4-B7 Modification Area, the locations of bird surveys are shown on **Figure 2.2**.

2.4.2 Herpetofauna Searches

Diurnal searches targeting reptiles and amphibians were undertaken during the warmest parts of the day. Diurnal searches were undertaken by two people for between half a person hour and one person hour (although were sometimes much less if the habitat present was limited to a small dam in which case the survey was limited to the time it took to meander the perimeter of the dam boundary).

Nocturnal searches targeted amphibians and nocturnal reptiles as part of the general spotlighting effort. All reptile and amphibian searches were undertaken by two ecologists for a period of at least 30 minutes. Nocturnal reptile and amphibian searches were undertaken using Petzl headlamps and/or 30 watt Lightforce spotlights.

Habitat features investigated during reptile and amphibian searches included water bodies, emergent vegetation, wet soak areas, logs, rocks, loose bark on tree trunks, exposed bedrock, leaf litter and open grassland areas. Amphibians not identifiable from their calls were captured for visual identification. All amphibians were handled according to the hygiene protocol for the control of disease in frogs (DECC 2008b). Non-venomous snake species and small lizards were captured for identification where necessary.

During the surveys a total of 15 (three in 2015 and 12 in 2016) herpetofauna searches were undertaken across the LWB4-B7 Modification Area (refer to **Figure 2.2**).

2.4.2.1 Targeted Green and Golden Bell Frog Surveys

In addition to general amphibian surveys, four (three during 2015 and one during 2016) water bodies within the LWB4-B7 Modification Area were assessed for potential to provide green and golden bell frog (*Litoria aurea*) habitat. This assessment included:

- searches for this species
- assessment of the presence of appropriate fringing vegetation and diurnal basking sites
- assessment of the clarity of the water
- size of the water body
- presence of tadpole predatorial species such as the plague minnow (*Gambusia holbrooki*).

2.4.3 Anabat Echolocation Surveys

Echolocation calls were detected using an Anabat II Bat Detector. Echolocation calls were recorded using an Anabat CF storage ZCAIM. The combination of detector and recording device is hereafter collectively referred to as the 'Anabat echolocation recorder'. The recorders were positioned horizontally on tree trunks or at an approximate 30 degree angle on the ground, with a small roof protecting the detector from rain. This protective cover enabled the recording of calls regardless of weather conditions. Anabat echolocation recorders were positioned in the vicinity of potential micro-bat flyways. Anabat echolocation recording was undertaken at three separate locations. At each of these locations Anabat echolocation recorders were left out for the duration of night work.

All Anabat detector recordings were analysed by Anna McConville (a micro-bat specialist) of ECHO Ecology. The echolocation calls were identified to one of four levels of confidence:

- definite
- probable
- possible
- species group (where the call could not be identified to species level and could belong to one of two or more species that were not necessarily of the same genus).

The first three levels of confidence (definite, probable and possible) were treated as positive identifications for the purposes of impact assessment. The 'species group' identification level was only treated as a possible identification, and only where species had previously been recorded in the vicinity of the LWB4-B7 Modification Area; otherwise confidence levels were considered too low to be accepted as a positive identification.

The locations of Anabat surveys are shown on **Figure 2.2**. Three Anabat echolocation sites were assessed during 2015, each over a single survey night. Three Anabat echolocation sites were also assessed during 2016, each over two survey nights.

2.4.4 Camera Traps

Remote-sensing camera trapping was undertaken at six locations and consisted of baited motion sensing remote cameras (herein referred to as remote cameras). At each of the monitoring sites, single remote cameras were positioned in an area of likely high fauna activity. The remote camera was set to record three photographs each time it was triggered. All remote cameras were left in-situ for three survey nights. Remote cameras were downloaded and resulting images analysed at the completion of the three nights.

2.4.5 Spotlighting

Spotlighting searches were undertaken both on foot and from a moving vehicle. Walking spotlighting searches were undertaken by two observers for a period of at least 30 minutes (total of one person hour) on each occasion. Vehicle spotlighting searches were undertaken by at least the passenger(s) from a slow moving vehicle along vehicle tracks between trapping sites. Walking and vehicle spotlighting searches were undertaken using 30 watt Lightforce spotlights. Vehicle spotlighting was typically taken from roadside vantage points for inaccessible areas, whereas walking spotlighting was undertaken for accessible areas.

A total of 11 survey sites (five in 2015 and six in 2016) were completed across the LWB4-B7 Modification Area (refer to **Figure 2.2**).

2.4.6 Nocturnal Call Playback

Nocturnal call playback sessions were undertaken within the first 4 hours after dusk. Calls were broadcast using a 10 watt directional loud hailer. Call playback sessions commenced and ended with a quiet listening period of approximately two minutes. Each species' call was played for a minimum of four minutes followed by a listening period of two minutes before the beginning of the next species' call. Mammal calls were played before bird calls to prevent the calls of predators (such as owls) decreasing the likelihood of prey species (such as gliders) responding to call playback. Call playback sessions included the calls of the:

- squirrel glider (*Petaurus norfolcensis*)
- koala (*Phascolarctos cinereus*)
- masked owl (*Tyto novaehollandiae*)
- barking owl (*Ninox connivens*)
- sooty owl (*Tyto tenebricosa*)
- powerful owl (*Ninox strenua*).

A total of ten nocturnal call playback sessions (five in 2015 and five in 2016) were undertaken (refer to **Figure 2.2**).

2.4.7 Signs of Presence Searches

Searches for indirect evidence of animal presence were conducted opportunistically during all survey activities, particularly during habitat searches and reptile and amphibian searches. Due to the opportunistic nature of signs of presence surveys the level of survey effort was not recorded. Evidence of presence included scats, feathers, nests, burrows, bones, tufts of hair and scratch marks on trees. All hair, scat and bone samples were identified by Barbara Triggs (scatologist, hair expert, author of *Scats, Tracks and Other Traces* (1996) and recognised in the *Survey Guidelines for Australia's Threatened Mammals* (DSEWPC 2011) as an expert in the field.

2.4.8 SEPP 44 Surveys

Any development application in a SEPP 44 specified local government area, affecting an area of 1 hectare or greater, must be assessed under SEPP 44. The Cessnock local government area is listed under Schedule 1 of SEPP 44. Assessment under SEPP 44 is based on an initial determination of whether the land constitutes potential koala (*Phascolarctos cinereus*) habitat. This is determined by assessing whether the eucalypt species present in Schedule 2 of the policy constitute 15 per cent or more of the total number of trees in the upper or lower strata of the tree component. If potential koala habitat is present, the area must be further assessed to determine if the land is core koala habitat.

The species listed in Schedule 2 of the policy are listed in **Table 2.3**.

Table 2.3 Species of Eucalypt listed in Schedule 2 of SEPP 44

Scientific Name	Common Name
Eucalyptus tereticornis	forest red gum
Eucalyptus microcorys	tallowwood
Eucalyptus punctata	grey gum
Eucalyptus viminalis	ribbon or manna gum
Eucalyptus camaldulensis	river red gum
Eucalyptus haemastoma	broad-leaved scribbly gum
Eucalyptus signata	scribbly gum
Eucalyptus albens	white box
Eucalyptus populnea	bimble box or poplar box
Eucalyptus robusta	swamp mahogany

Across the LWB4-B7 Modification Area, an assessment of the presence of koala feed tree species (as listed on **Table 2.3**) was made at 24 locations (seven in 2015 and 17 in 2016).

2.4.9 Habitat Assessment

Twenty-two habitat assessments (five in 2015 and 17 in 2016) were undertaken across the range of habitat types present (refer to **Figure 2.2**). The assessment targeted potential habitat and resources for fauna species, particularly threatened fauna species. Records of a number of habitat features were made at each site, including:

- evidence of disturbance such as fire, weeds, feral animals, dumping, erosion and logging
- presence of fallen timber/logs
- presence of stumps and stags
- presence of groundcover features such as rock, litter, grasses, logs, boulder, soil and lichen
- presence of dieback and/or insect attack
- mistletoe presence
- presence of perch sites, fallen and loose bark
- vegetation strata and composition
- tree size class (trunk diameter), and age (old growth, mature, regenerating, saplings)

- presence of other specific feed tree species (such as for cockatoos and honeyeaters)
- collection of detailed hollow data, including tree species and height, hollow size, orientation, position and height.

In addition to these general habitat features, searches for specific habitat requirements for threatened fauna species with potential to occur in the area were also made including the presence of winter-flowering eucalypt species for the regent honeyeater (*Anthochaera phrygia*) and the swift parrot (*Lathamus discolor*).

Habitat features such as tree hollows and fallen logs were inspected for any evidence of fauna occupation such as scratches on the trunks of trees, chewed entrances to hollows, scratchings or diggings near logs and scats at the base of trees or near logs.

2.5 Aquatic Surveys

An assessment was undertaken in order to record the aquatic habitats present in the ephemeral watercourses within the LWB4-B7 Modification Area and in a large ponded farm dam area in the north of the modification area. The assessment also sought to identify aquatic threatened species, populations or communities under the EPBC Act, FM Act or the TSC Act, that have potential to occur.

The AUSRIVAS sampling is a national, standardised sampling and prediction system used for the assessment of the ecological condition of Australia's rivers. It was developed in 1994 as part of the National River Health Program, which has been adopted by the major environmental federal, state and territory agencies in Australia. AUSRIVAS includes a habitat assessment component for recording the river substratum, flow conditions, water quality and aquatic riparian attributes. Locations of aquatic habitat assessment survey effort are identified on **Figure 2.3**.

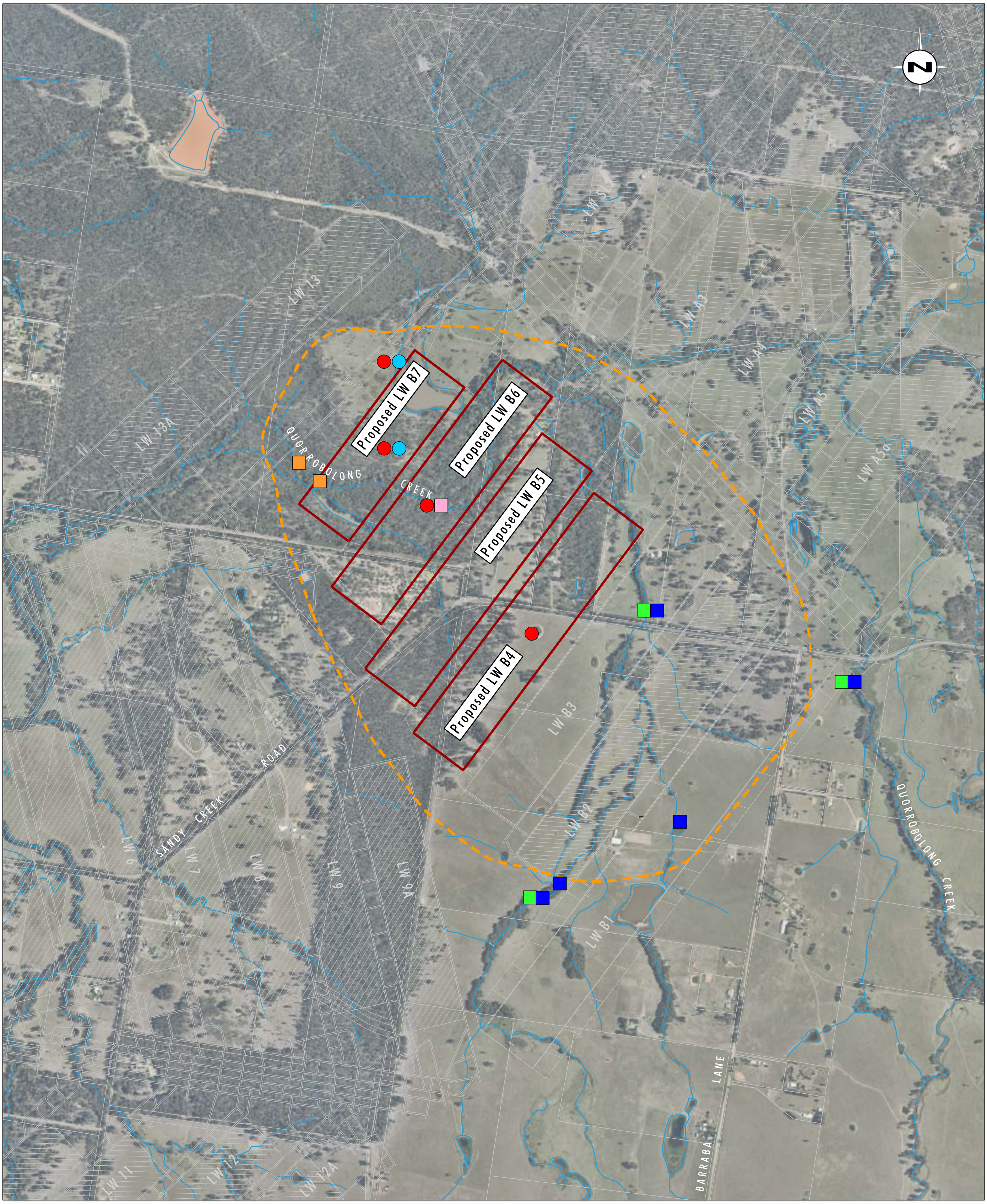

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

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Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- 2015 Aquatic Fauna Assessment Point
- 2015 Stream Assessment
- 2016 Dip-netting
- 2016 Box Trapping
- 2016 Stream Assessment
- 2017 Stream Assessment

FIGURE 2.3

Aquatic Survey Methods

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Assessment was undertaken along the three separate lengths of Quorrobolong Creek and the unnamed tributary of Quorrobolong Creek within the LWB4-B7 Modification Area, and at the large ponded farm dam area in the north of the modification area.

Water flow was absent at several points along Quorrobolong Creek and its unnamed tributary and in places was shallow (less than 5 cm depth). Aquatic fauna assessment points were undertaken at eight sites, four along Quorrobolong Creek, three along the unnamed tributary of Quorrobolong Creek and one at the large ponded in the north of the modification area. Visibility at each of these locations was good and dip-netting sessions for fish and large macroinvertebrates (such as yabbies (*Cherax destructor*)) were undertaken for approximately 15 minutes targeting areas of fringing vegetation and snags where available. Box traps were also deployed at two locations along Quorrobolong Creek where depths were appropriate to do so.

Captured aquatic vertebrates were identified in-situ with the aid of *Field Guide to Freshwater Fishes of Australia* (Allen et al. 2002) and released. Fauna captured were identified to at least a family level. Handling of any fish was undertaken in accordance with *A Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research* (Barker et al. 2009).

2.5.1 Aquatic Mammal Surveys

The likelihood of aquatic mammals occurring within the LWB4–B7 Modification Area was also considered during the habitat assessment, in particular the water rat (*Hydromys chrysogaster*) and the platypus (*Ornithorhynchus anatinus*). The potential presence of these species was assessed by searching for suitable bank habitat, burrows and also through searches for characteristic scats, tracks and other signs.

2.5.2 Aquatic Habitat Assessment

An assessment of the aquatic habitat characteristics was undertaken for the length of Quorrobolong Creek and its unnamed tributary within the LWB4-B7 Modification Area, with indicators of creek condition noted. Stream Assessment sampling in accordance with the AUSRIVAS sampling protocol was undertaken at five locations (see **Figure 2.3**) in areas considered likely to provide the greatest aquatic habitat value. The aquatic habitat characteristics were recorded using standard recording sheets (adapted from those developed for the AUSRIVAS sampling protocol). Some of the habitat features and creek condition indicators assessed included:

- local rainfall
- characteristics of bed substrate
- presence of woody debris
- presence of gravel beds
- presence of drought and flood refuge areas
- depth of water
- width of channel
- stream order
- presence of pool, riffle and edge habitats

- height of bank and evidence of erosion
- channel geomorphology
- evidence of sediment deposition
- degree of bank erosion
- presence of natural or artificial barriers to fish passage upstream and downstream
- anthropogenic disturbance
- colour and clarity of water, and any visual evidence of water quality
- characteristics of aquatic, riparian and floodplain vegetation.

An overview of the riparian condition was also made using the Riparian, Channel and Environmental Inventory (RCE) of Peterson (1992). The inventory assesses 16 characteristics for a 100 metre length of stream providing a maximum score of 360 and a lowest of 16 (with 360 indicating excellent habitat and 16 indicating poor habitat).

2.5.2.1 Fish Habitat

The quality of fish habitat at each surveyed site was assessed in accordance with the waterway classifications set out in the DPI 'Policy and Guidelines: Aquatic Habitat Management and Fish Conservation' (NSW Fisheries 1999), namely:

Class 1 – Major Fish Habitat

Waterways in this class consist of large, named and permanently flowing streams, creeks or rivers. These waterways provide threatened species habitat or are declared as 'critical habitat' under the FM Act. High quality native aquatic vegetation and structural habitat is present and it provides known fish habitat and/or fish have been observed inhabiting the water.

Class 2 – Moderate Fish Habitat

Moderate fish habitats are smaller named permanent or intermittent streams, creeks or watercourses with clearly defined drainage channels. They can be permanent waters or semi-permanent pools, or connected areas with limited aquatic vegetation or structure present. Known fish habitat and/or fish observed inhabiting the area.

Class 3 – Minimal Fish Habitat

Class 3 waterways can be named or unnamed with intermittent flows. They provide potential refuge, breeding or feeding areas for some aquatic fauna (such as yabbies). The drainage channel is often poorly defined with semi-permanent pools, ponds, farm dams or wetlands nearby, or in the form of watercourses after rain events. The watercourse may be interconnected with wetlands or other stream habitats.

Class 4 – Unlikely Fish Habitat

These waterways can be named or unnamed with intermittent flows during rain events only. There is little or no defined drainage channel. Little or no free standing water is present after rains and no permanent wetland aquatic flora is present. No aquatic or wetland vegetation is present.

2.5.3 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are described in the NSW GDE Policy (DLWC 2002) and can include terrestrial vegetation, base flow in streams, aquifer and cave ecosystems and wetlands.

A review of the Bureau of Meteorology Atlas of Groundwater Dependent Ecosystems (BoM Atlas) was completed in December 2016 to inform the identification of GDEs prior to detailed field surveys that were used to ground truth Atlas of Groundwater Dependent Ecosystems mapping and to identify any other potentially groundwater dependent ecosystems in the LWB4–B7 Modification Area.

It was also confirmed that no high priority GDEs listed under the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 were located within the region potentially impacted by the proposed modification.

3.0 Results

3.1 Floristics and Vegetation Communities

A full list of flora species recorded in the LWB4-B7 Modification Area is provided in **Appendix B**. A total of 220 flora species were recorded, of which 175 species are native and 45 are introduced. Four species were from the Class Filicopsida (ferns), and 216 from Magnoliopsida (flowering plants) (of which 67 were from sub-class Liliidae (monocots) and 149 from sub-class Magnoliidae (dicots)). Flora species were recorded from 69 plant families, the most speciose being Poaceae (grasses), Asteraceae (daisies), Fabaceae (legumes) and Myrtaceae (eucalypts, Melaleucas and Leptospermums).

Of the introduced species identified in the LWB4-B7 Modification Area, three are listed as noxious weeds under the *Noxious Weeds Act 1993* (NW Act), being blackberry (*Rubus fruticosus*), green cestrum (*Cestrum parqui*) and fireweed (*Senecio madagascariensis*). The two former tended to occur in damper riparian vegetation, whereas fireweed (*Senecio madagascariensis*) was more prevalent in open grassland areas.

3.1.1 Threatened Species, Endangered Populations and Regionally Significant Plants

Of the flora species identified within the LWB4-B7 Modification Area, three are listed as threatened species, being the netted bottlebrush (*Callistemon linearifolius*), small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) and heath wrinklewort (*Rutidosis heterogama*). Locations of threatened species are provided on **Figure 3.1**.

Heath wrinklewort (*Rutidosis heterogama*) was abundant (approximately 500 records documented) throughout partially disturbed areas in the centre of the LWB4-B7 Modification Area, particularly in areas of Spotted Gum – Ironbark Forest. It is likely that there are numerous more records present than those that were identified; however certain areas were inaccessible and surveys were not undertaken during peak flowering times for this species.

A total of 86 small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) were identified in the central areas of the LWB4-B7 Modification Area. These were found in similar habitats to the heath wrinklewort (*Rutidosis heterogama*).

Approximately 30 netted-bottle brush (*Callistemon linearifolius*) were identified in the LWB4-B7 Modification Area. These were only identified in the lower quality areas of Spotted Gum - Ironbark Forest in the east.

No endangered flora populations were identified occurring within the LWB4-B7 Modification Area, and based upon the habitats identified, none are expected to occur.

In addition to threatened species, the following flora species (**Table 3.1**) were identified in the LWB4-B7 Modification Area that is considered to be locally significant. These species may be considered regionally significant for a range of reasons, including:

- endemic taxa
- uncommon taxa
- records close to a geographic range extension
- significant reductions in population size or areas occupied.

Table 3.1 Locally Significant Flora Species

Species	Hunter Rare Plants Database (Peake 2003)	ROTAP
Grevillea montana	-	2VC
Parsonsia straminea	?W	-
Maytenus silvestris	U	-
Eucalyptus amplifolia subsp. *amplifolia*	T	-

Key to Criteria
2 = Restricted distribution - range extending over less than 100km
C = Species is known to occur within a proclaimed reserve
U = everywhere uncommon
V = Vulnerable - at risk over a longer period (20-50 years)
N or W = distributional limit in Hunter Region
T = may be threatened
? = code is uncertain

Regionally significant flora identified within the LWB4-B7 Modification Area is relatively widespread throughout the region, and therefore are not considered further within this assessment (particularly as none are proposed to be removed as part of the proposed modification).

3.1.2 Vegetation Communities

A total of seven vegetation communities (**Figure 3.1**) were identified in the LWB4-B7 Modification Area. These are all low-lying communities (between 130 and 163 metres AHD) as no hilltops or ridges are present within the LWB4-B7 Modification Area. The extent of each vegetation type within the LWB4-B7 Modification Area is presented in **Table 3.2** below.

Table 3.2 Vegetation Communities within the LWB4-B7 Modification Area

<table>
<tr><th>Community Name</th><th>Status</th><th>Approximate Extent (ha)</th></tr>
<tr><td colspan="3">Vegetation Communities</td></tr>
<tr><td>Riparian Swamp Oak Open Forest</td><td>-</td><td>18.1</td></tr>
<tr><td>Riparian Cabbage Gum Open Forest</td><td>River-flat Eucalypt Forest EEC (TSC Act)</td><td>56.7</td></tr>
<tr><td>Coastal Foothills Transition Forest</td><td rowspan="4">Lower Hunter Spotted Gum – Ironbark Forest EEC (TSC Act)</td><td>7.4</td></tr>
<tr><td>Coastal Foothills Transition Forest – underscrubbed</td><td>4.9</td></tr>
<tr><td>Spotted Gum - Ironbark Forest</td><td>24.3</td></tr>
<tr><td>Modified Spotted Gum - Ironbark Forest</td><td>62.0</td></tr>
</table>

Community Name	Status	Approximate Extent (ha)
Spotted Gum Ironbark forest -Underscrubbed		5.6
Melaleuca Shrubland with Emergent Eucalypts	Potential Quorrobolong Scribbly Gum Woodland EEC (TSC Act)[1]	1.6
Grassland	-	115.8
Planted Vegetation	-	0.7
Non Vegetated Areas		
Water Bodies	-	6.5
Total		**303.7**

1 Potential EEC however could not be confirmed without further detailed sampling.

Each of the vegetation communities identified in **Table 3.2** above is described in greater detail below.

umwelt

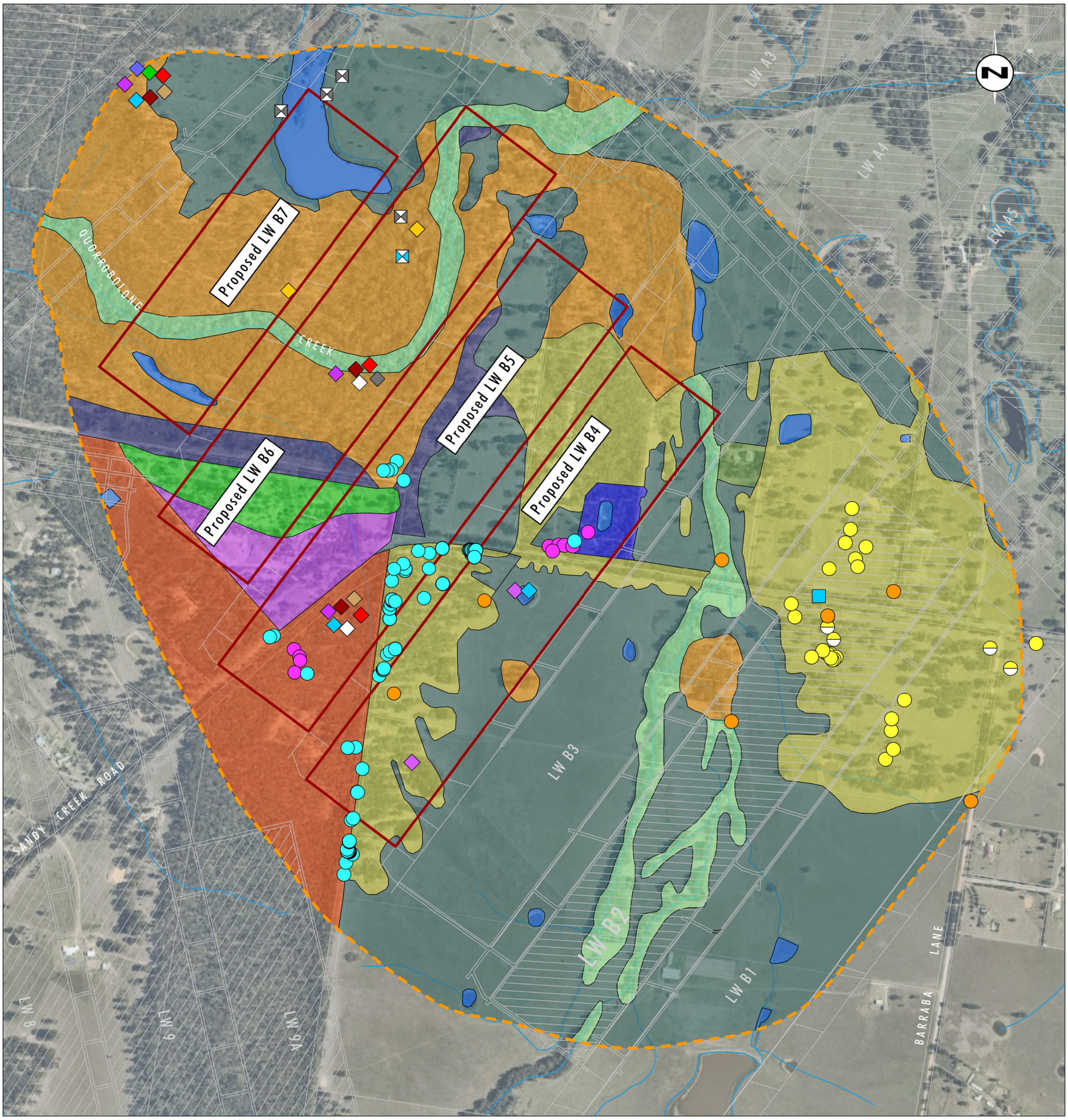

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)
Note: PR - Probable, SG - Species Group, D - Definite

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Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- Drainage Line
- Cadastral Boundary
- Modified Grassland
- Planted Vegetation
- Water Body
- Riparian Swamp Oak Open Forest

River Flat Eucalyptus Forest EEC:
- Riparian Cabbage Gum Open Forest

Lower Hunter Spotted Gum-Ironbark Forest EEC:
- Coastal Foothills Transition Forest
- Coastal Foothills Transition Forest - underscrubbed
- Spotted Gum Ironbark Forest
- Modified Spotted Gum Ironbark Forest
- Spotted Gum Ironbark Forest - underscrubbed

Potential Quorrobolong Scribbly Gum Woodland EEC:
- Melaleuca Shrubland with Emergent Eucalypts
- East-coast freetail-bat (Definite)
- Eastern bentwing-bat (Species Group)
- Eastern cave bat (Species Group)
- Eastern false pipistrelle (Species Group)
- Grey-crowned babbler (eastern subspecies)
- Grey-crowned babbler nests
- Grey-headed flying-fox
- Large-eared pied bat
- Greater broad-nosed bat (Species Group)
- Little bentwing-bat (Species Group)
- Little bentwing-bat (Probable)
- Squirrel glider
- Southern myotis (Species Group)
- Varied sittella
- White-bellied sea eagle
- White-bellied sea eagle Nest
- Yellow-bellied sheathtail-bat (Probable)
- *Callistemon linearifolius*
- *Grevillea parviflora* subsp. *parviflora*
- *Rutidosis heterogama*

FIGURE 3.1

Vegetation Communities and Threatened Species Results

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3.1.2.1 Riparian Swamp Oak Open Forest

The vegetation along the Quorrobolong Creek and its unnamed tributary within the LWB4-B7 Modification Area is dominated by Riparian Swamp Oak Open Forest. This community covers an area of approximately 18.1 hectares and occurs as a narrow, sometimes fragmented corridor. A representative photo of this vegetation type is presented in **Plate 3.1**.

Plate 3.1 Representative Photo of Riparian Swamp Oak Open Forest

This community is typified by an emergent occasional cabbage gum (*Eucalyptus amplifolia*), or rough-barked apple (*Angophora floribunda*), and rare occurrences of introduced camphor laurel (*Cinnamomum camphora*) (more commonly in the south). The height of the emergent layer was approximately 20 metres with typically less than 2 per cent cover.

This community typically supported a moderately dense (approximately 30 per cent) low tree stratum comprising swamp oak (*Casuarina glauca*), with occasional occurrences of river oak (*Casuarina cunninghamiana*) (mostly planted). The height of this layer was typically to approximately 15 metres.

This community typically lacked a shrub layer in southern grazed areas, however was moderately dense in the north. Where present, species included ball honeymyrtle (*Melaleuca nodosa*), *Leptospermum polygalifolium* and the introduced wild tobacco bush (*Solanum mauritianum*).

The ground stratum of the Riparian Swamp Oak Open Forest comprised a mixture of native and introduced grasses, graminoids and small herbs. Species recorded within this stratum include couch (*Cynodon dactylon*), weeping grass (*Microlaena stipoides*), native violet (*Viola hederacea*), native wandering Jew (*Commelina cyanea*), maidenhair fern (*Adiantum aethiopicum*), bracken fern (*Pteridium esculentum*) and *Lomandra longifolia*. Groundcover vegetation was much more dense and taller in northern areas compared to their grazed counterparts in the south.

A number of weed species were commonly recorded throughout this vegetation community, including sharp rush (*Juncus acutus*), panic veldtgrass (*Ehrharta erecta*), kikuyu (*Pennisetum clandestinum*), blackberry (*Rubus fruticosus* sp. agg.), fireweed (*Senecio madagascariensis*) and buffalo grass (*Stenotaphrum secundatum*). The weed species and their density varied throughout the LWB4-B7 Modification Area, as a result of the different land management practices.

The majority of riparian areas occurring within the southern LWB4-B7 Modification Area are unfenced from stock grazing and are subsequently degraded. Overall, the vegetation of this community is currently considered to be in low-moderate condition in the south and good to the north of Sandy Creek Road.

3.1.2.2 Riparian Cabbage Gum Open Forest

Riparian Cabbage Gum Open Forest covers an area of approximately 56.7 hectares, primarily occurring north of Sandy Creek Road. This community is characterised by a cabbage gum (*Eucalyptus amplifolia*) and to a lesser extent forest red gum (*Eucalyptus tereticornis*) and rough-barked apple (*Angophora floribunda*). The height of this layer was approximately 20 to 30 metres with approximately 20 per cent cover. A representative photo of this vegetation type is presented in **Plate 3.2**.

Plate 3.2 Representative Photo of Riparian Cabbage Gum Open Forest

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South of Sandy Creek Road, this community comprises small remnant fragments subject to moderate grazing and is considered to be in moderate condition due to historical clearing and ongoing land management practices.

North of Sandy Creek Road this vegetation is better connected and subject to less detrimental land management practices with lower stocking rates. Vegetation in these areas is in good condition.

Shrubby vegetation is dominated by silver wattle (*Acacia dealbata)*, silver-stemmed wattle (*Acacia parvipinnula*), native raspberry (*Rubus parvifolius*), native blackthorn (*Bursaria spinosa*), orange bush (*Maytenus silvestris*), dogwood (*Jacksonia scoparia*), flax-leaved paperbark (*Melaleuca linarifolia)*, and occasional introduced green cestrum (*Cestrum parqui*). Snake vine (*Stephania japnica*) was also regularly encountered.

The groundcover species diversity is dominated by blady grass (*Imperata cylindrica*), bracken fern (*Pteridium esculentum*), *Lomandra longifolia*, couch (*Cynodon dactylon*) and kidney weed (*Dichondra repens*). Introduced species were common in these areas (mainly in low numbers) and included flat weed (*Hypochaeris radicata*), fireweed (*Senecio madagascariensis*), fleabane (*Conyza bonariensis*) and variegated thistle (*Silybum marianum*).

3.1.2.3 Coastal Foothills Transition Forest

Coastal Foothills Transition Forest covers an area of approximately 7.4 hectares in LWB4-B7 Modification Area (**Figure 3.1**), occupying the drier low slopes in the north-west.

Canopy vegetation comprised grey gum (*Eucalyptus punctata*) and spotted gum (*Corymbia maculata*), as well as narrow-leaved ironbark (*Eucalyptus crebra*) and broad-leaved ironbark (*Eucalypts fibrosa*). The midstorey was open and dominated by *Melaleuca* sp.

Groundcovers provided moderate coverage and included kangaroo grass (*Themeda australis*), barbed wire grass (*Cymbopogon refractus*), common everlasting (*Chrysocephalum apiculatum*) and a variety of other grasses, graminoids and herbs. Commonly identified introduced species were fireweed (*Senecio madagascariensis*), *Gamochaeta* sp., fleabane (*Conyza bonariensis*) and flatweed (*Hypochaeris radicata*).

Coastal Foothills Transition Forest (Underscrubbed variant)

This variant comprises canopy vegetation consistent with Coastal Foothills Transition Forest, however has been underscrubbed and was subsequently largely devoid of shrubs. Groundcover vegetation was present, however is heavily maintained with many of the grasses present not identifiable. This vegetation comprised approximately 4.9 hectares. A representative photo of this vegetation type is presented in **Plate 3.3**.

Plate 3.3 Representative Photo of Coastal Foothills Transition Forest (Underscrubbed)[1]

3.1.2.4 Spotted Gum – Ironbark Forest

Spotted Gum – Ironbark Forest covers an area of approximately 24.3 hectares in LWB4-B7 Modification Area (**Figure 3.1**), occupying the drier low slopes in the central areas. This community is widespread within the local area, and is the dominant community within the nearby Werakata State Conservation Area and National Park. A representative photo of this vegetation type is presented in **Plate 3.4**.

[1] This underscrubbing has been undertaken by the private landholder on privately owned land within the LWB4-B7 Modification Area, and is not as a result of mining related works.

Plate 3.4 Representative Photo of Spotted Gum - Ironbark Forest

The canopy stratum of this community was dominated by broad-leaved ironbark (*Eucalyptus fibrosa*) with fewer occurrences of spotted gum (*Corymbia maculata*). A number of other canopy species occur within this community in different abundances, including grey box (*Eucalyptus moluccana*) typically with between 15 and 25 per cent cover (dependent on land management practices), growing to heights between 18 and 30 metres (depending on the age of vegetation). Regeneration of canopy species in this community was moderate.

The Spotted Gum – Ironbark Forest has an open shrub stratum in the eastern-most areas (generally less than 5 per cent cover as a result of historical clearing and ongoing grazing practices) and more dense in the west where vegetation was relatively undisturbed. Height ranges were consistently between 0.5 metres to 4 metres. The dominant species recorded include native blackthorn (*Bursaria spinosa*), narrow-leaved orange bark (*Maytenus silvestris*), *Daviesia ulicifolia* and western boobialla *(Myoporum montanum*).

The ground stratum of this community is dominated by native grasses, with a lesser extent of herbs, ferns and creepers. The more common species recorded include threeawn speargrass (*Aristida vagans*), hedgehog grass (*Echinopogon ovatus*), barbed wire grass (*Cymbopogon refractus*), threeawn speargrass (*Aristida vagans*), couch (*Cynodon dactylon*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), *Glycine clandestina* and *Goodenia rotundifolia*. Introduced species were also common encountered although not dominant. The ground stratum has a cover of approximately 70 per cent and was generally less than 0.5 metres in height.

Threatened species heath wrinklewort (*Rutidosis heterogama*), typically occurs in this vegetation community.

This vegetation community was considered to be in moderate condition in the east and good condition in the west.

Modified Spotted Gum – Ironbark Forest

The Modified Spotted Gum Ironbark Forest variant comprised 62.0 hectares. The modified variant of this community comprises areas subject to cattle grazing. Canopy vegetation was consistent with the undisturbed form. Regeneration of canopy species in this community was low.

The Modified Spotted Gum – Ironbark Forest has a sparse shrub stratum (generally less than 5 per cent cover as a result of historical clearing and ongoing grazing practices) and predominantly comprised native blackthorn (*Bursaria spinosa*). Many of the shrubs identified appeared to be stunted from grazing.

Groundcover vegetation in these areas comprised predominantly low grasses, with an abundance of introduced species, particularly fireweed (*Senecio madagascariensis*), onion grass (*Romulea rosea*), flatweed (*Hypochaeris radicata*) and burr medic (*Medicago polymorpha*).

Spotted Gum – Ironbark Forest (Underscrubbed)

The Spotted Gum - Ironbark Forest (Underscrubbed) variant comprised 5.6 hectares. This variant comprises canopy vegetation consistent with Spotted Gum – Ironbark Forest, however has been underscrubbed and was subsequently largely devoid of shrubs. Groundcover vegetation was present, however is heavily maintained with many of the grasses present not identifiable.

3.1.2.5 Melaleuca Shrubland with Emergent Eucalypts

A small area (1.6 hectares) in the north-west of the LWB4-B7 Modification Area comprised Melaleuca Shrubland with Emergent Eucalypts. The soil surface in this area appeared sandy. This community was typified by an open canopy to heights of approximately 25 metres with occasional occurrences of by grey gum (*Eucalyptus punctata*), forest red gum (*Eucalyptus tereticornis*), and smooth-barked apple (*Angophora costata*) (although no consistent canopy vegetation was identified). The dense understorey layer typified this vegetation and occurred to heights of 5 metres dominated by *Melaleuca nodosa*, *Banksia spinulosa*, needlebush (*Hakea sericea*), *Leptospemum trinerum* and occasional narrow-leaved geebung (*Persoonia linearis*). Groundcover vegetation was sparse as a result of shading from the dense midstorey, however typically encountered species included kangaroo grass (*Themeda australis*) and purple wiregrass (*Aristida vagans*). Typical weed species encountered were whisky grass (*Andropogon virginicus*) and fireweed (*Senecio madagascariensis*) however densities of these species were low. A representative photo of this vegetation type is presented in **Plate 3.5**.

Plate 3.5 Melaleuca Shrubland with Emergent Eucalypts

3.1.2.6 Grassland

Grassland covers an area of approximately 115.8 hectares in LWB4-B7 Modification Area (**Figure 3.1**). The areas of Grassland are likely to have previously supported woodland vegetation similar to that of surrounding vegetation remnants; however they have been cleared of tree and shrub species primarily for agricultural purposes. These are no longer considered to comprise grasslands derived from native vegetation communities as their species composition is not representative of native vegetation of any of the locally occurring communities and contain virtually no regeneration. A representative photo of this vegetation type is presented in **Plate 3.6** (higher quality areas) and **Plate 3.7** (lower quality areas).

Plate 3.6 Representative Photo of Grassland in the North

Plate 3.7 Representative Photo of Grazed Grassland in the South

The Grassland community generally lacks tree and shrub strata, however occasional individual paddock trees or shrubs are scattered throughout. Regeneration of shrubby vegetation is particularly prevalent; however due to the modification of the groundcover it was not possible to identify the source community of this vegetation. The community is characterised by a dense low layer of a range of native and introduced grasses, and also a diversity of small herbs. Species commonly recorded include slender rats tail grass (*Sporobolus creber*), couch (*Cynodon dactylon*), kangaroo grass (*Themeda australis*), and the introduced species paspalum (*Paspalum dilatatum*), flatweed (*Hypochaeris radicata*), plantain (*Plantago lanceolata*), *Setaria* sp., burr medic (*Medicago polymorpha*), chickweed (*Stellaria media*), and fireweed (*Senecio madagascariensis*). It should be noted that other grass species were present; however were unidentifiable due a lack of seed heads.

The floristic composition of the Grassland is variable between the different properties throughout the LWB4-B7 Modification Area, which is the result of different land management practices associated with different landholders.

This grassland was considered to be in a low condition as a result of historical clearing and current land management practices.

3.1.2.7 Planted Vegetation

This vegetation comprised a very small area of approximately 0.7 ha in size. This vegetation was planted around a residence and was not considered to be consistent with native vegetation.

3.1.2.8 Water Bodies

The LWB4-B7 Modification Area incorporates several water bodies, including a section of Quorrobolong Creek, an ephemeral tributary and first order drainage line associated with Quorrobolong Creek, a number of small farm dams and a larger ponded farm dam water body in the north of the modification area. The aquatic habitats present within the LWB4-B7 Modification Area are discussed in **Section 3.5**.

3.1.3 Threatened Ecological Communities

Two confirmed and one potential TEC were identified in the LWB4-B7 Modification Area being *River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* EEC (River-flat Eucalypt Forest EEC), the *Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin Bioregion EEC* (Lower Hunter Spotted Gum – Ironbark Forest EEC) and potential *Quorrobolong Scribbly Gum Woodland in the Sydney Basin Bioregion EEC* (potential Quorrobolong Scribbly Gum Woodland EEC). These EECs are listed under the TSC Act. No TECs were identified in the LWB4-B7 Modification Area that was consistent with listings under the EPBC Act. The details of these EECs as they occur within the LWB4-B7 Modification Area are provided in greater detail below.

River-flat Eucalypt Forest EEC

Based upon geographic location, geology, structural and floristic composition of the riparian vegetation within the LWB4-B7 Modification Area, 56.7ha of vegetation (those areas identified as Riparian Cabbage Gum Open Forest) were considered to be consistent with River-flat Eucalypt Forest EEC listed under the TSC Act (**Figure 3.1**).

River-Flat Eucalypt Forest EEC is associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains. The community generally occurs below 50 metres above sea level (ASL); however it may occur on localised river flats up to 250 metres ASL. The EEC ranges in structure from tall open forest to woodland, with a canopy dominated by forest red gum (*Eucalyptus tereticornis*), cabbage gum (*Eucalyptus amplifolia* subsp. *amplifolia*), rough-barked apple (*Angophora floribunda*) and broad-leaved apple (*Eucalyptus subvelutina*). A small tree layer often is present, which may comprise *Melaleuca decora*, prickly-leaved tea tree (*Melaleuca styphelioides*), grey myrtle (*Backhousia myrtifolia*), white cedar (*Melia azedarach*), river oak (*Casuarina cunninghamiana*) and swamp oak (*Casuarina glauca*). The mid-stratum is often absent, but where present may comprise species such as black thorn (*Bursaria spinosa*), forest nightshade (*Solanum prinophyllum*), native raspberry (*Rubus parvifolius*), coffee bush (*Breynia oblongifolia*) and *Ozothamnus diosmifolius*. The ground cover consists of a number of forbs, scramblers and grasses (NSW Scientific Committee 2011). The vegetation present is consistent with this EEC.

A seven part test of significance (in accordance with the EP&A Act) was undertaken to determine if the proposed modification would result in a significant impact on this EEC (**Appendix E**). The results of this test have been summarised in **Section 4**.

Lower Hunter Spotted Gum – Ironbark Forest EEC

Based on the geographic location, geology, structural and floristic composition of the Spotted Gum – Ironbark Forest and Coastal Foothills Transition Forest (including the variants of these communities) occurring on the lower slopes within the LWB4-B7 Modification Area, these communities are considered to be consistent with Lower Hunter Spotted Gum – Ironbark Forest EEC listed under the TSC Act (**Figure 3.1**). A total of 104.2 hectares of this EEC were identified.

The Lower Hunter Spotted Gum – Ironbark Forest EEC occurs in the central to lower Hunter Valley, principally on Permian geology. The EEC is restricted to a range of approximately 65 kilometres by 35 kilometres centred on the Cessnock – Beresfield area and corresponds to the Lower Hunter Spotted Gum – Red Ironbark Forest as described by Bell and Driscoll (2008) for the Vegetation of the Cessnock-Kurri Region. The dominant canopy species of this community are spotted gum (*Corymbia maculata*) and broad-leaved ironbark (*Eucalyptus fibrosa*), with grey gum (*Eucalyptus punctata*) and narrow-leaved ironbark (*Eucalyptus crebra*) present occasionally in lower frequency. A sparse (due a history of clearing and grazing) understorey comprising the following shrub species is present: (*Daviesia ulicifolia*), black thorn (*Bursaria spinosa* subsp. *spinosa*) and ball honeymyrtle (*Melaleuca nodosa*). The ground layer has a moderate species diversity, comprising poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), barbed-wire grass (*Cymbopogon refractus*), blue-flax lily (*Dianella revoluta*), wiry panic (*Entolasia stricta*), love creeper (*Glycine clandestina*), many-flowered mat-rush (*Lomandra multiflora*), weeping grass (*Microlaena stipoides* var. *stipoides*), kangaroo grass (*Themeda australis*) and white root (*Pratia purpurascens*) although dominated by introduced species in patches (NSW Scientific Committee 2010). The vegetation present is consistent with this EEC.

A seven part test of significance (in accordance with the EP&A Act) was undertaken to determine if the proposed modification would have a significant impact on this EEC (**Appendix E**). The results of this test have been summarised in **Section 4**.

Potential Quorrobolong Scribbly Gum Woodland EEC

The Melaleuca Shrubland with Emergent Eucalypts on the lower slopes in the centre of the LWB4-B7 Modification Area (refer to **Figure 3.1**) has the potential to conform to the Quorrobolong Scribbly Gum Woodland EEC listed under the TSC Act. This is based on the geographic location, geology, structural and floristic composition of the vegetation observed during rapid assessment survey. This area was not surveyed for confirmation of presence during the 2016 surveys as landholder access was not permitted, as such the presence of this community could not be confirmed.

The Quorrobolong Scribbly Gum Woodland EEC occurs on residual sand deposits overlying Permian clay sediments in the Hunter Valley. The EEC is only known to occur between Quorrobolong and Mulbring in the Hunter Valley NSW, but may occur elsewhere. The dominant canopy species that typify this EEC are scribbly gum (*Eucalyptus racemosa*), Sydney peppermint (*Eucalyptus piperita*) and red mahogany (*Eucalyptus resinifera*). Although these species were not identified within this area, the composition of the dense shrubby vegetation was sufficiently different from the adjacent areas of Spotted Gum - Ironbark Forest to warrant separation of the communities. The following flora species (out of a total list of 57 species) were identified during walking transects and rapid assessments of this area undertaken during 2015 and are considered characteristic from the final determination for this community (NSW Scientific Committee 2011b):

- *Allocasuarina littoralis*
- *Angophora costata*
- *Aristida vagans*
- *Banksia spinulosa*
- *Billardiera scandens*
- *Daviesia ulicifolia*
- *Dillwynia retorta*

- *Eucalyptus punctata*
- *Eragrostis brownii*
- *Glycine clandestina*
- *Hakea sericea*
- *Imperata cylindrica*
- *Hardenbergia violacea*
- *Jacksonia scoparia*
- *Leptospermum polygalifolium*
- *Leptospermum trinerum*
- *Lomandra multiflora*
- *Melaleuca nodosa*
- *Persoonia linearis*
- *Themeda australis.*

Given the regenerating condition of this community, the floristic dominants of this community are difficult to define. Despite this, the key species present, lead to the possibility of this community comprising the Quorrobolong Scribbly Gum Woodland EEC. As such, this Ecological Assessment has adopted a conservative approach and assessed the community as being the EEC.

A seven part test of significance (in accordance with the EP&A Act) was undertaken to determine if the proposed modification would have a significant impact on this potentially occurring EEC (**Appendix E**). The results of this test have been summarised in **Section 4**.

3.2 Fauna Results

The following section provides the results of the fauna surveys undertaken. This includes a list of fauna species recorded, threatened species identified and with potential to occur and habitats available to fauna species.

3.2.1 Fauna Species Recorded

A total of 123 fauna species were confidently recorded in the LWB4-B7 Modification Area. The following sections provide detail on the fauna species recorded, with a complete list of species recorded during field surveys provided in **Appendix C**.

3.2.1.1 Amphibian Species

Eleven frog species were recorded within the LWB4-B7 Modification Area. This included the following commonly identified species, bleating tree frog (*Litoria dentata*), eastern dwarf tree frog (*Litoria fallax*), Peron's tree frog (*Litoria peroni*), Gunther's frog (*Litoria latopalmata*), Tyler's tree frog (*Litoria tyleri*) and the striped marsh frog (*Limnodynastes peroni*).

No threatened amphibian species were recorded within the LWB4-B7 Modification Area.

3.2.1.2 Reptile Species

Eleven reptile species were recorded within the LWB4-B7 Modification Area during the surveys. Commonly recorded species were the eastern water-skink (*Eulamprus quoyii*), pale-flecked garden sunskink (*Lampropholis guichenoti*), water dragon (*Intellagama lesueurii*), eastern snake-necked turtle (*Chelodina longicollis*), Jacky dragon (*Amphibolurus muricatus*), southern rainbow-skink (*Carlia tetradactyla*) and the delicate garden skink (*Lampropholis delicata*). All of these species are considered to be locally common.

No threatened reptile species were recorded at within the LWB4-B7 Modification Area.

3.2.1.3 Bird Species

A total of 74 bird species were recorded within the LWB4-B7 Modification Area. The species recorded are typical of those associated with open woodland and grassland habitats, such as the Australian magpie (*Gymnorhina tibicen*), noisy miner (*Manorina melanocephala*), masked lapwing (*Vanellus miles*) and Australian magpie-lark (*Grallina cyanoleuca*). The most commonly encountered bird family was Meliphagidae (honeyeaters).

Three threatened bird species was recorded within the LWB4-B7 Modification Area, being the grey-crowned babbler (*Pomatostomus temporalis temporalis*), varied sittella (*Daphoenositta chrysoptera*) and the white-bellied sea eagle (*Haliaeetus leucogaster*). These species are listed as vulnerable under the TSC Act. The locations of threatened fauna species recorded in the LWB4-B7 Modification Area are shown on **Figure 3.1**.

3.2.1.4 Mammal Species

A total of 27 mammal species were confidently recorded within the LWB4-B7 Modification Area, with a further 11 (micro-bat) species that could not be confidently (either identified as a possible record or as part of a species group due to the echolocation recordings). Commonly recorded species included common brush-tail possum (*Trichosurus vulpecula*) and common ring-tailed possum (*Pseudocheirus peregrinus*).

Seven threatened mammal species, squirrel glider (*Petaurus norfolcensis*), grey-headed flying fox (*Pteropus poliocephalus*), little bentwing-bat (*Miniopterus australis*), east-coast freetail-bat (*Mormopterus norfolkensis*), yellow-bellied sheath-tail bat (*Saccolaimus flaviventris*), large-eared pied bat (*Chalinolobus dwyeri*) and greater broad-nosed bat (*Scoteanax rueppellii*) were confidently identified (either visually or by echolocation call) with in the LWB4-B7 Modification Area (**Figure 3.1**). The eastern falsistrelle (*Falsistrellus tasmaniensis*), eastern bentwing-bat (*Miniopterus schreibersii oceanensis*), southern myotis (*Myotis macropus*), and eastern cave bat (*Vespadelus troughtoni*) were also identified however only as possible records, however for the purposes of this impact assessment, and undertaking a conservative approach these have been assumed as positive records.

All threatened mammals species identified are listed as vulnerable under the TSC Act, with the large-eared pied bat (*Chalinolobus dwyeri*) and grey-headed flying-fox (*Pteropus poliocephalus*) additionally listed as vulnerable under the EPBC Act.

Although not recorded during surveys undertaken by Umwelt, a single record of the koala (*Phascolarctos cinereus*), has also been identified from Atlas records (BioNet 2016) in the LWB4-B7 Modification Area. The koala (*Phascolarctos cinereus*) is listed as vulnerable under both the TSC Act and the EPBC Act.

Six introduced fauna species were also identified, being the fox (*Vulpes vulpes*), rabbit (*Oryctolagus cuniculus*), rusa deer (*Rusa timorensis*), fallow deer (*Dama dama*), the domesticated cattle (*Bos taurus*) and horse (*Equus caballus*).

3.2.1.5 Threatened Fauna Species

A total of 15 threatened fauna species were identified in the LWB4-B7 Modification Area, being the:

- grey-crowned babbler (*Pomatostomus temporalis temporalis*)
- varied sittella (*Daphoenositta chrysoptera*)
- white-bellied sea eagle (*Haliaeetus leucogaster*)
- grey-headed flying fox (*Pteropus poliocephalus*)
- koala (*Phascolarctos cinereus*) (OEH database record)
- squirrel glider (*Petaurus norfolcensis*)
- little bentwing-bat (*Miniopterus australis*)
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*)
- east-coast freetail-bat (*Mormopterus norfolkensis*)
- yellow-bellied sheath-tail bat (*Saccolaimus flaviventris*)
- eastern falsistrelle (*Falsistrellus tasmaniensis*),
- southern myotis (*Myotis macropus*)
- eastern cave bat (Vespadelus troughtoni)
- large-eared pied bat (*Chalinolobus dwyeri*)
- greater broad-nosed bat (*Scoteanax rueppellii*).

A range of potentially occurring threatened flora and fauna species were also identified on the basis of the presence of potential habitat and local records. These species are included in **Appendix A**, along with a preliminary impact assessment to determine the need for further assessment under the EP&A Act or EPBC Act.

Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)

Records of the grey-crowned babbler were made at two locations (**Figure 3.1**) being a group of three and a group of eight birds. It is considered likely that the LWB4-B7 Modification Area provides habitat for a resident population of grey-crowned babblers.

Varied Sittella (*Daphoenositta chrysoptera*)

Varied sittellas were recorded at a single location within the LWB4-B7 Modification Area. This record comprised four individuals and was made in the south of the LWB4-B7 Modification Area in riparian vegetation. Although no evidence of breeding was observed, it is considered that a resident population exists due to the sedentary nature of this species.

White-bellied Sea Eagle (*Haliaeetus leucogaster*)

The white-bellied sea eagle was recorded on three separate occasions surrounding the large farm dam water body in the north, a nest of this species was also identified. Due to the occurrence of nesting, this species is a resident of this area, however is likely to not be exclusively reliant on the habitats present for foraging.

Large-eared Pied Bat (*Chalinolobus dwyeri*)

Two definite records of the large-eared pied bat (*Chalinolobus dwyeri*) were made in the centre of the LWB4-B7 Modification Area. One record was from over a farm dam, and one was made from an area of Spotted Gum - Ironbark Forest along the western boundary. It is unlikely that this species would be utilising the habitats of the LWB4-B7 Modification Area for anything other than foraging habitat as this is a cave-roosting species. No cave habitats, cliffs, old mine workings or similar were identified within the LWB4-B7 Modification Area.

This species would only likely be utilising the habitats present as part of a wider habitat range that extends outside of the LWB4-B7 Modification Area.

Grey-headed flying fox (*Pteropus poliocephalus*)

Records of the grey-headed flying fox were made at two locations (**Figure 3.1**). Although no camp sites were identified in the LWB4-B7 Modification Area during surveys undertaken by Umwelt in 2016, the LWB4-B7 Modification Area would likely support low densities of this species during mass flowering of canopy eucalypts and as a stepping stone between higher quality areas of habitat.

Koala (*Phascolarctos cinereus*)

The Atlas of NSW Wildlife identifies a single record of a koala (*Phascolarctos cinereus*) occurring within the LWB4-B7 Modification Area in 2006, however the accuracy of this record is to within 10km (i.e. highly inaccurate). The sighting was made by a community group (Dan Lunney's Community Wildlife Survey) and based on the limited availability of koala feed trees present within the modification area (refer to **Section 3.2.3**), it is considered highly likely that this record consisted of an individual passing through the LWB4-B7 Modification Area travelling to areas of better quality habitat.

The *EPBC Act Referral Guidelines for the Vulnerable Koala* (DoE 2014) were considered to assist in the determination of the significance of koala habitat in the LWB4-B7 Modification Area. In accordance with the Guideline, assessment of significant impacts on the koala is undertaken primarily through the assessment of habitat critical to the survival of the koala and actions that interfere substantially with the recovery of the koala.

The habitat assessment tool was applied to the LWB4-B7 Modification Area to determine the extent of vegetation that contains at least one known koala food tree. This process identified one SEPP 44 feed resource (grey gum (*Eucalyptus punctata*)), one primary food tree resource (cabbage gum (*Eucalyptus amplifolia*)) and one secondary food tree resource (grey box (*Eucalyptus moluccana*)).

The koala habitat assessment tool (a Federal assessment tool under the EPBC Act) resulted in a score of 5 indicating that the habitat present in the LWB4-B7 Modification Area provides habitat critical to the koala. However, no koalas, or evidence of koalas (such as scats or scratchings) were identified in the LWB4-B7 Modification Area, in addition, the SEPP 44 assessment (state assessment mechanism of presence of koala habitat covered in greater detail in **Section 3.2.3**), identified that this vegetation is not considered potential koala habitat.

Squirrel Glider (*Petaurus norfolcensis*)

A single record of a squirrel glider (*Petaurus norfolcensis*) was made within the LWB4-B7 Modification Area, during surveys undertaken by Umwelt in 2015. It is considered likely that the species is resident in the LWB4-B7 Modification Area, with potential habitat present to both forage and den (in the small amount of hollow-bearing trees). However it is likely that this is only as part of a wider habitat that extends outside of the LWB4-B7 Modification Area, particularly higher quality and more dense areas of vegetation to the west and north.

Little Bentwing-bat (*Miniopterus australis*)

A single confident record of the little bentwing-bat (*Miniopterus australis*) at one location and two possible records at two other locations were made in LWB4-B7 Modification Area (all in the north-west). It is possible that this species consists of a resident population given that it is a hollow-roosting (this species also roosts in caves however none were identified) species and appropriate hollow-bearing trees are present. This species could therefore be utilising the habitats available for both roosting and foraging.

It is likely, however, that this is only part of a wider habitat for this species that extends outside of the LWB4-B7 Modification Area, particularly in higher quality and more dense areas of vegetation to the north.

Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)

One possible record of the eastern bentwing-bat (*Miniopterus schreibersii oceanensis*) was made in the north-west of the LWB4-B7 Modification Area. For the purposes of this Ecological Assessment, this has been assumed as a positive indication. It is unlikely that this species would be utilising the habitats of the LWB4-B7 Modification Area for anything other than foraging habitat as this is a cave-roosting species. No cave habitats, cliffs, old mine workings or similar were identified within the LWB4-B7 Modification Area.

This species would only likely be utilising the habitats present as part of a wider habitat range that extends outside of the LWB4-B7 Modification Area, likely the higher quality habitats to the north.

East-coast Freetail-bat (*Mormopterus norfolkensis*)

This species was confidently recorded at two separate locations in the north-west of the LWB4-B7 Modification Area. It is possible that this species consists of a resident population given that it is a hollow-roosting species and appropriate hollow-bearing trees are present. This species could therefore be utilising the habitats available for both roosting and foraging. It is likely, however, that this is only part of a wider habitat for this species that extends outside of the LWB4-B7 Modification Area, particularly in higher quality and more dense areas of vegetation to the north.

Yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*)

A single confident record of the yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*) was made of this species in the north-west of the LWB4-B7 Modification Area. It is possible that this species consists of a resident population given that it is a hollow-roosting species and appropriate hollow-bearing trees are present. This species could therefore be utilising the habitats available for both roosting and foraging.

It is likely, however, that this is only part of a wider habitat for this species that extends outside of the LWB4-B7 Modification Area, particularly in higher quality and more dense areas of vegetation to the north.

Eastern Falsistrelle (*Falsistrellus tasmaniensis*)

This species was possibly recorded at three separate locations in the north-west of the LWB4-B7 Modification Area. For the purposes of this Ecological Assessment, these records have been assumed as positive identifications. It is possible that this species consists of a resident population given that it is a hollow-roosting species and appropriate hollow-bearing trees are present. This species could therefore be utilising the habitats available for both roosting and foraging.

It is likely, however, that this is only part of a wider habitat for this species that extends outside of the LWB4-B7 Modification Area, particularly in higher quality and more dense areas of vegetation to the north.

Southern Myotis (*Myotis macropus*)

This species was possibly recorded at three separate locations in the north-west of the LWB4-B7 Modification Area. For the purposes of this Ecological Assessment, these records have been assumed as positive identifications. It is possible that this species consists of a resident population given that it is a hollow-roosting species and appropriate hollow-bearing trees are present. This species could therefore be utilising the habitats available for both roosting and foraging (particularly over water bodies).

It is likely, however, that this is only part of a wider habitat for this species that extends outside of the LWB4-B7 Modification Area, particularly in higher quality and more dense areas of vegetation to the north.

Eastern Cave Bat (*Vespadelus troughtoni*)

This species was possibly recorded at three separate locations in the north-west of the LWB4-B7 Modification Area. For the purposes of this Ecological Assessment, these records have been assumed as positive identifications. It is unlikely that this species would be utilising the habitats of the LWB4-B7 Modification Area for anything other than foraging habitat as this is a cave-roosting species. No cave habitats, cliffs, old mine workings or similar were identified within the LWB4-B7 Modification Area.

This species would only likely be utilising the habitats present as part of a wider habitat range that extends outside of the LWB4-B7 Modification Area.

Greater Broad-nosed Bat (*Scoteanax rueppellii*)

A single probable record of the greater broad-nosed bat (*Scoteanax rueppellii*) was made over a farm dam in the west of the LWB4-B7 Modification Area. For the purposes of this Ecological Assessment, this has been assumed as a positive identification. It is possible that this species consists of a resident population given that it is a hollow-roosting species and appropriate hollow-bearing trees are present. This species could therefore be utilising the habitats available for both roosting and foraging.

It is likely, however, that this is only part of a wider habitat for this species that extends outside of the LWB4-B7 Modification Area, particularly in higher quality and more dense areas of vegetation to the west and north.

Large-eared Pied Bat (*Chalinolobus dwyeri*)

Two definite records of the large-eared pied bat (*Chalinolobus dwyeri*) were made in the north-west of the LWB4-B7 Modification Area. One record was from over a farm dam, and one was made from an area of Spotted Gum Ironbark Forest along the western boundary. It is unlikely that this species would be utilising the habitats of the LWB4-B7 Modification Area for anything other than foraging habitat as this is a cave-roosting species. No cave habitats, cliffs, old mine workings or similar were identified within the LWB4-B7 Modification Area.

This species would only likely be utilising the habitats present as part of a wider habitat range that extends outside of the LWB4-B7 Modification Area.

Threatened Fauna Species with Potential to Occur Within LWB4-B7 Modification Area

Although not identified in the LWB4-B7 Modification Area during surveys undertaken by Umwelt in 2015 or 2016, the threatened and migratory fauna species presented in **Table 3.3** below were considered to have potential to occur based on the presence of appropriate habitat

Table 3.3 Threatened Fauna Species with Potential to occur in the LWB4-B7 Modification Area

Species	Status		Comment on Likely Occurrence in the LWB4-B7 Modification Area
	TSC Act	EPBC Act	
Green and golden bell frog (*Litoria aurea*)	E	V	There is a low potential that this species may use the areas of higher quality water bodies in the north.
green-thighed frog (*Litoria brevipalmata*)	V	-	There is a low potential that this species may use the areas of higher quality riparian habitat.
Australian bittern (*Botaurus poiciloptilus*)	E	E	There is a low potential that this species may use the areas of higher quality water bodies in the north.
Black bittern (*Ixobrychus flavicollis*)	V	-	There is a low potential that this species may use the areas of higher quality water bodies in the north.
Black-necked stork (*Ephippiorhynchus asiaticus*)	E	-	There is a low potential that this species may use the areas of higher quality water bodies in the north.
Australian painted snipe (*Rostratula australis*)	E	E	There is a low potential that this species may use the areas of higher quality water bodies in the north.
Freckled duck (*Stictonetta naevosa*)	V	-	There is a low potential that this species may use higher quality water bodies in the north of the LWB4-B7 Modification Area when areas west of the Great Dividing Range are experiencing drought.

Species	Status		Comment on Likely Occurrence in the LWB4-B7 Modification Area
	TSC Act	EPBC Act	
swift parrot (*Lathamus discolor*)	E	CE	Potential habitat identified based on the presence of winter flowering eucalypts in the Spotted Gum Ironbark Forest areas and Riparian Cabbage Gum Open Forest. This species would not be utilising the habitats available for breeding.
regent honeyeater (*Anthochaera phrygia*)	CE	CE	Potential habitat identified based on the presence of winter flowering eucalypts in the Spotted Gum Ironbark Forest areas and Riparian Cabbage Gum Open Forest. This species is not likely to use the habitats available for breeding.
Japanese snipe (*Gallinago hardwickii*)		MIG	There is a low potential that this species may use the areas of higher quality water bodies in the north as part of a wider migratory range.
Sharp-tailed sandpiper (*Calidris acuminata*)		MIG	There is a low potential that this species may use the areas of higher quality water bodies in the north as part of a wider migratory range.
Common greenshank (*Tringa nebularia*)		MIG	There is a low potential that this species may use the areas of higher quality water bodies in the north as part of a wider migratory range.

3.2.2 Habitat Assessment

Four habitat types were identified within the LWB4-B7 Modification Area, and a description of each is provided below.

3.2.2.1 Riparian Habitat

Approximately 74.8 hectares of riparian habitat occurs along the ephemeral watercourses within the LWB4-B7 Modification Area. Riparian vegetation communities identified included Riparian Swamp Oak Open Forest and Riparian Cabbage Gum Open Forest. These areas are typically quite linear and have a linking function within the landscape rather than providing areas of core habitat for a wide range of species. Riparian vegetation breaks up large expanses of grassland that would otherwise be devoid of treed vegetation.

Riparian habitat areas are typically dominated by swamp oak (*Casuarina glauca*) and subsequently have potential to provide a foraging resource for threatened species such as the glossy black-cockatoo (*Calyptorhynchus lathami*); however this would only likely be in passing between larger areas of higher quality habitat. Less common occurrences of cabbage gum (*Eucalyptus amplifolia*) are also present, these patches of eucalypt vegetation have potential to provide a foraging resources for threatened winter migrant bird species such as the regent honeyeater (*Anthochaera phrygia*) and swift parrot (*Lathamus discolor*).

The groundcover and understory in these riparian areas is typically sparse as a result of grazing. However riparian habitats have the potential to provide foraging habitat for small woodland birds, small reptiles, amphibians and arboreal mammals. These areas may also provide a water resource for micro-bats and terrestrial mammals when water is present.

Some areas of hollow-bearing trees were identified; however these were sparse, and when occurring were typically only very small (<25mm) or small (26 – 50 mm) hollows, or peeling bark/timber fissures that would generally only be suitable as denning habitat for micro-bat species such as the little bentwing-bat (*Miniopterus australis*) or eastern free-tailed bat (*Mormopterus norfolkensis*).

3.2.2.2 Open Forest Habitat

The open forest habitats occur in the north of the LWB4-B7 Modification Area, and comprise *Spotted Gum – Ironbark Forest* (and its variants), *Lower Coastal Foothils Transition Forest* (and its variant), *Planted Vegetation* and *Melaleuca Shrubland with Emergent Eucalypts*. The canopy in the open forest habitats is dominated by eucalypt species, which, when flowering, would provide foraging resources for nectarivorous species. This may include a diversity of birds, micro-bats and small mammals, including threatened species such as the squirrel glider (*Petaurus norfolcensis*) and the grey-headed flying-fox (*Pteropus poliocephalus*). The Eucalypt species would also harbour a diversity of invertebrate species, which would be utilised by insectivorous species such as micro-bats. The canopy trees comprise a predominantly young age-class, with few large, hollow-bearing trees observed (with the exception of riparian areas (particularly in the north)). As such, nesting habitat for hollow-dependent fauna species is moderate.

The open forest habitats comprise an understorey of low, prickly shrubs which provide refuge areas for small birds, mammals and reptiles. The grassy ground stratum provides foraging resources for granivorous bird species.

3.2.2.3 Grassland Habitat

Much of the LWB4-B7 Modification Area is vegetated with open grassland habitats. These areas have been heavily cleared and grazed and now support a ground stratum dominated by pasture grass species, some of which are native and some introduced. These areas provide foraging habitat for a range of fauna species, however these are more limited than those of the open forest habitat areas. The scattered trees that occur throughout the Grassland areas are important refuges for fauna, birds in particular, that use these trees for foraging, and for roost and perch sites.

It is not considered that these areas provide substantial habitat for any threatened fauna species.

3.2.2.4 Dam and Waterbody Habitats

The LWB4-B7 Modification Area contains several constructed farm dams ranging in size from approximately 10 metres by 10 metres to 40 metres by 30 metres as well as a large ponded farm dam waterbody in the far north. The LWB4-B7 Modification Area contains approximately 6.5 ha of farm dam and waterbody habitat.

These areas typically have an absence of fringing treed vegetation; however do typically have fringing riparian sedge vegetation. Typical sedges in these areas comprise *Carex appressa*, nardoo (*Marsilea muricata*) and introduced sharp acutus (*Juncus acutus*). Emergent and floating vegetation are largely absent. Grazing is likely to be the key contributor to an absence of fringing vegetation of these dams.

The large ponded farm dam waterbody in the north provides a substantial area of open water as well as muddy banks in places that could be utilised for migratory bird species.

These areas likely provide an important freshwater resource to local fauna, particularly for native birds and mammals. It is likely that these water bodies also provide foraging habitat for water birds as well as several micro-bat species. These areas also provide moderate quality refuge habitat for local amphibian species.

3.2.3 SEPP 44 Koala Habitat Assessment Results

SEPP 44 listed tree species typically comprised 5 per cent or less of treed vegetation within each vegetation community present in the LWB4-B7 Modification Area. The exception to this was in the Coastal Foothills Transition Forest, where grey gum (*Eucalyptus punctata*) comprised approximately 10 per cent of the treed vegetation and a very small pocket in the north-west of the LWB4-B7 Modification Area that also comprised approximately 10 per cent of treed vegetation. However, in accordance with SEPP 44 the total koala feed trees must comprise at least 15 per cent in order to be considered potential habitat. Subsequently none of this vegetation is considered as potential koala habitat under the SEPP 44 assessment guidelines.

Although a record of the koala exists in the LWB4-B7 Modification Area, it is likely that the LWB4-B7 Modification Area provides supplementary habitat and connectivity links across the landscape for dispersing individuals, rather than habitat that supports a population of the species. It is more likely that this species would be utilising the large areas of Grey Gum woodland to the immediate west.

The vegetation present in the LWB4-B7 Modification Area is not considered to comprise core koala habitat as there is no evidence of recent presence or breeding and the BioNet record of this species from 2006 (over ten years ago).

3.3 Connectivity

Connectivity within the LWB4-B7 Modification Area is high in a north-south alignment along the eastern boundary and low-moderate in an east-west alignment (with the majority of the area subject to historical clearing and agriculture). Vegetation occurring in the north-west shows connectivity to a large remnant of vegetation associated with Quorrobolong Creek; however internal connectivity in the south-east comprises highly fragmented riparian vegetation along the unnamed tributary of Quorrobolong Creek.

3.4 Critical Habitat

There are currently four critical habitat declarations in NSW that are listed under the TSC Act. None of these areas are within or in proximity to the LWB4-B7 Modification Area. There is no potential for the proposed modification to have an impact on any areas of declared critical habitat.

3.5 Aquatic Results

Results of aquatic surveys have been summarised in **Appendix D**. **Plates 3.8, 3.9 and 3.10** present photos of the range in quality of aquatic habitats recorded in the LWB4-B7 Modification Area.

Plate 3.8 Higher Quality Aquatic Habitats provided by Quorrobolong Creek in the North of the LWB4-B7 Modification Area

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Plate 3.9 Lower Quality Aquatic Habitats provided by Unnamed Tributary of Quorrobolong Creek in the South of the LWB4-B7 Modification Area

Plate 3.10 Habitat Provided by Large Ponded Farm Dam Waterbody in the North of the LWB4-B7 Modification Area

In general the aquatic habitats provided were of a higher quality in the north than the south of the LWB4-B7 Modification Area (generally differentiated by Sandy Creek Road), as these areas are subject to fewer disturbances as a result of cattle grazing. Northern (upstream) reaches of Quorrobolong Creek had a greater diversity of native emergent as well as macrophytic aquatic vegetation as well as greater habitat diversity present (such as snags etc.). However at the time of survey these higher quality areas were not flowing and largely consisted of large standing pools.

Southern watercourses (unnamed tributary of Quorrobolong Creek mostly occurring south of Sandy Creek Road) contained moderate amounts of woody debris and tree roots which would provide moderate habitat and refugia for aquatic fauna. However are more susceptible to trampling by cattle.

All watercourses provide habitat for small aquatic fauna species and small fish (all fish identified were small (less than 10cm long)), such as the introduced mosquito fish (*Gambusia holbrooki*). The mosquito fish were identified in abundance throughout the watercourses and are likely to be impeding colonisation by native fish species.

The following additional fish species were identified, however only in the higher quality aquatic habitats in the north:

- Dwarf flathead gudgeon (*Philypnodon macrostomus*)
- Australian smelt (*Retropinna semoni*)

Invertebrate shrimp were also observed in each water course. Usage by the eastern long-neck turtle (*Chelodina longicollis*) was also common.

The unnamed tributary of Quorrobolong Creek occurring in the east of the LWB4-B7 Modification Area has several barriers to fish passage in the LWB4-B7 Modification Area, mostly in the form of sand/silt bars and was assessed as providing Class 3 or minimal fish habitat (as defined in **Section 2.5.2.1**). Quorrobolong Creek itself within the northern upstream areas of the LWB4-B7 Modification Area was considered relatively un-impeded and was classified as providing Class 2 or moderate fish habitat. All watercourses are slow-moving due to low flows and as such only riffles in general were rare. The large farm dam water body in the north of the LWB4-B7 Modification Area provides good quality fish habitat.

All watercourses are ephemeral in nature. The volume of water in all watercourses (where present) was identified as slightly lower than capacity at the times of the field investigations. The water in these watercourses was generally clear, occasionally with some minor tannins, and occasional areas of turbidity associated with disturbance by cattle.

Watercourses are all sinuous, and both banks and the substrate were comprised of silt/clay/sands with no gravel beds identified. Some bank erosion was present in the form of under-cutting; however this was minor and tended to occur along bends in areas where cattle grazing was more intense.

Out of a score of 200 (200 being high quality and 0 being low quality), the Riparian, Channel and Environmental inventory (RCE) assessments provided a score of:

- 138 for the west-most point of Quorrobolong Creek assessed
- 154 for Quorrobolong Creek as it occurs over LWB7
- 141 for northern Quorrobolong Creek over LWB6
- 119 for the unnamed tributary of Quorrobolong Creek as it occurs to the east of the LWB4-B7 Modification Area over LWB1;and
- 136 for southern reaches of the eastern-most unnamed tributary of Quorrobolong Creek north of Sandy Creek Road above LWB3.

Riparian channel condition scores of which are considered to indicate sub-optimal physical and biological conditions, with the exception of the north-western sections of Quorrobolong Creek which are in moderate condition.

Typically encountered fringing flora species included narrow-leaved typha (*Typha domingensis*) and the introduced sharp rush (*Juncus acutus)*; and typically encountered aquatic vegetation included water ribbons (*Triglochin procerum*) and nardoo (*Marsilea mutica*). Higher quality habitats in the north also included the following species:

- water plantain (*Alisma plantago-aquatica*)
- *Eleocharis* sp.
- frogsmouth (*Philydrum lanuginosum*)
- *Carex* sp.
- *Juncus* sp.

Also present were occasional infestations of introduced parrot's feather (*Myriophyllum aquaticum*).

No areas were identified in the LWB4-B7 Modification Area that were considered to have potential to provide habitat for the water rat (*Hydromys chrysogaster*) or platypus (*Ornithorhynchus anatinus*).

No threatened aquatic species listed as threatened under the TSC Act, EPBC Act or FM Act were identified or considered likely to occur.

3.6 Groundwater Dependent Ecosystems

The groundwater resources present in the LWB4-B7 Modification Area occur in the shallow alluvial aquifers associated with Quorrobolong Creek and its unnamed tributary, within shallow water bearing zones in the massive sandstones of the Branxton Formation and within the deeper Newcastle Coal Measures. There are no known GDEs within the LWB4-B7 Modification Area that rely on groundwater within the Branxton Formation or Coal Measures. However, it is highly likely that the riparian vegetation comprising Riparian Swamp Oak Open Forest and Riparian Cabbage Gum Open Forest is at least partially dependent upon shallow alluvial groundwater sources during periods of reduced surface water flow. The BOM Atlas identifies the areas north of Sandy Creek Road as comprising vegetation that has "moderate potential for groundwater interaction", these areas are reflective of the former identified vegetation communities.

The BoM Atlas identified Congewai Creek and Ellalong Lagoon as the only known GDEs (or partial GDEs) in the vicinity of the LWB4-B7 Modification Area. Ellalong Lagoon occurs approximately 4km west of the proposed LWB4-B7 Modification Area and Congewai Creek occurs more than 5km west and south of the LWB4-B7 Modification Area. Based on this mapping, Congewai Creek and Ellalong Lagoon are both classed as "Ecosystems that rely on the surface expression of groundwater"; however the southern end of Congewai Creek was classified as having a "low potential for groundwater interaction", the northern end was classified as having a "moderate potential for groundwater interaction" and Ellalong Lagoon was classified as having a "high potential for groundwater interaction". Neither of these GDEs occurs within the LWB4-B7 Modification Area and based on predictions of the subsidence, flooding and groundwater impact assessment reports, the proposed modification will not adversely impact these mapped GDEs.

4.0 Impact Assessment

4.1 Potential Impacts of the Proposed Modification

The proposed modification does not involve any additional surface development and therefore will have no direct impact on vegetation as a result of clearing. The potential impacts of the project on flora and fauna are therefore limited to impacts associated with subsidence.

Biodiversity values have the potential to be impacted by subsidence related surface cracking in the soil, and by any associated remediation of surface cracking post mining. Secondary impacts associated with hydrological changes are also possible and typically impact greatest on riparian areas. Such secondary impacts could include:

- changes to runoff and flow volumes through subsidence induced changes to catchment boundaries
- changes to bank stability and channel alignment
- changes to in-channel and out of channel ponding through changes to the bed profile of the creeks which may result in drying or waterlogging of root systems
- loss of water to near-surface groundwater flows due to subsidence-induced cracks occurring beneath a stream or other surface water body (this is of particular relevance to the large farm dam water body in the north of the LWB4-B7 Modification Area).

4.1.1 Subsidence Related Surface Cracking and Remediation

Potential changes in the ground surface resulting from subsidence have been assessed by MSEC (2017). MSEC notes that surface cracking in soils as the result of conventional subsidence movements is not commonly observed where the depths of cover are greater than 400 m, as is the case for the proposed modification. The subsidence assessment findings indicate that due to the depth of mining within the proposed modification area (minimum 400 metres), the massive nature of the Branxton Formation sandstones overlying the coal seam resulting in the small magnitudes of predicted ground curvatures and strains and the absence of steep slopes or cliffs within the modification area, the potential for surface cracking is low.

This conclusion is supported by subsidence monitoring evidence within the Stage 2, Stage 3 and LWB1-B3 areas, where there has been no significant or visible surface cracking above previously extracted longwalls A3 to A8 or LWB2. Similarly, ecological monitoring undertaken within the Stage 2 and Stage 3 areas since 2008 and 2012 respectively shows no evidence of any impacts on ecological features as a result of longwall mining (Austar 2014).

Any surface cracking that does occur is expected to be minor and isolated and unlikely to directly or adversely impact site vegetation communities and fauna habitat. Based on previous experience within the broader Austar Coal Mine, remediation of surface cracking is unlikely to be required within the LWB4-B7 Modification Area.

4.1.2 Subsidence Related Hydrological Changes

The proposed modification will result in the undermining of the main channel of Quorrobolong Creek. Quorrobolong Creek has been directly undermined previously by LWSL1 and LW1 to 5 in the Ellalong Colliery area and LWA3 to A5a in the Stage 2 area, with a total length of approximately four kilometres located directly above these previously extracted longwalls. No significant surface cracking or loss of surface water flow has been observed within Quorrobolong Creek or other streams within the Austar Coal Mine following undermining. MSEC (2017) considers it is unlikely, therefore, that there would be a net loss of water from the streams within the LWB4-B7 Modification Area resulting from the extraction of the proposed longwalls.

In the unlikely event that surface cracking does occur within drainage lines, this surface cracking would tend to be naturally filled with the natural surface soils during subsequent flow events, especially during times of heavy rainfall. If the surface cracks were found not to fill naturally, remedial measures may be required at the completion of mining.

Flood modelling has been undertaken by Umwelt (2017) to assess the changes in flooding and surface water flows resulting from predicted subsidence associated with the extraction of LWB4-B7. The flooding and drainage assessment concludes that the proposed modification is unlikely to have a significant impact on runoff regimes, bank stability or channel alignment and will result in only minor changes to flood depths and velocities. The assessment predicts minor changes to remnant ponding around some existing flow paths and farm dams. The locations of existing and proposed remnant ponding locations relative to vegetation communities and threatened species records are provided on **Figure 4.1**.

Figure 4.1 identifies two key areas where the extent of remnant ponding is predicted to increase from current levels, being:

- approximately 1.5 hectares of additional ponding upstream of an overflow channel from Quorrobolong Creek at the southern end of LWB6 and LWB7 within an area of Riparian Cabbage Gum Open Forest (River-flat Eucalypt Forest EEC (TSC Act)), and

- Approximately 0.1 hectares of ponding to the north-west of LWB5 occurring around an existing farm dam within an area of Introduced Grassland.

It is not anticipated that there will be any impacts to ecological values resulting from increased ponding within the Introduced Grassland and as such, no further assessment of the potential impacts to this community has been undertaken.

Further assessment was undertaken to determine the potential impacts on the ecological values of the area of Riparian Cabbage Gum Open Forest subject to additional ponding. This included additional analysis of ponding frequency and duration and additional survey effort within this community.

Analysis of ponding frequency and duration was undertaken based on historical meteorological data in order to provide an estimate of the number of days that the predicted additional ponding area may be inundated annually. The results of this analysis are provided in **Table 4.1**.

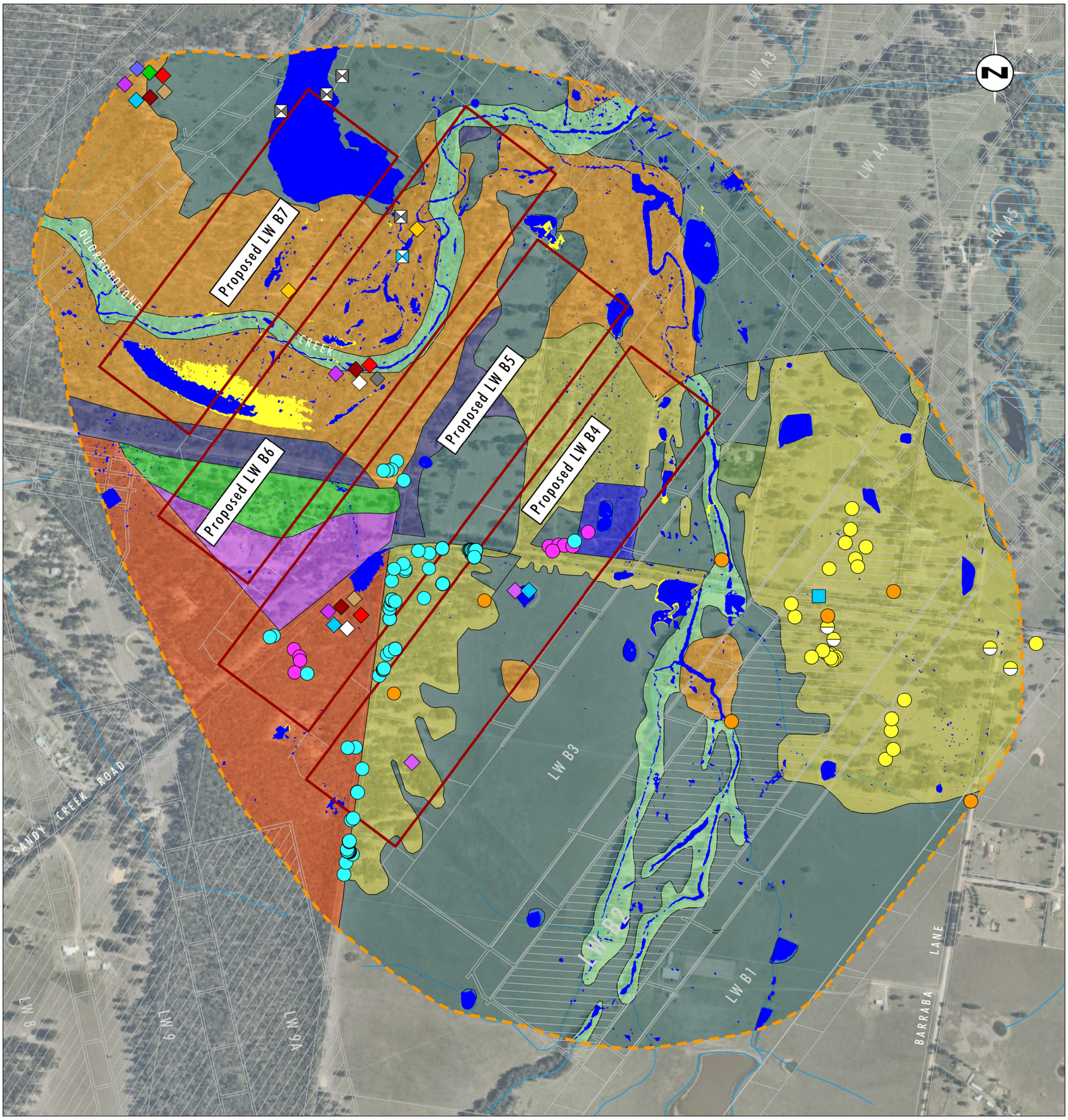

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)
Note: PR - Probable, SG - Species Group, D - Definite

0 200 400 600m
1:12 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- Remnant Ponding Approved Mining Scenario
- Remnant Ponding Proposed Mining Scenario
- Modified Grassland
- Planted Vegetation
- Water Body
- Riparian Swamp Oak Open Forest

River Flat Eucalyptus Forest EEC:
- Riparian Cabbage Gum Open Forest

Lower Hunter Spotted Gum-Ironbark Forest EEC:
- Coastal Foothills Transition Forest
- Coastal Foothills Transition Forest - underscrubbed
- Spotted Gum Ironbark Forest
- Modified Spotted Gum Ironbark Forest
- Spotted Gum Ironbark Forest - underscrubbed

Potential Quorrobolong Scribbly Gum Woodland EEC:
- Melaleuca Shrubland with Emergent Eucalypts
- East-coast freetail-bat (Definite)
- Eastern bentwing-bat (Species Group)
- Eastern cave bat (Species Group)
- Eastern false pipistrelle (Species Group)
- Grey-crowned babbler (eastern subspecies)
- Grey-crowned babbler nests
- Grey-headed flying-fox
- Large-eared pied bat
- Greater broad-nosed bat (Species Group)
- Little bentwing-bat (Species Group)
- Little bentwing-bat (Probable)
- Squirrel glider
- Southern myotis (Species Group)
- Varied sittella
- White-bellied sea eagle
- White-bellied sea eagle Nest
- Yellow-bellied sheathtail-bat (Probable)
- *Callistemon linearifolius*
- *Grevillea parviflora* subsp. *parviflora*
- *Rutidosis heterogama*

FIGURE 4.1

Ponding Impacts to Ecological Values

Table 4.1 Predicted Ponding Duration - Riparian Cabbage Gum Open Forest

Rainfall	Percentile	Estimated Number of Days of Inundation per Year
Dry year [1]	10	30
Average year	50	85
Wet year	90	156

Note 1: Based on Bureau of Meteorology data 1976-2006

As noted in **Table 4.1**, based on the analysis of historical meteorological data, the area of remnant ponding predicted within Riparian Cabbage Gum Open Forest to the south of Quorrobolong Creek is expected to be present between 30 and 156 days per year, depending on rainfall, with ponding to a depth of approximately 0.5 metres expected.

In the final determination for River-flat Eucalypt Forest (NSW Scientific Committee 2004), this community is described as having the following relevant attributes:

> *Associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains.*
>
> and
>
> *The composition of River-flat Eucalypt Forest on Coastal Floodplains is primarily determined by the frequency and duration of waterlogging and the texture, nutrient and moisture content of the soil.*

By its definition, this vegetation community naturally occurs on areas subject to periodic inundation and can have a variable floristic composition dependent upon the level of waterlogging that the particular site is subject to. The proposed alteration to ponding duration remains consistent with the definition of “periodic inundation”. Although the localised ponding will increase in duration and frequency in this area, this vegetation type is well-suited to coping with periods of regular water inundation. It is anticipated that increased ponding will have some implications for the understorey vegetation composition, which will likely increase with time towards species that are more capable of enduring sustained periods of inundation, such as sedges and rushes, however will not change the actual vegetation community itself. While some changes in understory composition and structure may be expected as a result of the modification, the overall quality should remain broadly consistent and no tree death is anticipated to occur.

An assessment of potential impacts on groundwater has also been undertaken by Dundon Consulting (2017). The groundwater assessment concludes that given the depth of mining, the geomorphology of the area and the geology overlying the coal seam, the potential for the LWB4-B7 Modification to adversely impact on groundwater availability or quality within the alluvium is negligible. This is supported by monitoring of shallow groundwater levels within the Stage 2 and LWB1-B3 mining areas that indicate no detectable impact on the alluvium as a result of mining (Auercon 2013, Dundon 2017). Potential impacts on groundwater dependent ecosystems are considered further in **Section 4.5**.

Based on the findings of the surface water and groundwater assessments, the potential for the proposed modification to result in secondary impacts on ecological values as a result of changes in hydrology is therefore considered low.

4.2 Impact on Biodiversity Values

Based on the assessment provided in **Section 4.1** above, there is little potential for longwall mining to significantly adversely impact vegetation communities and terrestrial fauna habitat identified in the LWB4-B7 Modification Area.

Similarly aquatic fauna habitats are considered to have little potential to be impacted as surface cracking and subsequent loss of surface flows are not predicted to occur. The proposed modification is not likely to result in an adverse impact to the biodiversity values identified in the LWB4-B7 Modification Area and therefore negligible changes to flora and fauna species diversity, vegetation community extent and aquatic species and habitat complexity is predicted. The only change likely to occur to overall biodiversity is a minor alteration in the understorey vegetation occurring within an approximately 1.5ha area directly above the proposed LWB6-LWB7 associated with remnant ponding. This is anticipated to remain native and consistent with the current River-flat Eucalypt Forest EEC community, with potential to increase in composition to vegetation capable of sustaining more prolonged periods of inundation (such as sedges and reeds).

4.3 Impact on Threatened Species, Endangered Populations and Communities under the TSC Act

4.3.1 Threatened Species

The following threatened flora and fauna species listed under the TSC Act were assessed in accordance with Section 5A of the EP&A Act (provided in **Appendix E**) as they were identified within the LWB4-B7 Modification Area or were considered to be potentially affected as a result of the proposed modification:

- heath wrinklewort (*Rutidosis heterogama*) – listed as vulnerable under the TSC Act
- small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) – listed as vulnerable under the TSC Act
- netted bottle brush (*Callistemon linearifolius*) – listed as vulnerable under the TSC Act
- green-thighed frog (*Litoria brevipalmata*) – listed as vulnerable under the TSC Act
- green and golden bell frog (*Litoria aurea*) – listed as endangered under the TSC Act
- Australasian bittern (*Botaurus poiciloptilus*) – listed as endangered under the TSC Act
- black bittern (*Ixobrychus flavicollis*) – listed as vulnerable under the TSC Act
- black-necked stork (*Ephippiorhynchus asiaticus*) – listed as endangered under the TSC Act
- Australia painted snipe (*Rostratula australis*) – listed as endangered under the TSC Act
- freckled duck (*Stictonetta naevosa*) – listed as vulnerable under the TSC Act
- white-bellied sea eagle (*Haliaeetus leucogaster*) – listed as vulnerable under the TSC Act
- regent honeyeater (*Anthochaera phrygia*)- listed as critically endangered under the TSC Act
- swift parrot (*Lathamus discolor*) – listed as endangered under the TSC Act

- grey-crowned babbler (*Pomatostomus temporalis temporalis*) – listed as vulnerable under the TSC Act
- varied sittella (*Daphoenositta chrysoptera*) – listed as vulnerable under the TSC Act
- grey-headed flying fox (*Pteropus poliocephalus*) – listed as vulnerable under the TSC Act
- squirrel glider (*Petaurus norfolcensis*) - listed as vulnerable under the TSC Act
- koala (*Phascolarctos cinereus*) – listed as vulnerable under the TSC Act
- large-eared pied bat (*Chalinolobus dwyeri*) listed as vulnerable under the TSC Act
- southern myotis (*Myotis macropus*) – listed as vulnerable under the TSC Act
- east-coast freetail bat (*Mormopterus norfolkensis*) – listed as vulnerable under the TSC Act
- little bentwing bat (*Miniopterus australis*) – listed as vulnerable under the TSC Act
- eastern bentwing bat (*Miniopterus schreibersii oceanensis*) – listed as vulnerable under the TSC Act
- greater broad nosed bat (*Scoteanax rueppellii*) – listed as vulnerable under the TSC Act
- yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*) – listed as vulnerable under the TSC Act
- eastern falsistrelle (*Falsistrellus tasmaniensis*) – listed as vulnerable under the TSC Act
- eastern cave bat (*Vespadelus troughtoni*) – listed as vulnerable under the TSC Act.

As discussed in **Sections 4.1** and **4.2**, the proposed modification will not result in any direct clearing of vegetation and the potential impacts associated with subsidence are not predicted to impact adversely on vegetation communities or fauna habitat. Given the mobile nature of the fauna species assessed, that most of these species would only be likely to be utilising the habitats present as part of a wider habitat range and that only negligible change to the overall landscape is predicted as a result of the proposed modification, it was not considered likely that there would be a significant impact on any threatened fauna species listed under the TSC Act as a result of the proposed modification.

4.3.2 Endangered Populations

There are no endangered flora or fauna populations identified or likely to occur within the LWB4-B7 Modification Area. The proposed modification will not result in a significant impact on endangered populations.

4.3.3 Endangered Ecological Communities

Two EECs and one potential EEC were recorded within the LWB4-B7 Modification Area being River-flat Eucalypt Forest EEC, Lower Hunter Spotted Gum – Ironbark Forest EEC and potential Quorrobolong Scribbly Gum Woodland EEC. Each of these communities is listed under the TSC Act, no EECs are present that are listed under the EPBC Act. These were present in the vegetation communities identified in **Table 4.2** below.

Table 4.2 Vegetation Communities within the LWB4-B7 Modification Area that Conform to EECs

Community Name	Status	Approximate Extent (ha)
Riparian Cabbage Gum Open Forest	River-flat Eucalypt Forest EEC (TSC Act)	56.7
Coastal Foothills Transition Forest	Lower Hunter Spotted Gum – Ironbark Forest EEC (TSC Act)	7.4
Coastal Foothills Transition Forest – underscrubbed		4.9
Spotted Gum - Ironbark Forest		24.3
Modified Spotted Gum - Ironbark Forest		62.0
Spotted Gum Ironbark forest - Underscrubbed		5.6
Melaleuca Shrubland with Emergent Eucalypts	Potential Quorrobolong Scribbly Gum Woodland EEC (TSC Act)[1]	1.6

[1] Potential EEC however could not be confirmed without further detailed sampling.

The predicted subsidence, surface cracking and surface and groundwater impacts of the proposed modification are not expected to result in a significant impact on the floristic diversity, condition or extent of EECs occurring in the LWB4-B7 Modification Area. A small increase in the extent of remnant ponding (approximately 1.5 hectares) within the River-flat Eucalypt Forest EEC is predicted; however as this vegetation is already subject to and resilient to periodic water inundation, it is expected that there will be no significant impact to the condition and quality of this EEC.The significance of any potential impacts on the River-flat Eucalypt Forest EEC, Lower Hunter Spotted Gum – Ironbark Forest EEC and potential Quorrobolong Scribbly Gum Woodland EEC, were assessed in accordance with the requirements of the EP&A Act. This assessment, provided in **Appendix E**, concludes that the proposed modification will not have a significant impact on the River-flat Eucalypt Forest, Lower Hunter Spotted Gum – Ironbark Forest and potential Quorrobolong Scribbly Gum Woodland EECs such that it would place the local occurrence of the EECs at risk of extinction.

4.3.4 Threatened Aquatic Species and Ecosystems

The Darling River Hardyhead Endangered Population is the only species listed under the FM Act that occurs within the Hunter Catchment. This species is usually found in slow flowing, clear, shallow waters or in aquatic vegetation at the edge of such waters. The species has also been recorded from the edge of fast flowing habitats such as the runs at the head of pool. This species is rarely recorded in the Hunter catchment but has been found in the headwaters of the Hunter system near Pages River. The species is not expected to occur in the LWB4-B7 Modification Area due to a lack of suitable habitat and the species will not be significantly impacted as a result of the proposed modification.

4.4 Matters of National Environmental Significance

Under the Commonwealth EPBC Act, the approval of the Commonwealth Minister for the Environment is required for any action that may have a significant impact on matters of national environmental significance (MNES). These matters are:

- listed threatened species and communities
- migratory species protected under international agreements
- Ramsar wetlands of international importance
- the Commonwealth marine environment
- the Great Barrier Reef Marine Park
- World Heritage properties
- National Heritage places
- nuclear actions
- a water resource, in relation to coal seam gas development and large coal mining development.

The LWB4-B7 Modification Area includes the following

- listed threatened species and communities
- listed migratory species
- a water resource, in relation to coal seam gas development and large coal mine development.

The EPBC Act lists criteria which are used to determine whether an action is likely to have a significant impact on the MNES relevant to the proposed modification, that is, listed threatened species and communities; and listed migratory species. These criteria are addressed in the Assessment of Significance provided in **Appendix F** and included the EPBC Act listed species identified below.

- regent honeyeater (*Anthochaera phrygia*) - listed as critically endangered under the EPBC Act
- swift parrot (*Lathamus discolor*) – listed as critically endangered under the EPBC Act
- Australian painted snipe (*Rostratula australis*) – listed as endangered under the EPBC Act
- Australasian bittern (*Botaurus poiciloptilus*) – listed as endangered under the EPBC Act
- green and golden bell frog (*Litoria aurea*) – listed as vulnerable under the EPBC Act
- grey-headed flying fox (*Pteropus poliocephalus*) - listed as vulnerable under the EPBC Act
- koala (*Phascolarctos cinereus*) – listed as vulnerable under the EPBC Act
- large-eared pied bat (*Chalinolobus dwyeri*) – listed as vulnerable under the EPBC Act
- heath wrinklewort (*Rutidosis heterogama*) – listed as vulnerable under the EPBC Act
- small-flower grevillea(*Grevillea parviflora* subsp. *parviflora*) – listed as vulnerable under the EPBC Act
- Japanese snipe (*Gallinago hardwickii*) - listed as migratory under the EPBC Act

- sharp-tailed sandpiper (*Calidiris acuminata*) - listed as migratory under the EPBC Act
- common greenshank (*Tringa nebularia*) - listed as migratory under the EPBC Act.

The assessments of significance undertaken for threatened and migratory species listed under the EPBC Act determined that the proposed modification would be unlikely to result in a significant impact on these species. Subsequently, referral of the proposed modification to the Minister of the Environment on the basis of impacts on listed threatened species or listed migratory species is not required.

4.5 Groundwater Dependent Ecosystems

It is considered likely that the approximately 74.8 ha of Riparian Swamp Oak Forest and Riparian Cabbage Gum Open Forest present in the modification area is at least partially dependent on alluvial groundwater flows. As outlined in **Section 3.5** these areas are considered to have at least some dependence on shallow alluvial groundwater resources during periods of reduced surface water flow.

An assessment of the potential impacts of the proposed modification on the alluvial groundwater resources within the modification area has been undertaken by Dundon Consulting (2017). This assessment identifies that the predicted heights of either connected or discontinuous fracturing above the Greta Seam as a result of subsidence are significantly less than the depth of cover above the Greta Seam. Therefore, impacts on either the shallow alluvial groundwater or on stream baseflows as a result of the LWB4-B7 Modification will be negligible. Accordingly, no impacts on any GDEs dependent on the alluvial groundwater or on groundwater baseflow are predicted to occur (Dundon 2017).

This conclusion is supported by the results of previous monitoring of the impacts of mining on shallow aquifers within the Austar Coal Mine has identified no observable impact on alluvial aquifers as a result of mining (Austar 2014). Fluctuations in groundwater level within these shallow aquifers have reflected rainfall conditions, with groundwater levels trending higher during periods of above average rainfall and lower during periods of below average rainfall. No noticeable divergence in this trend has occurred over time within alluvial monitoring bores, suggesting no mining related impacts have occurred (Dundon 2017).

The potential impacts of changes in flooding and remnant ponding behaviour on riparian vegetation has also been assessed (refer to **Section 4.1.2**) and found that any changes to surface water hydrology within the modification area is unlikely to result in significant adverse impacts to these communities.

Therefore groundwater dependent ecosystems occurring in the LWB4-B7 Modification Area, including the Riparian Swamp Oak Open Forest and Riparian Cabbage Gum Open Forest identified, are unlikely to be adversely impacted as a result of the proposed modification.

4.6 Key Threatening Processes

A number of Key Threatening Processes (KTPs) listed under the Schedules of the TSC Act, the EPBC Act and the FM Act, are relevant to the proposed modification. A discussion of the implications of the relevant KTPs under each Act is detailed below.

4.6.1 Threatened Species Conservation Act 1995 Listed KTPs

There are four KTPs listed under the TSC Act that are potentially relevant to the LWB4-B7 Modification, being:

Alteration of habitat following subsidence due to longwall mining

This KTP is most relevant to the proposed modification. Subsidence as a consequence of longwall mining is recognised as potentially altering habitats as well as the species and communities dependent on these habitats. Some habitats such as aquatic and riparian areas are considered to be particularly susceptible to subsidence (as a result of subsidence, tilt, curvature, cracking and subsequent hydrological changes).

Three threatened species are identified within this KTP determination as being susceptible to subsidence as a result of longwall mining that are considered to have potential to occur within the LWB4-B7 Modification Area, being the southern myotis (*Myotis macropus*), black bittern (*Ixobrychus flavicollis*) and grey-headed flying fox (*Pteropus poliocephalus*). As such these three species have been included within the relevant assessments of significance.

Longwall mining has the potential for surface movement (change to surface tilt and curvature) to cause habitat tree fall and the potential for disruption to natural water flow regimes and retention capacity in water bodies.

The subsidence predictions prepared by MSEC (2017) indicate that subsidence experienced over LWB4-B7 are expected to be less than those experienced elsewhere within the Stage 2 and 3 areas, where longwall top coal caving methods were used, and similar to the predicted levels within the adjacent LWB1-B3 area. The overall magnitude of predicted subsidence parameters is also relatively small given the depth of cover (between 400 and 505 metres), the geology of the area and local topography. It is anticipated that longwall mining will result in a similar final land surface to that currently present with some minor overall lowering. If any surface cracking were to result these are expected to be of a minor nature that could be readily remediated by infilling with appropriate materials by locally regarding and recompacting the surface

Given the small magnitude of predicted tilts and curvatures, tree fall as a result of subsidence is highly unlikely. There is also considered to be a low potential for any significant hydrological alterations such that there will be an impact on threatened flora, fauna or TECs.

Minor changes to the extent of remnant ponding are predicted to occur in the areas indicated in **Figure 4.1**. These changes occur within areas that are already subject to periodic inundation and are not anticipated to substantially alter the vegetation community present.

Alteration to natural flow regimes of rivers and streams and their floodplains and wetlands

Based on the predicted subsidence expected as a result of the project described above, no significant changes to the natural flow regime of the surface water and groundwater regimes currently operating in the LWB4-B7 Modification Area is predicted.

Minor changes to the extent of remnant ponding are predicted to occur. This additional ponding (approximately 1.5ha) is located within areas currently subject to inundation. The inundation will continue to be periodic and is not anticipated to have long-term ecological implications to overall biodiversity values in these areas.

Anthropogenic climate change

As an indirect impact of the proposed modification, greenhouse gas emissions will contribute to anthropogenic climate change as part of the energy production from the coal extracted from the LWB4-B7 Modification Area. This will not occur directly as a result of the proposed modification and the extent of this contribution is considered to be minor (see the Greenhouse Gas Assessment undertaken within the main text of this Environmental Assessment).

Loss of hollow-bearing trees

The predicted alterations to the topography of the land in terms of tilt and curvature are not predicted to be substantially modified to the extent that they will result in tree-fall and subsequent hollow-bearing tree loss.

4.6.2 Environment Protection and Biodiversity Conservation Act 1999 Listed KTPs

There is one KTP listed under the EPBC Act that is potentially relevant to this project, being:

Loss of climactic habitat caused by anthropogenic emissions of greenhouse gases

Greenhouse gas emissions will be generated both directly and indirectly as a result of the proposed modification. The vast majority of these emissions (95 per cent) will be indirect emissions attributable to third party emissions as a result of use of the coal extracted from the LWB4-B7 Modification Area. Direct emissions attributable to the LWB4-B7 Modification will contribute approximately 0.00019 per cent to global emissions per annum, the extent of this contribution is considered to be minor (see the Greenhouse Gas Assessment undertaken within the main text of this Environmental Assessment).

4.6.3 Fisheries Management Act Listed KTPs

There are two KTPs listed under the FM Act that are potentially relevant to this project, being:

Human-caused climate change

As an indirect impact of the proposed modification, greenhouse gas emissions will contribute to human-caused climate change as part of the energy production from the coal extracted from the LWB4-B7 Modification Area. This will not occur directly as a result of the proposed modification and the extent of this contribution is considered to be minor (see the Greenhouse Gas Assessment undertaken within the main text of this Environmental Assessment).

Degradation of native riparian vegetation along NSW water courses

Increased ponding in an approximate 1.5 ha area above the southern end of LWB6 and LWB7 will likely result in some minor changes to the composition of the understorey vegetation in this area due to greater periods of water inundation, however it is not anticipated that these changes will result in tree death and changes to composition will most likely comprise a gradual change to native flora species with a higher tolerance to prolonged inundation such as sedges and reeds (which are already present).

5.0 Mitigation and Management

5.1 Biodiversity Management Plan

Prior to the commencement of secondary extraction of LWB4-B7, an Extraction Plan will be prepared for the proposed longwalls. A Biodiversity Management Plan (BMP) will be prepared as a component plan of this Extraction Plan to manage any potential impacts from secondary extraction of LWB4-B7 on biodiversity values within the extraction plan area. The BMP will identify baseline information on ecological values within the extraction plan area, and the potential impacts to those aspects by predicted subsidence as identified in this assessment report (particularly in relation to increased ponding). The BMP will identify specific monitoring recommendations as outlined in **Section 5.2** below. Any monitoring on private lands is subject to landowner access.

Subsidence predictions are such that there is not predicted to be any significant adverse impact to ecological features within the LWB4-B7 Modification Area, however, in the unlikely event that subsidence remediation works are required, it is proposed that contingency measures for subsidence remediation works will be provided in the BMP.

5.2 Recommended Ecological Monitoring

The Biodiversity Management Plan to be prepared for the LWB4-B7 Modification should include a detailed ecological monitoring program. The ecological monitoring program should include baseline monitoring to allow identification of any subsidence or required land remediation impacts on threatened species, populations, their habitats or EEC. The ecological monitoring program should be designed in a manner consistent with the existing ecological monitoring program for the LWB1-B3 area (Austar 2016) and with current OEH policy.

In order to ensure subsidence predictions are accurate and that there will be no significant impacts to EECs, it is recommended that the ecological monitoring program include ecological monitoring of:

- River-flat Eucalypt Forest EEC vegetation (occurring within the predicted 1.5 ha area of ponding)
- Lower Hunter Spotted Gum – Ironbark Forest EEC vegetation
- Potential Quorrobolong Scribbly Gum Woodland EEC vegetation (although it is understood that access to this area is not currently available).

At least one monitoring site will be established in each EEC, subject to landholder access.

Given the results of vegetation monitoring undertaken within subsidence affected areas of the Austar Coal Mine since 2007 do not show any evidence of adverse impacts on vegetation, the monitoring of threatened flora species, including the netted bottlebrush (*Callistemon linearifolius*) population, heath wrinklewort (*Rutidosis heterogama*) population, and small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) population, is not proposed. Should the results of EEC monitoring surveys reveal sufficient reason to conduct further surveys of threatened species populations, the monitoring program should be appropriately adapted.

Specific surveys targeting fauna groups is also not deemed necessary given the minimal surface disturbances predicted and the extensive effort required to collect sufficient data on fauna species to allow reliable comparisons to be made. Should the results of vegetation monitoring surveys reveal sufficient reason to conduct fauna surveys, the monitoring program should be appropriately adapted.

Ecological monitoring should be undertaken as mining proceeds to ensure that any actual impacts are discovered quickly and managed appropriately. In the event that monitoring does reveal impacts, mitigation and management measures will be implemented in accordance with procedures to be outlined in the BMP. In addition, monitoring should ensure that any mitigation measures recommended are successfully implemented.

In line with current monitoring requirements, it is proposed that monitoring be undertaken on an annual basis for areas of Lower Hunter Spotted Gum – Ironbark Forest and areas of potential Quorrobolong Scribbly Gum Woodland. Bi-annual (six monthly) monitoring is recommended for the River-flat Eucalypt Forest monitoring site in order to more closely monitor the influence of any changes in ponding on the understorey vegetation composition of this community.

A baseline survey should be undertaken at each site prior to the commencement of subsidence impacts in a manner consistent with the current ecological monitoring regime at Austar Coal Mine. The cessation of monitoring will be linked with the results of the subsidence monitoring. The timeframe for completion of monitoring will depend strongly on whether any impacts are observed and whether subsidence remediation works are required. Monitoring will need to continue for a longer period of time if subsidence remediation works are required or if changes to the ecological values are observed that are linked to subsidence impacts, in which case monitoring would continue until the condition of the site is found to be stable.

The monitoring program would incorporate survey methods such as: permanent vegetation plots, vegetation condition assessment, habitat assessment and photo monitoring, where relevant.

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APPENDIX A

Threatened and Migratory Species, Endangered Populations and Threatened Ecological Communities with potential to occur

Threatened and migratory species, endangered populations, and threatened ecological communities (TECs) recorded during surveys of the LWB4-B7 Modification Area, and records from ecological database searches are listed in **Tables A1** and **A2.** To assist in the impact assessment process, the tables also contain relevant ecological details of each listing, including their habitat requirements, known range and reservation within conservation reserves. For the purposes of these tables, the 'region' is broadly defined as the Lower Hunter Valley, the western limit being Singleton and the eastern limit being approximately West Wallsend. The northern and southern boundaries of the region are approximately 30 kilometres north and south of the LWB4-B7 Modification Area.

The tables presented below are intended to streamline the impact assessment process, ensuring that only those species with reasonable potential to occur in the LWB4-B7 Modification Area and with reasonable potential to be impacted by the proposed modification are assessed under a 7 part test.

The 7 part tests of significance for species listed under the TSC Act are provided in **Appendix E** (EP&A Act). Species listed under the EPBC Act with reasonable potential to be impacted by the proposed modification are further assessed in **Appendix F** following the guidelines of that Act.

Table A1 - Threatened Flora, Endangered Populations and TECs Assessment

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
THREATENED FLORA SPECIES						
Bynoes wattle *Acacia bynoeana*	E (TSC) V (EPBC) 3VC- (ROTAP)	Occurs in heath or dry sclerophyll forest on sandy soils. Often prefers open, sometimes slightly disturbed sites such as track margins, edges of roadside spoil mounds and in recently burnt areas.	Occurs in central eastern NSW, from Morisset to the Illawarra region and west to the Blue Mountains. It has recently been found in the Colymea and Parma Creek areas west of Nowra, and in the Kurri Kurri, Cessnock and Ellalong areas in the lower Hunter Valley.	Olney SF Yengo NP	There is a low potential for this species to occur within the woodland habitats of the LWB4-B7 Modification Area. The proposed modification will not modify habitat of this species. There is no potential for a significant impact on potential habitat for this species.	No
Allocasuarina glareicola	E (TSC) E (EPBC)	This species is found in open Castlereagh woodland in lateritic soils.	This species is only known from the north-west Cumberland Plains district, with an additional outlying population at Liverpool.	This species is not known to occur in any reserves in the region.	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Charmhaven apple *Angophora inopina*	V (EPBC) V (TSC) 2R- (ROTAP)	This species typically occurs on the shallow sandy soils of the Narrabeen Group, on exposed ridges and slopes with westerly or northerly aspect. It has also been recorded on shallow alluvial soils of this geological type, in upper catchments and in embedded clay soil lenses with sandstone. This species is known to naturally hybridise with rough-barked apple (*A. floribunda*) particularly around major drainage lines.	Distribution confined to the Wyong, Lake Macquarie and Port Stephens LGA of NSW. Pure forms of this species have been recorded from the Wallarah catchment in the south and north to the Toronto area. Disjunct populations have been identified at Karuah.	This species is not known to occur in any reserves in the region.	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Asterolasia elegans	E (TSC) E (EPBC) 2ECa (ROTAP)	This species occurs on Hawkesbury sandstone on the mid to lower slopes of valleys within sheltered forests. This species is typically associated with turpentine (*Syncarpia glomulifera* subsp. *glomulifera*), smooth-barked apple (*Angophora costata*), Sydney Peppermint (*Eucalyptus piperita*), forest oak (*Allocasuarina torulosa*) and Christmas bush (*Ceratopetalum gummiferum*).	This species is known to the Baulkham Hills, Hawkesbury and Hornsby LGAs and is predicted to occur in the Gosford LGA. Only six populations of this species are known, all of which are within either the Colo or Hawkesbury River Catchment. Only one of the known populations of this species occurs within a conservation reserve.	This species is not known to occur in any reserves in the region.	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
nettled bottle brush *Callistemon linearifolius*	V (TSC) 2RCi (ROTAP)	Typically grows in dry sclerophyll forest on the coast and adjacent ranges	The distribution of this species is primarily known from the areas of the Georges River and the Hawkesbury River near Sydney, reaching to Nelsons Bay in the north (although species have been recorded in the past from as far north as Woolgoolga), and to the west at Cessnock in the Hunter Valley.	Heaton SF Werakata NP	This species was identified in the LWB4-B7 Modification Area. This species is potentially sensitive to the proposed modification.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
leafless tongue orchid *Cryptostylis hunteriana*	V (TSC) V (EPBC) 3VC- (ROTAP)	This species appears to favour moist soils on the flat coastal plains. Occupies swamp heath, but also in sclerophyll forest and woodland, often on sandy soils. Typically found in communities containing hard-leaved scribbly gum (*Eucalyptus haemastoma*), brown stringybark (*E. capitellata*) and red bloodwood (*Corymbia gummifera*).	This species is known to occur in the Karuah Manning and Wyong CMA sub-regions in the Hunter Central Rivers region.	This species is not known to occur in any reserves in the region.	There is a low potential for this species to occur within the woodland habitats of the LWB4-B7 Modification Area. The proposed modification will not modify habitat of this species. There is no potential for a significant impact on potential habitat for this species.	No
Singleton Mallee *Eucalyptus castrensis*	E (TSC)	Very restricted in range, but locally dominant, occurring as a dense mallee stand over about three hectares, on a low broad ridgetop on loam over sandstone. Occurs on a low broad ridgetop on loam over sandstone. The understorey consists of grasses and scattered shrubs, with bare ground and litter. *Eucalyptus fibrosa* and *Corymbia maculata* grow adjacent to, but not within, the stand.	Known only from a single dense stand near Singleton in the lower Hunter Valley. Here it is locally dominant stand over about ten hectares with a number of smaller outlying stands over a 2.5 km range	This species is not known to occur in any reserves in the region.	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Broken Back ironbark *Eucalyptus fracta*	V (TSC)	The dominant tree in a narrow band along the upper edge of a sandstone escarpment. Occurs in dry eucalypt woodland in shallow soils. Associated species in slightly deeper soils include *Eucalyptus sparsifolia*, *E. punctata*, *Corymbia maculata* and *Angophora euryphylla*.	Confined largely to State Forest. Locally common but restricted to the northern Broken Back Range near Cessnock, NSW.	Broken Back Range	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
slaty red gum *Eucalyptus glaucina*	V (TSC) V (EPBC) 3VCa (ROTAP)	This species grows in grassy woodland and dry eucalypt forest on deep, moderately fertile and well-watered soils.	Found only on the North Coast of NSW and in separate districts: near Casino (where it can be locally common) and further south, from Taree to Broke, west of Maitland. Scattered occurrences around Singleton.	Pokolbin SF Uffington SF Werakata NP	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Craven grey box *Eucalyptus largeana*	E (TSC)	Craven grey box is often found in areas of wet forest in the sub-coastal ranges.	Only known to occur in the Gloucester-Craven district from near Pokolbin.	Copeland Tops SCA Berrico NR Talawahl NR Glen NR Willi Willi NP	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Parramatta red gum *Eucalyptus parramattensis* subsp. *decadens*	V (EPBC) V (TSC) 2V (ROTAP)	Typically grows on deep, low-nutrient sands, often those subject to periodic inundation. Occurs in dry sclerophyll woodland with dry heath understorey and also as an emergent in dry or wet heathland.	There are two separate meta-populations, in the Kurri Kurri and Tomago areas.	Heaton SF Werakata NP Werakata SCA	There is no potential for this species to occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Pokolbin mallee *Eucalyptus pumila*	V (TSC) V (EPBC) 2VCi (ROTAP)	The single known population occupies north-west-facing slopes derived from sandstone.	Currently known only from a few small populations west of Pokolbin in the Hunter Valley. Historical records also exist for Wyong and Sandy Hollow, however, has not been recorded recently in these areas.	Pokolbin SF	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Euphrasia arguta	CE (TSC) CE (EPBC) 3X (ROTAP)	This species grows in eucalypt forest with a mixed grass and shrub understory; with plants appearing to be most dense in open disturbed areas.	*Euphrasia arguta* was historically recorded in relatively few places extending from Sydney to Bathurst and north to Walcha and was believed extinct until 2008 when it was rediscovered in the Nundle area. This species is not known to occur within 20 km of the centre of the Project area.	This species is not known to occur in any reserves in the region.	There is a low potential for this species to occur within the woodland habitats of the LWB4-B7 Modification Area. The proposed modification will not modify habitat of this species. There is no potential for a significant impact on potential habitat for this species.	No
variable midge orchid *Genoplesium insignis*	E (TSC) CE (EPBC)	Grows in patches of kangaroo grass (*Themeda australis*) amongst shrubs and sedges in heathland and forest.	Recorded from four localities between Chain Valley Bay and Wyong in Wyong LGA.	This species is not known to occur in any reserves in the region.	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
small-flower grevillea *Grevillea parviflora* subsp. *parviflora*	V (EPBC) V (TSC)	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest and a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	Sporadically distributed throughout the Sydney Basin mainly occurring around Picton, Appin, Bargo and possibly Moss Vale, as well as in the north from Putty to Wyong, Lake Macquarie, Cessnock and Kurri Kurri in the lower Hunter.	Werakata NP Werakata SCA	This species was identified in the LWB4-B7 Modification Area over LWB4 and LWB5. This species is potentially sensitive to the proposed modification.	Yes
biconvex paperbark *Melaleuca biconvexa*	V (TSC)	Biconvex paperbark generally grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects.	Scattered and dispersed populations of this species are known to occur in the Karuah Manning and Wyong sub-regions of the Hunter-Central Rivers CMA area.	Olney SF Sugarloaf SCA	There is no potential for this species to occur within the LWB4-B7 as it was not identified during surveys and has not been recorded within 10km of the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Groves paperbark *Melaleuca groveana*	V (TSC) 3RC- (ROTAP)	Groves paperbark grows in heath and shrubland, often in exposed sites, at high elevations, on rocky outcrops and cliffs. It also occurs in dry woodlands.	Widespread, scattered populations in coastal districts north of Port Stephens to south-east Queensland.	Corrabare SF Yengo NP Werakata SCA	There is no potential for this species to occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Omeos stork's-bill *Pelargonium* sp. Striatellum	E (EPBC)	Typically occurs just above the high water level of irregularly inundated or ephemeral lakes. During dry periods it is known to colonise dry lake beds.	This species is known to occur in both Victoria and NSW. It occurs within the south-eastern highlands and South East Corner IBRA Bioregions and the Hawkesbury-Nepean, Murrumbidgee, Southern Rivers and North East Natural Resource Management Regions.	This species is not known to occur in conservation reserves in the region.	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Singleton mint bush *Prostanthera cineolifera*	V (TSC) V (EPBC) 2K (ROTAP)	Grows in open woodlands on exposed sandstone ridges. Usually found in association with shallow or skeletal sands.	Restricted to only a few localities near Walcha, Scone and St Albans. The species was once known in Yengo NP, however, no records have been made here in many years.	Yengo NP	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Illawarra greenhood *Pterostylis gibbosa*	E (TSC) E (EPBC) 2E (ROTAP)	All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage.	Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra).	This species is not known to occur in any reserves in the region.	There is a low potential for this species to occur within the woodland habitats of the LWB4-B7 Modification Area. The proposed modification will not modify habitat of this species. There is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
eastern underground orchid *Rhizanthella slateri*	V (TSC) E (EPBC) K (ROTAP)	Habitat requirements are poorly understood and no particular vegetation type has been associated with the species, although it is known to occur in sclerophyll forest. Highly cryptic given that it grows almost completely below the soil surface, with flowers being the only part of the plant that can occur above ground. Therefore usually located only when the soil is disturbed.	Occurs from south-east Queensland to south-east NSW. In NSW, currently known from fewer than 10 locations, including near Bulahdelah, the Watagan Mountains, the Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra.	This species is not known to occur in any reserves in the region.	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
heath wrinklewort *Rutidosis heterogama*	V (TSC) V (EPBC) 2VCa (ROTAP)	Occurs mostly in heath, often along disturbed roadsides, and also in open forest, primarily in coastal districts.	In coastal districts from Maclean to the Hunter Valley and inland to Torrington. It has also been recently recorded at Cooranbong on the Central Coast and extensively around the Cessnock district.	Werakata NP Werakata SCA	This species was identified in the LWB4-B7 Modification Area over LWB4 and LWB5, and is considered potentially sensitive to the development.	Yes
black-eyed Susan *Tetratheca juncea*	V (TSC) V (EPBC) 3VCa (ROTAP)	Low open forest, woodland, heathland and moist forest, with a shrub understorey and grassy groundcover on low nutrient soils. Generally prefers well-drained slopes (often south-facing) and ridges, although it also found on upper and mid-slopes and occasionally in gullies.	Confined to coastal districts from Bulahdelah to Lake Macquarie. Furthest inland occurrences are at Buttai, near Mt Sugarloaf.	Heaton SF Sugarloaf SCA	This species was not recorded in the LWB4-B7 Modification Area and there is no potential for it to occur. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Austral toadflax *Thesium australe*	V (TSC) V (EPBC)	This species occurs in grassland or grassy woodland and is often found in damp sites in association with kangaroo grass (*Themeda australis*). This species is a root parasite that takes water and some nutrient from other plants, especially kangaroo grass.	This species is found in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania, Queensland and in eastern Asia. Occurs also at Mangoola, west of Muswellbrook, NSW.	This species is not known to occur in any reserves in the region.	This species was not recorded in the LWB4-B7 Modification Area and there is no potential for it to occur. There is no potential for a significant impact on this species.	No
Zannichellia palustris	E (TSC)	Grows in fresh or slightly saline stationary or slowly flowing water.	Known to occur in the Hunter, Karuah Manning and Wyong sub-regions of the Hunter/Central Rivers CMA area.	This species is not known to occur in any reserves in the region.	This species was not recorded in the LWB4-B7 Modification Area and there is considered to be a very low potential for its occurrence. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
ENDANGERED FLORA POPUALTIONS						
weeping myall *Acacia pendula* in the Hunter Catchment	EP (TSC)	Grows on major river floodplains on heavy clay soils, sometimes as the dominant species and forming low open woodlands. Within the Hunter catchment it typically occurs on heavy soils, sometimes at the margins of small floodplains, but also in more undulating locations remote from floodplains, such as at Jerrys Plains.	There are 17 confirmed and four unconfirmed naturally occurring remnants of the *A. pendula* population in the Hunter catchment. These range as far east as Warkworth, and as far west as Kerrabee, west of Sandy Hollow. *Acacia pendula* is not known to occur naturally further north than the Muswellbrook-Wybong area. Eight planted *A. pendula* populations (not naturally occurring) have been recorded in the Hunter, and it is likely that numerous more planted populations occur.	This population is not known to occur in any reserves in the region.	No individuals of *Acacia pendula* were recorded within the LWB4-B7 Modification Area, and there is no potential for this species to occur. There is no potential for a significant impact on this endangered population.	No
tiger orchid *Cymbidium canaliculatum* in the Hunter Catchment	EP (TSC)	This species occurs within dry sclerophyll forests and woodlands of tablelands and western slopes, growing in hollows of trees. It is usually found occurring singly or as a single clump, typically between two and six metres above the ground.	The population of *Cymbidium canaliculatum* in the Hunter Catchment is at the south-eastern limit of the geographic range for this species.	This population is not known to occur in any reserves in the region.	No individuals of *Cymbidium canaliculatum* were recorded within the LWB4-B7 Modification Area. There is no potential for a significant impact on this endangered population.	No.

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Leionema lamprophyllum subsp*. obovatum* in the Hunter Catchment	EP (TSC)	Grows in heath on exposed ridges at higher altitudes. The Hunter population occurs on a rocky cliff line in a dry eucalypt forest.	The Hunter Catchment population of *L. lamprophyllum* subsp. *obovatum* is currently known to occur in Pokolbin State Forest. The total number of mature individuals is estimated to be very low with only 4 individuals currently known.	This population is not known to occur in any reserves in the region.	No individuals of *Leionema lamprophyllum* subsp. *obovatum* were recorded within the LWB4-B7 Modification Area. There is no potential for a significant impact on this endangered population.	No
Spyridium burragorang in the Cessnock Local Government Area	PD EP (TSC)	This population is found on a steep hill at 150 m altitude in a dry ridge forest dominated by *Corymbia eximia*, *C. maculata* and *Eucalyptus* aff. *agglomerata*, with *E. squamosa* and *E. punctata* also present. The shrubby understorey is mainly *Leptospermum trinervium* with *Isopogon anemonifolius*, *Dillwynia retorta*, *Xanthorrhoea* sp., *Hakea sericea*, *Grevillea montana*, *Leucopogon* sp., *Bossiaea obcordata*, and the grasses *Rytidosperma pallidum* and *Aristida* sp.	*Spyridium burragorang* is endemic to New South Wales (NSW) and is known from the Lake Burragorang area in the Wollondilly River and adjacent Nattai River Valleys in the Blue Mountains (Thiele and West 2004) and from a disjunct population located approximately 150 km to the north in the Cessnock area of the Hunter Valley.	Werakata SCA	There is a low potential for this species to occur within the woodland habitats of the LWB4-B7 Modification Area. The proposed modification will not modify habitat of this species. There is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
THREATENED ECOLOGICAL COMMUNITIES						
Central Hunter Valley Eucalypt Forest and Woodland Complex	CEEC (EPBC)	This CEEC is dominated by one or more of the following canopy species narrow-leaved ironbark (*Eucalyptus crebra*), spotted gum (*Corymbia maculata*), slaty gum (*Eucalyptus dawsonii*), grey box (*Eucalyptus moluccana*) and may occasionally contain bulloak (*Allocasuarina luehmannii*) as a dominant. This CEEC generally occurs on Permian sedimentary bedrock on valley floors, lower hill slopes and lower ridges.	This CEEC occurs in the central region of the Hunter valley within the Hunter catchment. It is mostly present within the Muswellbrook and Singleton LGAs, with smaller occurrences within the Cessnock, Maitland, Lake Macquarie, Newcastle and Port Stephens LGAs.	Singleton Military Area	This CEEC does not occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this CEEC.	No
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	EEC (TSC)	Associated with coastal areas subject to periodic flooding and in which standing fresh water persists for at least part of the year in most years. Typically occurs on silts, mud or humic loams in low-lying parts of floodplains, alluvial flats, depressions, drainage lines, back-swamps, lagoons and lakes but may also occur in back-barrier landforms where floodplains adjoin coastal sand plains. Generally occur below 20 m elevation on level areas.	Known from along the majority of the NSW coast. There is less than 150 ha remaining on the Tweed lowlands (estimate in 1985); about 10,600 ha on the lower Clarence floodplain (in 1982); about 11,200 ha on the lower Macleay floodplain (in 1983); about 3500 ha in the lower Hunter – Central Hunter region (in 1990s); less than 2700 ha on the NSW south coast from Sydney to Moruya (in the mid 1990s), including about 660 ha on the Cumberland Plain (in 1998) and about 100 ha on the Illawarra Plain (in 2001); and less than 1000 ha in the Eden region (in 1990).	This community is poorly reserved but is known from Hunter Estuary NP	This EEC has no potential to occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this EEC.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions	EEC (TSC)	This community generally occurs on floodplains and their associated floodplain rises in along the Hunter River and its tributaries. The community is generally tall woodland, with typical canopy species consisting of rough-barked apple (*Angophora floribunda*), river red gum (*Eucalyptus camaldulensis*), forest red gum (*Eucalyptus tereticornis*) and yellow box (*Eucalyptus melliodora*). Other common species are inclusive of kurrajong (*Brachychiton populneus* subsp. *populneus*) and river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*)	This community can be found along the Hunter River and its associated tributaries and is only known to occur in the NSW North Coast and Sydney Basin Bioregions. It has been recorded from the LGAs of Maitland, Mid-Western, Muswellbrook, Singleton and Upper Hunter.	This EEC is not known from any conservation reserves in the region.	This EEC does not occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this EEC.	No
Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregion	EEC (TSC)	This EEC occurs on the Permian sediments of the Hunter Valley floor. Much of the remaining community is disturbed and fragmented. The floristic composition and structure of the community is influenced by both the size and disturbance history of the remaining fragments. Consequently at heavily disturbed sites only some of the species which characterise the community may be present.	This EEC occurs from Muswellbrook to the Lower Hunter in the Sydney Basin and North Coast bioregions. It has been recorded from the Maitland, Cessnock, Port Stephens, Muswellbrook and Singleton LGAs, but may occur elsewhere in these bioregions.	Werakata NP Werakata SCA.	This EEC does not occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this EEC.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin Bioregion	EEC (TSC)	This EEC occurs in the central to lower Hunter Valley, principally on Permian geology.	The EEC is restricted to a range of approximately 65 km by 35 km centred on the Cessnock – Beresfield area.	Corrabare SF Pokolbin SF Werakata NP	This EEC occurs within the LWB4-B7 Modification Area, on the drier slopes	Yes
Potential Quorrobolong Scribbly Gum Woodland in the Sydney Basin Bioregion	EEC (TSC)	This EEC occurs on a residual sand deposit overlying the Permian clay sediments in the Hunter Valley.	This EEC is known from a small area between Quorrobolong and Mulbring in the Cessnock LGA but may occur elsewhere.	This EEC is not known from any conservation reserves in the region.	A small quantity of the vegetation is considered potentially consistent with this EEC. This EEC is potentially sensitive to the proposed modification.	Yes
River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	EEC (TSC)	Given its habitat, the community has an important role in maintaining river ecosystems and riverbank stability. Occurs on with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains. Generally occurs below 50 m elevation, but may occur on localised river flats up to 250 m above sea level. The composition of this EEC is highly variable, although typical species include forest red gum (*Eucalyptus tereticornis*), cabbage gum (*E. amplifolia*), rough-barked apple (*Angophora floribunda*) and broad-leaved apple (*A. subvelutina*).	This EEC occurs in numerous LGAs on the south coast of NSW. It is believed to be bounded to the north by Port Stephens, to the south by the NSW-VIC border and to occur no further west than Canberra.	This EEC is not known from any conservation reserves in the region.	This EEC occurs within the LWB4-B7 Modification Area, on the drier slopes associated with drainage lines.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	EEC (TSC)	Associated with grey-black clay-loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains. Generally occurs below 20 m (rarely above 10 m) elevation	This community is known from parts of the LGAs of Tweed, Byron, Lismore, Ballina, Richmond Valley, Clarence Valley, Coffs Harbour, Bellingen, Nambucca, Kempsey, Hastings, Greater Taree, Great Lakes and Port Stephens, Lake Macquarie, Wyong, Gosford, Hornsby, Pittwater, Warringah, Manly, Liverpool, Rockdale, Botany Bay, Randwick, Sutherland, Wollongong, Shellharbour, Kiama and Shoalhaven but may occur elsewhere in these bioregions.	Hunter Estuary NP	This EEC has no potential to occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this EEC.	No
Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	EEC (TSC)	Associated with humic clay loams and sandy loams, on waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal floodplains. Generally occurs below 20 m (though sometimes up to 50 m) elevation. The composition of the community is primarily determined by the frequency and duration of water logging and the texture, salinity nutrient and moisture content of the soil, and latitude. The composition and structure of the understorey is influenced by grazing and fire history, changes to hydrology and soil salinity and other disturbance, and may have a substantial component of exotic grasses, vines and forbs.	This community is known to occur in numerous LGAs, but is believed to be restricted to the areas of coastal NSW; no further south than the Shoalhaven LGA and as far north as the NSW-Queensland border, but no further west than Bathurst.	Ellalong Lagoon LCA Hunter Estuary NP	This EEC has no potential to occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this EEC.	No

Species	Legal Status	Specific Habitat	Distribution in relation to LWB4-B7 Modification Area	Reservation in the Region (Bionet 2016)	Potential to be Impacted	Detailed Assessment of Significance Required?
Hunter Valley Weeping Myall (*Acacia Pendula*) Woodland	CEEC (EPBC)	This TEC consists of weeping myall (*Acacia pendula*) with coobah (*Acacia salicina*) and scrub wilga (*Geijera salicifolia*). Yarran (*Acacia omalophylla*) and stiff canthium (*Canthium buxifolium*) are also present in the small tree/shrub layer. The ground stratum is dense and primarily grassy. Grasses include kangaroo grass (*Themeda triandra/australis*), wallaby grass (*Austrodanthonia* spp.), snow grass (*Poa sieberiana*) and barbed wire grass (*Cymbopogon refractus*).	The CEEC occurs in a small stand on heavy, brown clay soil at Jerrys Plains in the Hunter Valley, in the South Hunter Province of the Sydney Basin Bioregion.	This CEEC is not known to occur in any conservation reserves in the region.	This CEEC has no potential to occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this EEC.	No

Note:

2:	found over < 100 km	K:	poorly known
3:	found over > 100 km	LCA:	Landscape Conservation Area
a:	adequately reserved	LGA:	Local Government Area
C:	in a conservation reserve	NR:	Nature Reserve
CE:	critically endangered	NP:	National Park
CEEC:	Critically endangered ecological community	R:	rare
E:	endangered	TSC:	Threatened Species Conservation Act
EEC:	endangered ecological community	V:	Vulnerable
EP:	endangered population	X:	extinct
EPBC:	Environment Protection Biodiversity Conservation Act	-	species recorded from a reserve but population size unknown
i:	inadequately reserved	PD	Preliminary determination

Table A2 - Threatened and Migratory Fauna Assessment

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
AMPHIBIANS						
giant burrowing frog *Heleioporus australiacus*	V (TSC) V (EPBC)	Found in heath, woodland and open forest with sandy soils.	Occurs from the NSW Central Coast to eastern Victoria, but is most common on the Sydney sandstone. It has been found from the coast to the Great Dividing Range.	Yengo NP	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
stuttering frog *Mixophyes balbus*	E (TSC) V (TSC)	Found in rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range.	Occur along the east coast of Australia from southern Queensland to the north-eastern Victoria	Killarney NR Watagans NP	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
giant barred frog *Mixophyes iteratuts*	E (TSC) E (EPBC)	This species forages and lives amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m. They breed around shallow, flowing rocky streams.	Coast and ranges from south-eastern Queensland to the Hawkesbury River in NSW. North-eastern NSW, particularly the Coffs Harbour-Dorrigo area, is now a stronghold.	Watagans NP	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
green and golden bell frog *Litoria aurea*	E (TSC) V (EPBC)	Occurs amongst emergent aquatic or riparian vegetation and amongst vegetation, fallen timber, including grassland, cropland and modified pastures. Breeds in still or slow flowing waterbodies with some vegetation such as *Typha* spp. and *Eleocharis* spp.	NSW North Coast near Brunswick Heads, southwards along the NSW Coast to Victoria where it extends into east Gippsland. The Survey Area is close to the inland limit of this species' known distribution.	This species is not known to occur in any reserves in the region.	There is a low potential for this species to occur in the riparian habitats of the LWB4-B7 Modification Area. The species is potentially sensitive to the proposed modification.	Yes
green-thighed frog *Litoria brevipalmata*	V (TSC)	Occur in a range of habitats from rainforest and moist eucalypt forest to dry eucalypt forest and heath, typically in areas where surface water gathers after rain.	Isolated localities along the coast and ranges from the NSW central coast to south-east Queensland.	This species is not known to occur in any reserves in the region.	There is a low potential for this species to occur in the riparian habitats of the LWB4-B7 Modification Area. The species is potentially sensitive to the proposed modification.	Yes
Littlejohns treefrog *Litoria littlejohni*	V (TSC) V (EPBC)	Occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops.	Distribution includes the plateaus and eastern slopes of the Great Dividing Range from Watagan State Forest south to Buchan in Victoria.	Olney SF	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
REPTILES						
broad-headed snake *Hoplocephalus bungaroides*	E (TSC) V (EPBC)	This species is nocturnal and shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring. Moves from the sandstone rocks to shelters in hollows in large trees within 200 m of escarpments in summer.	The broad-headed snake is largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within the coast and ranges in an area within approximately 250 km of Sydney.	Olney SF Yengo NP	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Stephens banded snake *Hoplocephalus stephensii*	V (TSC)	Occurs in rainforest and eucalypt forests and rocky areas up to 950 m in altitude.	Coast and ranges from Southern Queensland to Gosford in NSW.	Killarney NR Watagans NP	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
BIRDS						
black-necked stork *Ephippiorhynchus asiaticus*	E (TSC)	Inhabits permanent freshwater wetlands including margins of billabongs, swamps, shallow floodwaters, and adjacent grasslands and savannah woodlands; can also be found occasionally on inter-tidal shorelines, mangrove margins and estuaries.	This species is widespread across coastal northern and eastern Australia, becoming uncommon further south into NSW, and rarely found south of Sydney.	Hunter Estuary NP	There is potential that small ponded areas, farm dams, and a large ponded farm dam water body within the LWB4-B7 Modification Area would provide suitable habitat for this species. The species is potentially sensitive to the proposed modification.	Yes
Australasian bittern *Botaurus poiciloptilus*	E (TSC)	Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Eleoacharis* spp.).	This species may be found over most of the state except for the far north-west.	Hunter Estuary NP	There is potential that small ponded areas, farm dams, and a large ponded farm dam water body within the LWB4-B7 Modification Area would provide suitable habitat for this species. The species is potentially sensitive to the proposed modification.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
black bittern *Ixobrychus flavicollis*	V (TSC)	Inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, the species may occur in flooded grassland, forest, woodland, rainforest and mangroves.	Records of the species are scattered along the east coast, with individuals rarely being recorded south of Sydney or inland.	Werakakta NP Yengo NP	There is potential that small ponded areas, farm dams, and a large ponded farm dam water body within the LWB4-B7 Modification Area would provide suitable habitat for this species. The species is potentially sensitive to the proposed modification.	Yes
Eastern bristlebird *Dasyornis brachypterus*	E (TSC) E (EPBC)	The eastern bristlebird inhabits low, dense vegetation across a variety of habitats inclusive of sedgeland, heathland, swampland, shrubland, sclerophyll forest and woodland, and rainforest. This species occurs in coastal areas, tablelands and ranges.	This species occurs in three geographically separate areas of south-east Australia; a northern population in south-eastern Queensland and north-eastern NSW; a central population on the central coast of NSW; and a southern population in the south-east of NSW and eastern Victoria. There are no known records of this species within 20 km of the centre of the Project area.	This species is not known to occur in conservation reserves in the region.	There are no habitats present within the LWB4-B7 Modification Area that would be suitable for this species. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
Australian painted snipe *Rostratula australis*	E (TSC) V (EPBC)	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.	In NSW, this species has been recorded at the Paroo wetlands, Lake Cowal, Macquarie Marshes and Hexham Swamp. Most common in the Murray-Darling Basin.	Pambalong NR	There is potential that small ponded areas, farm dams, and a large ponded farm dam water body within the LWB4-B7 Modification Area would provide suitable habitat for this species. The species is potentially sensitive to the proposed modification.	Yes
Curlew sandpiper *Calidris ferruginea*	E (TSC)	The curlew sandpiper is distributed around most of the coastline of Australia (including Tasmania) It occurs along the entire coast of NSW, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. It generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts.	A regular summer migrant from Siberia and other Arctic breeding grounds to most of the Australian coastline. It is uncommon to locally common along the NSW coast, with occasional inland sightings.	This species is not known to occur in any reserves in the region.	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
freckled duck *Stictonetta naevosa*	V (TSC)	This species prefers permanent freshwater swamps and creeks with heavy growth of cumbungi, lignum or tea-tree. During drier times it moves from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds. This species generally rests in dense cover during the day, usually in deep water. Nesting usually occurs between October and December but can take place at other times when conditions are favourable. The nests are usually located in dense vegetation at or near water level.	The freckled duck is found primarily in south-eastern and south-western Australia, occurring as a vagrant elsewhere. This species may also occur as far as coastal NSW and Victoria during such times.	This species is not known to occur in any reserves in the region.	There is potential that small ponded areas, farm dams, and a large ponded farm dam water body within the LWB4-B7 Modification Area would provide suitable habitat for this species. The species is potentially sensitive to the proposed modification.	Yes
rose-crowned fruit-dove *Ptilinopus regina*	V (TSC)	Occur mainly in sub-tropical and dry rainforest and occasionally in moist eucalypt forest and swamp forest, where fruit is plentiful.	Coast and ranges of eastern NSW and Queensland, from Newcastle to Cape York. Vagrants are occasionally found further south to Victoria.	Corrabare SF	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
black-breasted buzzard *Hamirostra melanosternon*	V (TSC)	Lives in a range of inland habitats, especially along timbered watercourses which is the preferred breeding habitat. Hunts over grasslands and sparsely timbered woodlands.	Found sparsely in areas of less than 500 mm rainfall, from north-western NSW and north-eastern South Australia to the east coast at about Rockhampton, then across northern Australia south almost to Perth, avoiding only the Western Australian deserts.	Werakata NP	There is no potential for this species to occur in the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
black falcon *Falco niger*	V (TSC)	The black falcon is associated with a wide variety of habitats.	The black falcon is distributed widely yet sparsely across NSW. It is assumed that all individuals comprise a single population.	This species is not known to occur in any reserves in the region.	There is potential foraging and nesting habitat for this species in various habitats throughout the LWB4-B7 Modification Area. There will be no modification to the potential habitats of this species as a result of the proposed modification. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
little eagle *Heiraaetus morphnoides*	V (TSC)	This species is typically identified in open eucalypt forests, woodlands and open woodlands, and other areas where prey are plentiful. The nest in tall living trees within remnant patches.	The little eagle is distributed throughout mainland Australia except for the most densely forested parts of the Great Dividing Range escarpment.	Olney SF Werakata SCA	There is potential foraging and nesting habitat for this species in various habitats throughout the LWB4-B7 Modification Area. There will be no modification to the potential habitats of this species as a result of the proposed modification. There is no potential for a significant impact on this species.	No
square-tailed kite *Lophoictinia isura*	V (TSC)	Found in a variety of timbered habitats including dry woodlands and open forests. Shows a particular preference for timbered watercourses.	Scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems.	This species is not known to occur in any reserves in the region.	The LWB4-B7 Modification Area supports potential foraging and nesting habitat for this species. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
spotted harrier *Circus assimilis*	V (TSC)	Their habitat of choice is open grassy woodland, grassland, inland riparian woodland and shrub steppe. Although mostly associated with native grasslands it has also been identified in agricultural farmland. Their nest is made in a tree and composed of sticks.	The spotted harrier can be found throughout mainland Australia except for areas of dense forest on the coast, escarpments and ranges and rarely ever in Tasmania.	This species is not known to occur in any reserves in the region.	The LWB4-B7 Modification Area supports potential foraging and nesting habitat for this species. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
white-bellied sea-eagle *Haliaeetus leucogaster*	V (TSC)	These birds are typically sighted perched in tall trees and soaring above bodies of water and land. They are territorial and form permanent breeding pairs (Australian Museum Online 2005).	This species is distributed across Australia, China, India, Indonesia, New Guinea, and south-east Asia. Within Australia it is distributed along and near the coast.	Werakata NP	This species was recorded within the LWB4-B7 Modification Area. This species is potentially sensitive to the proposed modification.	Yes
comb-crested jacana *Irediparra gallinacea*	V (TSC)	Inhabits permanent wetlands with a good surface cover of floating vegetation, especially water-lilies.	Occurs throughout coastal Australia and well inland in the north from the Kimberley to Sydney. Vagrants occasionally appear further south, possibly in response to unfavourable conditions further north in NSW.	This species is not known to occur in any reserves in the region.	There are no habitats suitable for this species within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
little lorikeet *Glossopsitta pusilla*	V (TSC)	This species can be found in dry-open eucalypt forests and woodlands, and have been identified in remnant vegetation, old growth vegetation, logged forests, and roadside vegetation. The little lorikeet usually forages in small flocks, not always with birds of their own species. They nest in hollows, mostly in living smooth-barked apples.	This species is distributed from just north of Cairns, around the east coast of Australia down to Adelaide. In NSW this species is found from the coast to the western slopes of the Great Dividing Range, extending as far west as Albury, Dubbo, Parkes and Narrabri.	Olney SF Pokolbin SF Sugarloaf SCA Werakata NP Werakata SCA Yengo NP	The LWB4-B7 Modification Area provides potential foraging and nesting habitats for this species. The proposed modification will not modify any habitat requirements of this species. As such, there is no potential for a significant impact on potential habitat for this species.	No
glossy black-cockatoo *Calyptorhynchus lathami*	V (TSC)	Habitat for this species includes forests on low-nutrient soils, specifically those containing key *Allocasuarina* feed species. They will also eat seeds from eucalypts, angophoras, acacias, cypress pine and hakeas, as well as eating insect larvae. Breeding occurs in autumn and winter, with large hollows required.	The glossy black-cockatoo has a sparse distribution along the east coast and adjacent inland areas from western Victoria to Rockhampton in Queensland. In NSW, it has been recorded as far inland as Cobar and Griffith.	Killarney NR Watagans NP Werakata NP Yengo NP	The LWB4-B7 Modification Area provides potential foraging habitat, and potential nest sites. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
gang-gang cockatoo *Callocephalon fimbriatum*	V (TSC)	In summer this species occurs in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In winter this species moves to drier more open eucalypt forests and woodlands. It favours old growth trees for nesting and roosting.	In NSW this species occurs from the south east coast to the Hunter region and inland to the Central Tablelands and South-west Slopes.	Pambalong NR Watagans NP Werakata NP Yengo NP	The LWB4-B7 Modification Area provides potential foraging and nesting habitats for this species. The proposed modification will not modify any habitat requirements of this species. As such, there is no potential for a significant impact on potential habitat for this species.	No
swift parrot *Lathamus discolor*	E (TSC) CE (EPBC)	This species often visits box-ironbark forests, feeding on nectar and lerps. In NSW, typical tree species in which it forages include mugga ironbark, grey box, swamp mahogany, spotted gum, red bloodwood, narrow-leaved red ironbark, forest red gum and yellow box. This bird is a migratory species that breeds in Tasmania during the spring and summer, and migrates to the mainland during the cooler months of the year.	In NSW this species has been recorded from the western slopes region along the inland slopes of the Great Dividing Range, as well as forests along the coastal plains from southern to northern NSW. The project area is within the known distribution of this species.	Werakata NP	Several winter-flowering species occur in the LWB4-B7 Modification Area which may provide foraging resources for this species and the species is known to occur in the local area. The species is potentially sensitive to the proposed modification.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
regent honeyeater *Anthochaera phrygia*	CE (TSC) CE (EPBC)	This species generally occurs in temperate eucalypt woodlands and open forests of south eastern Australia. It is commonly recorded from box-ironbark eucalypt associations, wet lowland coastal forests dominated by swamp mahogany, spotted gum and riverine casuarina woodlands. An apparent preference exists for the wettest, most fertile sites within these associations, such as creek flats, river valleys and foothills.	Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland.	Corrabare SF Werakata NP Werakata SCA Yengo NP	Several winter-flowering species occur in the LWB4-B7 Modification Area which may provide foraging resources for this species and it is known to occur in the local area. The species is potentially sensitive to the proposed modification.	Yes
turquoise parrot *Neophema pulchella*	V (TSC)	This species lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland. It nests in tree hollows, logs or posts, from August to December.	The turquoise parrots range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range.	This species is not known to occur in any reserves in the region.	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
powerful owl *Ninox strenua*	V (TSC)	The powerful owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. It generally requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation.	The powerful owl occurs in eastern Australia, mostly on the coastal side of the Great Dividing Range, from south western Victoria to Bowen in Queensland.	Killarney NP Monkerai NP Werakata NP Yengo NP	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
barking owl *Ninox connivens*	V (TSC)	Habitat for this species includes dry forests and woodlands, often in association with hydrological features such as rivers and swamps.	The barking owl is distributed sparsely throughout temperate and semi-arid areas of mainland Australia; however it is most abundant in the tropical north. Most records for this species occur west of the Great Dividing Range.	Watagans NP Werakata NP	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
masked owl *Tyto novaehollandiae*	V (TSC)	This species is generally recorded from open forest habitat with sparse mid-storey but patches of dense, low ground cover. It is also recorded from ecotones between wet and dry eucalypt forest, along minor drainage lines and near boundaries between forest and cleared land.	The masked owl occurs sparsely throughout the continent and nearby islands, including Tasmania and New Guinea.	Killarney NR Pokolbin SF Watagans NP Werakata SCA	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
sooty owl *Tyto tenebricosa*	V (TSC)	Occurs in rainforest, including dry rainforest, subtropical and warm temperate rainforest, as well as moist eucalypt forests. Nests in very large tree hollows.	Occupies the eastern most one-eighth of NSW, occurring on the coast, coastal escarpment and eastern tablelands.	Corrabare SF Heaton SF Olney SF Pokolbin SF Watagans NP	There is no potential habitat for this species to occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
brown treecreeper (eastern subsp.) *Climacteris picumnus victoriae*	V (TSC)	Typical habitat for this species includes drier forests, woodlands and scrubs with fallen branches; river red gums on watercourses and around lake-shores; paddocks with standing dead timber; and margins of denser wooded areas. This species prefers areas without a dense understorey.	This species occurs over central NSW, west of the Great Dividing Range and sparsely scattered to the east of the divide in drier areas such as the Cumberland Plain of Western Sydney, and in parts of the Hunter, Clarence, Richmond and Snowy River valleys.	Werakata NP	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
black-chinned honeyeater (eastern subspecies) *Melithreptus gularis*	V (TSC)	Occupies mostly upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts, especially mugga ironbark, white box, grey box, yellow box and forest red gum. Also inhabits open forests of smooth-barked gums, stringybarks, ironbarks and tea-trees.	The subspecies is widespread, from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. It is rarely recorded east of the Great Dividing Range, although regularly observed from the Richmond River district. It has also been recorded at a few scattered sites in the Hunter, Central Coast and Illawarra regions.	Werakata NP	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
speckled warbler *Chthonicola sagittata*	V (TSC)	The speckled warbler occurs in eucalypt-dominated communities that have a grassy understorey, leaf litter and shrub cover, often on rocky ridges or in gullies.	Patchy distribution throughout south-eastern Queensland, eastern half of NSW and into Victoria, as far west as the Grampians.	Werakata NP Yengo NP	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
grey-crowned babbler (eastern subspecies) *Pomatostomus temporalis temporalis*	V (TSC)	Open box-gum woodlands on the slopes. Box-cypress-pine and open box woodlands on alluvial plains. Also found in acacia shrubland and adjoining areas.	Occurs throughout northern and south-eastern Australia. In NSW, this species occurs on the western slopes of the Great Dividing Range and on the western plains reaching as far west as Louth and Hay. It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW. The Survey Area is not at the limit of this species' known distribution.	Werakata NP Yengo NP	This species was recorded within the LWB4-B7 Modification Area. This species is potentially sensitive to the proposed modification.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
varied sittella *Daphoenositta chrysoptera*	V (TSC)	The varied sittella can typically be found in eucalypt forests and woodlands, especially of rough-barked species and mature smooth-barked gums with dead branches, it can also be identified in mallee and acacia woodlands. This species builds a cup shaped nest made of plant fibres and spiders webs which is placed at the canopy level in the fork of a living tree.	The varied sittella is a sedentary species that inhabits the majority of mainland Australia with the exception of the treeless deserts and open grasslands. Its NSW distribution is basically continuous from the coast to the far west.	Corrabare SF Olney SF Pokolbin SF Werakata NP Werakata SCA Yengo NP	This species was recorded within the LWB4-B7 Modification Area. This species is potentially sensitive to the proposed modification.	Yes
olive whistler *Pachycephala olivacea*	V (TSC)	Mostly inhabit wet forests above about 500m. During the winter months they may move to lower altitudes. Forage in trees and shrubs and on the ground.	Inhabits the wet forests on the ranges of the east coast. It has a disjunct distribution in NSW chiefly occupying the beech forests around Barrington Tops and the MacPherson Ranges in the north and wet forests from Illawarra south to Victoria.	Corrabare SF	There is no potential for this species to occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
Painted honeyeater *Grantiella picta*	V (TSC)	Inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests.	The greatest concentration of this bird species; and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution.	This species is not known to occur in any reserves in the region.	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
Dusky woodswallow *Artamus cyanopterus cyanopterus*	V (TSC)	Woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including regenerating forests; very occasionally in moist forests or rainforests.	Widespread in eastern, southern and south-western Australia. In NSW it is widespread from coast to inland, including the western slopes of the Great Dividing Range and farther west. It is sparsely scattered in, or largely absent from, much of the Upper Western region.	This species is not known to occur in any reserves in the region.	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
Hooded robin (south-eastern form) *Melanodryas cucullata*	V (TSC)	Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses.	Widespread, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania. However, it is common in few places, and rarely found on the coast. It is considered a sedentary species, but local seasonal movements are possible. The south-eastern form (subspecies cucullata) is found from Brisbane to Adelaide and throughout much of inland NSW, with the exception of the extreme north-west, where it is replaced by subspecies picata. Two other subspecies occur outside NSW.	This species is not known to occur in any reserves in the region.	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
scarlet robin *Petroica boodang*	V (TSC)	This robin can be found in woodlands and open forests from the coast through to inland slopes. The birds can sometimes be found on the eastern fringe of the inland plains in the colder months of the year. Woody debris and logs are both important structural elements of its habitat. It forages from low perches on invertebrates either on the ground or in woody debris or tree trunks.	The scarlet robin can be found in south-eastern Australia, from Tasmania to the southern end of Queensland, to western Victoria and south SA.	Olney SF Werakata NP Yengo NP	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
flame robin Petroica phoenicea	V (TSC)	This species is known to breed in moist eucalypt forests and woodlands. It can usually be seen on ridges and slopes in areas where there is an open understorey layer. This species migrates during the winter to more lowland areas such as grasslands where there are scattered trees, as well as open woodland of the inland slopes and plains.	This robin is located in south-eastern Australia from the Queensland border to Tasmania and into Victoria as well as south-east SA.	Chichester SF Yengo NP	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
diamond firetail *Stagonopleura guttata*	V (TSC)	Habitat includes a range of eucalypt dominated communities with a grassy understorey, including woodland, forest and mallee. It appears that populations are unable to persist in areas where there are no vegetated remnants larger than 200 ha.	The diamond firetail occurs through central and eastern NSW, north into southern and central Queensland and south through Victoria to South Australia. In NSW it mainly occurs west of the Great Dividing Range, although populations are known from drier coastal areas such as the Cumberland Plain and the Hunter, Clarence, Richmond and Snowy River valleys.	Werakata SCA Yengo NP	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
MAMMALS						
spotted-tailed quoll *Dasyurus maculatus*	V (TSC) E (EPBC)	Habitat for this species is highly varied, ranging from sclerophyll forest, woodlands, coastal heathlands and rainforests. Records exist from open country, grazing lands and rocky outcrops. Suitable den sites including hollow logs, tree hollows, rocky outcrops or caves.	In NSW the spotted-tailed quoll occurs on both sides of the Great Dividing Range, with the highest densities occurring in the north-east of the state. It occurs from the coast to the snowline and inland to the Murray River.	Awaba SF Corrabare SF Heaton SF Killarney NP Olney SF Pokolbin SF Uffington SF Watagans NP Watagan SF Werakata SCA Yengo NP	There is potential for this species to occur in the more densely vegetated habitats in the north of the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
koala *Phascolarctos cinereus*	V (TSC) V (EPBC)	This species inhabits eucalypt forest and woodland, with suitability influenced by tree species and age, soil fertility, climate, rainfall and fragmentation patterns. The species is known to feed on a large number of eucalypt and non-eucalypt species; however it tends to specialise on a small number in different areas. *Eucalyptus tereticornis, E. punctata, E. cypellocarpa, E. viminalis, E. microcorys, E. robusta, E. albens, E. camaldulensis* and *E. populnea* are some preferred species.	The koala has a fragmented distribution throughout eastern Australia, with the majority of records from NSW occurring on the central and north coasts, as well as some areas further west. It is known to occur along inland rivers on the western side of the Great Dividing Range.	Awaba SF Corrabare SF Heaton SF Killarney NR Monkerai NR Olney SF Pokolbin SF Uffington SF Watagans NP Watagan SF Werakata NP Werakata SCA Yengo NP	A single atlas of NSW wildlife record of this species is present within the LWB4-B7 Modification Area. However, no records or evidence of this species have been recorded apart from this previous record in 2006. This species is potentially sensitive to the proposed modification.	Yes
greater glider *Petauroides volans*	V (EPBC)	Feeds exclusively on eucalypt leaves, buds, flowers and mistletoe. Shelter during the day in tree hollows and will use up to 18 hollows in their home range. Occupy a relatively small home range with an average size of 1 to 3 ha.	The Greater Glider occurs in eucalypt forests and woodlands along the east coast of Australia from north east Queensland to the Central Highlands of Victoria	This species is not known to occur in any reserves in the region.	There is no potential for this species to occur within the LWB4-B7 Modification Area.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
yellow-bellied glider *Petaurus australis*	V (TSC)	Occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary with latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south.	The yellow-bellied Glider is found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria.	Corrabare SF Heaton SF Olney SF Pokolbin SF Watagans NP Watagan SF Werakata NP Yengo NP	There is no potential for this species to occur within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
squirrel glider *Petaurus norfolcensis*	V (TSC)	Inhabits a variety of mature or old growth habitats, including box, box-ironbark woodlands, river red gum forest, and blackbutt-bloodwood forest with heath understorey. It prefers mixed species stands with a shrub or acacia mid-storey, and requires abundant tree hollows for refuge and nest sites.	The species is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria.	Olney SF Uffington SF Werakata NP Werakata SCA Yengo NP	This species was identified within the LWB4-B7 Modification Area. The species is potentially sensitive to the proposed modification.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
long-nosed potoroo *Potorous tridactylus*	V (TSC) V (EPBC)	Inhabits coastal heaths and dry and wet sclerophyll forests. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature.	This species is found on the south-eastern coast of Australia, from Queensland to eastern Victoria and Tasmania, including some of the Bass Strait islands. In NSW it is generally restricted to coastal heaths and forests east of the Great Dividing Range.	Heaton SF Killarney NR	There is potential for this species to occur within the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
brush-tailed rock-wallaby *Petrogale penicillata*	E (TSC) V (EPBC)	This species occupies rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north. It browses on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees. This species shelters or bask during the day in rock crevices, caves and overhangs and is most active at night.	The brush-tailed rock-wallaby was once abundant and ubiquitous throughout the mountainous country of south-eastern Australia. Its distribution roughly followed the Great Dividing Range for 2500 km from the Grampians in West Victoria to Nanango in south-east Queensland, with outlying populations in coastal valleys and ranges to the east of the divide, and the slopes and plains as far west as Cobar in NSW and Injune (500 km NW of Brisbane) in Queensland.	Watagans NP Heaton SF Olney SF Pokolbin SF Watagans NP Yengo NP	The LWB4-B7 Modification Area does not support suitable habitat for this species. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
parma wallaby *Macropus parma*	V (TSC)	Preferred habitat for this species is moist eucalypt forest with thick, shrubby understorey, often with nearby grassy areas, rainforest margins and occasionally drier eucalypt forest. It typically feeds at night on grasses and herbs in more open eucalypt forest and the edges of nearby grassy areas. During the day it shelters in dense cover.	Although it once occurred from north-eastern NSW to the Bega area in the southeast, its range is now confined to the coast and ranges of central and northern NSW.	Corrabare SF Killarney NR Olney SF Yengo NP	This species has potential to utilise the foraging resources of the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on this species.	No
grey-headed flying-fox *Pteropus poliocephalus*	V (TSC) V (EPBC)	This species occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy.	Grey-headed flying-foxes are found within 200 km of the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria.	Olney SF Pokolbin SF Watagan SF Werakata NP Werakata SCA Yengo NP	This species has been recorded. The LWB4-B7 Modification Area supports potential foraging habitat for this species, however, there are no known roost sites.	Yes
East-coast freetail-bat *Mormopterus norfolkensis*	V (TSC)	This species occurs in dry sclerophyll forest and woodland east of the Great Dividing Range. It roosts mainly in tree hollows but will also roost under bark or in man-made structures.	The eastern freetail-bat is found along the east coast from south Queensland to southern NSW.	Awaba SF Werakata NP Werakata SCA Yengo NP	This species was identified within the LWB4-B7 Modification Area. The species is potentially sensitive to the proposed modification.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
eastern bentwing-bat *Miniopterus schreibersii oceanensis*	V (TSC)	This species hunts in forested areas and uses caves as the primary roosting habitat, but also uses derelict mines, storm-water tunnels, buildings and other man-made structures. It forms discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young.	Eastern bent-wing bats occur along the east and north-west coasts of Australia.	Awaba SF Olney SF Uffington SF Werakata NP Yengo NP	This species was potentially identified within the LWB4-B7 Modification Area. The species is potentially sensitive to the proposed modification.	Yes
eastern false pipistrelle *Falsistrellus tasmaniensis*	V (TSC)	Habitat for this species includes sclerophyll forest. It prefers wet habitats, with trees over 20 m high, and generally roosts in tree hollows or trunks.	This species has a range from south eastern Queensland, through NSW, Victoria and into Tasmania, and occurs from the Great Dividing Range to the coast.	Heaton SF Olney SF Werakata NP Yengo NP	This species was potentially identified within the LWB4-B7 Modification Area. The species is potentially sensitive to the proposed modification.	Yes
little bentwing-bat *Miniopterus australis*	V (TSC)	Prefers moist eucalypt forest, rainforest or dense coastal banksia scrub. This species roost in caves, tunnels and sometimes tree hollows during the day, and at night forage for small insects beneath the canopy of densely vegetated habitats.	Occurs in coastal north-eastern NSW and eastern Queensland.	Awaba SF Uffington SF Werakata NP Werakata SCA	This species was potentially identified within the LWB4-B7 Modification Area. The species is potentially sensitive to the proposed modification.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
large-eared pied bat *Chalinolobus dwyeri*	V (TSC) V (EPBC)	The large-eared pied bat is generally found in a variety of drier habitats, including dry sclerophyll forests and woodlands, however, it probably tolerates a wide range of habitats. It tends to roost in the twilight zones of mines and caves, generally in colonies or common groups.	This species has a distribution from south western Queensland to NSW from the coast to the western slopes of the Great Dividing Range.	Awaba SF Olney SF Pokolbin SF Watagans NP Yengo NP	This species was recorded in the LWB4-B7 Modification Area. There is potential for a significant impact on this species.	Yes
southern myotis *Myotis macropus*	V (TSC)	This species generally roosts in groups of 10-15 close to water in caves, mine shafts, hollow-bearing trees, and storm-water channels, buildings, under bridges and in dense foliage. It forages over streams and pools catching insects and small fish by raking its feet across the water surface.	The large-footed myotis is found in the coastal band from the north-west of Australia, across the Top-End and south to western Victoria. It is rarely found more than 100 km inland, except along major rivers.	Awaba SF Pokolbin SF Uffington SF Werakata NP	This species was potentially identified within the LWB4-B7 Modification Area. The species is potentially sensitive to the proposed modification.	Yes
greater broad-nosed bat *Scoteanax rueppellii*	V (TSC)	The greater broad-nosed bat appears to prefer moist environments such as moist gullies in coastal forests, or rainforest. They have also been found in gullies associated with wet and dry sclerophyll forests and open woodland. It roosts in hollows in tree trunks and branches and has also been found to roost in the roofs of old buildings.	The greater broad-nosed bat is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however it does not occur at altitudes above 500 metres.	Awaba SF Olney SF Pokolbin SF Werakata NP Werakata SCA Yengo NP	This species was identified within the LWB4-B7 Modification Area. There is potential for a significant impact on this species.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
eastern cave bat *Vespadelus troughtoni*	V (TSC)	This species is a cave-roosting bat that is usually found in dry open forest and woodland, near cliffs or rocky overhangs. It has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals, and is occasionally found along cliff-lines in wet eucalypt forest and rainforest.	The eastern cave bat is found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT.	Pokolbin SF Yengo NP	This species was potentially identified within the LWB4-B7 Modification Area. The species is potentially sensitive to the proposed modification.	Yes
New Holland mouse *Pseudomys novaehollandiae*	V (EPBC)	This species inhabits a range of habitats from open heathlands, open woodlands with a heath understorey, as well as vegetated dunes. The New Holland mouse lives in a burrow which is shared with other individuals.	This species has a disjunct distribution across Tasmania, Victoria, Queensland and NSW.	This species is not known to occur in any reserves in the region.	The LWB4-B7 Modification Area does not support suitable habitat for this species. There is no potential for a significant impact on this species.	No
Hastings River mouse *Pseudomys oralis*	E (TSC) E (EPBC)	Known to inhabit a variety of dry open forest types with dense, low ground cover and a diverse mixture of ferns, grass, sedges and herbs. Access to seepage zones, creeks and gullies is important, as is permanent shelter such as rocky outcrops. Nests may be in either gully areas or ridges and slopes.	This species has a patchy distribution along the east side of the Northern Tablelands and great escarpment of north-east NSW, usually but not always at elevations between 500 m and 1100 m. Also recorded in south-east Queensland.	This species is not known to occur in any reserves in the region.	This species has potential to utilise the foraging resources of the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
FISH						
Darling River Hardyhead in the Hunter River Catchment	EP (FM Act)	This species is usually found in slow flowing, clear, shallow waters or in aquatic vegetation at the edge of such waters. The species has also been recorded from the edge of fast flowing habitats such as the runs at the head of pools.	The species is rarely recorded in the Hunter catchment but has been found in the headwaters of the Hunter system near Pages River.	This species is not known to occur in any reserves in the region.	The aquatic habitats in the LWB4-B7 Modification Area do not conform with the known habitat range of this species There is no potential for a significant impact on this species.	No
MIGRATORY SPECIES						
fork-tailed swift *Apus pacificus*	MIG (EPBC)	The fork-tailed swift is mostly found in Australia through the months of October through to April. This swift spends most of its time when in flight ahead of storm fonts and updraughts (Slater et al. 2003).	The fork-tailed swift can be found throughout Australia during migrating. In Australia it is most common west of the Great Dividing Range. This species is uncommon in Tasmania.	Pokolbin SF	The LWB4-B7 Modification Area provides potential habitat for this species. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
Japanese snipe *Gallinago hardwickii*	MIG (EPBC)	The Japanese snipe can be found in permanent and ephemeral wetlands up to 2000 m ASL. These water bodies are usually freshwater with low, dense vegetation. They forage in areas of mud with some vegetation cover and roost nearby to these areas. The Japanese snipe does not breed in Australia, only passing through for migration.	This species has been recorded from Cape York through to south-east SA. The range of this species extends from inland of the eastern tablelands in south-east Queensland to west of the Great Dividing Range in NSW. Richmond River, NSW is a favourite area for non-breeding birds.	This species is not known to occur in any reserves in the region.	There is potential that small ponded areas, farm dams, and a large ponded farm dam water body within the LWB4-B7 Modification Area would provide suitable habitat for this species. The species is potentially sensitive to the proposed modification.	Yes
eastern osprey *Pandion cristatus*	V (TSC) MIG (EPBC)	Favours coastal areas, especially the mouths of large rivers, lagoons and lakes.	This species is found right around the Australian coast line, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. There are a handful of records from inland areas.	This species is not known to occur in any reserves in the region.	The LWB4-B7 Modification Area provides potential habitat for this species. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
white-throated needletail *Hirundapus caudacutus*	MIG (EPBC)	This species is only in Australia approximately between the months of October and May. They forage upon flying insects and drink whilst in flight. Feeding is typically associated with rising thermal currents typical with storm fronts and bushfires. (Australian Museum Online 2003)	This species is distributed over eastern and northern Australia	Heaton SF Pokolbin SF Werakata NP Werakata SCA Yengo NP	The LWB4-B7 Modification Area provides potential habitat for this species. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
rainbow bee-eater *Merops ornatus*	MIG (EPBC)	The preferred habitat of the rainbow bee-eater is open forests and woodlands, shrublands, and cleared or semi-cleared areas (commonly farmland). These areas are usually in close proximity to permanent water, however, during migration this bird may fly over areas of non-preferential habitat.	This species is distributed throughout most of mainland Australia as well as several near-shore islands. It is not found in Tasmania and has only been identified in a thin strip in the most arid regions of central WA.	Corrabare SF Pokolbin SF Werakata SCA Werakata SF Yengo NP	This species has potential to occur in the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
black-faced monarch *Monarcha melanopsis*	MIG (EPBC)	This bird can be identified in coastal scrub, damp gullies, eucalypt woodlands and rainforests. This bird can be seen foraging for insects amongst foliage, and builds a deep, cup-shaped nest in a tree fork (3 to 6 m above the ground) which is made up of cobwebs, casuarinas needles, bark, moss and roots (Australian Museum Online2005).	The black-faced monarch is distributed along the eastern coast of Australia, gradually becoming less common towards the south.	Awaba SF Corrabare SF Heaton SF Pokolbin SF Werakata NP Watagan SF Yengo NP	There is no potential habitat for this species within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
spectacled monarch *Monarcha trivigatus*	MIG (EPBC)	This species prefers habitats with a thick understorey including mangroves, rainforests, wet gullies and waterside vegetation.	This species is found along the coast of north-east and eastern Australis. It is also known from Papua New Guinea, the Moluccas and Timor.	This species is not known from conservation reserves in the region.	There is no potential habitat for this species within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
satin flycatcher *Myiagra cyanoleuca*	MIG (EPBC)	This species typically inhabits wet areas of tall forests, particularly in gullies. The satin flycatcher moves north in the winter and is seldom seen in NSW, Tasmania, Victoria or SA during these times. This bird nests in loose colonies in broad-based cup-shaped nests on a bare horizontal branch. These nests are constructed from bark, grass, lichen and cobwebs (Australian Museum Online 2005).	The satin flycatcher can be found in both Australia and New Guinea. In Australia it is distributed along the east coast from Cape York through to Tasmania, also covering parts of south-eastern SA.	Pokolbin SF	This species has the potential to occur in the LWB4-B7 Modification Area. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No
rufous fantail *Rhipidura rufifrons*	MIG (EPBC)	The rufous fantail typically inhabits areas of dense wet forest, mangrove, rainforest or swamp woodlands. It prefers areas where there is intense shade available and is often seen close to ground. In winter it is seldom found in NSW or Victoria.	This species is distributed across the north and eastern coast of Australia, but is also found in Guam, New Guinea, the Solomon Islands and Sulawesi.	Awaba SF Belford NP Heaton SF Pokolbin SF Uffington SF Watagan SF Werakata NP Werakata SCA Yengo NP	The LWB4-B7 Modification Area provides potential habitat for this species. The proposed modification will not modify any habitat requirements of this species. As such there is no potential for a significant impact on potential habitat for this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
sharp-tailed sandpiper *Calidris acuminata*	MIG (EPBC)	This species prefers the grassy edges of shallow inland freshwater wetlands. It is also found around sewage treatment plants, flooded fields, mudflats, mangroves, rocky shores and beaches.	This species is a summer migrant from Arctic Siberia, being found on wetlands throughout Australia.	This species is not known from conservation reserves in the region.	There is potential that small ponded areas, farm dams, and a large ponded farm dam water body within the LWB4-B7 Modification Area would provide suitable habitat for this species. The species is potentially sensitive to the proposed modification.	Yes
common greenshank *Tringa nebularia*	MIG (EPBC)	The common greenshank is a marine and migratory bird species, it is typically found in coastal habitats such as estuaries, mudflats and saltmarshes, but can also be identified in appropriate fresh or saline inland habitats such as clay pans, commercial saltfields, lake margins and sewage ponds (Pizzey & Knight 1997).	This species is known to breed from Scotland to Siberia. It has also been identified in Europe, Asia, Africa, Papua New Guinea, Australia and New Zealand. In Australia, this species is widespread and has been identified in coastal areas across the entire country. On the mainland it does not occur in the central areas of WA and the north-west of SA (Pizzey & Knight 1997).	This species is not known from conservation reserves in the region.	There is potential that small ponded areas, farm dams, and a large ponded farm dam water body within the LWB4-B7 Modification Area would provide suitable habitat for this species. The species is potentially sensitive to the proposed modification.	Yes

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
bridled tern *Onychoprion anaethetus*	MIG (EPBC)	This species inhabits offshore tropical and subtropical seas.	This species occurs across tropical areas of the Pacific and Atlantic oceans. Including Central America, Caribbean, western Africa, India as well as much of south-east Asia and Australasia.	This species is not known from conservation reserves in the region.	There is no potential habitat for this species within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Oriental cuckoo *Cuculatus optatus*	MIG (EPBC)	Solitary and rather elusive species . Ooccurs in mixed, deciduous and coniferous forest. It is present at all levels of the forest canopy, and can be found at a range of elevations, occasionally being recorded in mountains as high up as 1,100 metres	Breeding occurs from Siberia to the Himalayas, across Southeast Asia, southern China, Korea, Japan and Taiwan. Over winter this species migrates to the Malay Peninsula, Indonesia, the Philippines, New Guinea, the Solomon Islands, northern and eastern Australia, and occasionally as far as New Zealand.	This species is not known from conservation reserves in the region.	There is no potential habitat for this species within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Yellow wagtail *Motacilla flava*	MIG (EPBC)	Occupies a range of damp or wet habitats with low vegetation, from damp meadows, marshes, waterside pastures, sewage farms and bogs to damp steppe and grassy tundra. In the north of its range it is also found in large forest clearings	Has an extremely large range, extending from Europe, east through Siberia to west Asia and north-western China; and south through the Arabian Peninsula to Egypt. Breeds in temperate Europe and Asia.	This species is not known from conservation reserves in the region.	There is no potential habitat for this species within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Species	Legal Status	Specific Habitat	Distribution in relation to Survey Area	Reservation in the Region (BioNet 2015)	Potential to be Impacted	Detailed Assessment of Significance Required?
Curlew sandpiper *Calidris ferruginea*	MIG (EPBC)	The curlew sandpiper is distributed around most of the coastline of Australia (including Tasmania) It occurs along the entire coast of NSW, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. It generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts.	A regular summer migrant from Siberia and other Arctic breeding grounds to most of the Australian coastline. It is uncommon to locally common along the NSW coast, with occasional inland sightings.	This species is not known from conservation reserves in the region.	There is no potential habitat for this species within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No
Eastern curlew *Numenius madagascariensis*	MIG (EPBC)	This species is typically found in areas of sheltered coast, particularly bays, coastal lagoons, estuaries, bays, harbours and inlets. They tend to feed on soft-sheltered intertidal sand or mudflats. They are rarely seen in grassy areas and roost on sandy spits and islets.	In Australia this species can be found in all states, but generally along the north, east or south-east coasts. It has been recorded on Lord Howe and Norfolk Islands.	This species is not known from conservation reserves in the region.	There is no potential habitat for this species within the LWB4-B7 Modification Area. There is no potential for a significant impact on this species.	No

Note

CE	critically endangered
E:	endangered
EP:	Endangered Population
EPBC:	Environment Protection Biodiversity Conservation Act
FM	Fisheries Management Act
LGA:	Local Government Area
MIG	migratory
NR:	Nature Reserve
NP:	National Park
SCA	State Conservation Area
SF	State Forest
TSC:	Threatened Species Conservation Act
V:	vulnerable

APPENDIX B

Flora Species List

The following list was developed from surveys as detailed in **Section 4.0** of the main report. It includes all species of vascular plants observed in the LWB4-B7 Modification Area.

Not all species are readily detected at any one time of the year; therefore the list will not necessarily include all plant species likely to occur in the LWB4-B7 Modification Area. Many species flower only during restricted periods of the year, and some flower only once in several years. In the absence of flowering material, many of these species cannot be identified, or even detected.

Names of classes and families follow a modified Cronquist (1981) System.

Any species that could not be identified to the lowest taxonomic level are denoted in the following manner:

sp.	specimens that are identified to genus level only;
poss.	specimens for which identification was considered likely but not definite.
Spp agg	species complex (group of closely related species similar in appearance such that species distinctions are often unclear).

The following abbreviations or symbols may be used in the list:

asterisk (*)	denotes species not indigenous to the LWB4-B7 Modification Area;
subsp.	subspecies; and
var.	variety;

Note: Those species highlighted in bold are threatened species.

All vascular plants recorded or collected were identified using keys and nomenclature in Harden (1992, 1993, 2000 & 2002) and Wheeler et al. (2002). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from *PlantNET* (Botanic Gardens Trust 2017), the on-line plant name database maintained by the National Herbarium of New South Wales.

Common names used follow Harden (1992, 1993, 2000 & 2002) where available, and draw on other sources such as local names where these references do not provide a common name.

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
FILICOPSIDA (FERNS)					
Dennstaedtiaceae	*Pteridium esculentum*	bracken	x	x	x
Marsileaceae	*Marsilea mutica*	nardoo	x	x	
Pteridaceae	*Adiantum aethiopicum*	common maidenhair fern	x	x	
Pteridaceae	*Cheilanthes sieberi* subsp. *sieberi*	poison rock fern	x	x	
MAGNOLIOPSIDA (FLOWERING PLANTS) – LILIIDAE (MONOCOTS)					
Anthericaceae	*Laxmannia gracilis*	slender wire lily		x	
Commelinaceae	*Commelina cyanea*	scurvy weed		x	x
Cyperaceae	*Baumea* sp.		x		
Cyperaceae	*Carex appressa*	tall sedge	x	x	x
Cyperaceae	*Cyperus* sp.		x	x	
Cyperaceae	*Eleocharis sphacelata*			x	
Cyperaceae	*Schoenoplectus pungens*			x	
Cyperaceae	*Schoenus* sp.		x	x	
Cyperaceae	*Lepidosperma laterale*		x	x	
Iridaceae	**Romulea rosea*	onion grass	x		
Juncaceae	**Juncus acutus* subsp. *acutus*	sharp rush	x		
Juncaceae	*Juncus* sp.	common rush	x	x	
Juncaceae	*Juncus usitatus*		x	x	
Juncaginaceae	*Triglochin procerum*	water ribbons	x	x	
Linaceae	*Linum marginale*	native flax	x		
Lomandraceae	*Lomandra filiformis* subsp. *filiformis*	wattle mat-rush	x	x	
Lomandraceae	*Lomandra glauca*		x		
Lomandraceae	*Lomandra longifolia*	spiny-headed mat-rush	x	x	x
Lomandraceae	*Lomandra multiflora*		x	x	

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
Orchidaceae	*Caladenia catenata*	white fingers	x		
Orchidaceae	*Calochilus robertsonii*		x		
Orchidaceae	*Diuris sulphurea*		x		
Orchidaceae	*Microtis parviflora*		x		
Orchidaceae	*Thelymitra* sp.		x		
Phormiaceae	*Dianella caerulea var. cinerascens*		x		
Phormiaceae	*Dianella longifolia*		x		
Phormiaceae	*Dianella* sp.		x	x	
Philydraceae	*Philydrum lanuginosum*	frogsmouth	x	x	
Poaceae	**Andropogon virginicus*	whisky grass	x		
Poaceae	*Aristida* sp.	a speargrass	x		
Poaceae	*Aristida ramosa*	purple wire grass		x	
Poaceae	*Aristida vagans*	threeawn speargrass	x		
Poaceae	*Austrostipa scabra.*	spear grass	x		
Poaceae	**Axonopus fissifolius*	narrow-leaved carpet grass		x	x
Poaceae	**Briza maxima*		x		
Poaceae	**Briza minor*	shivery grass	x	x	
Poaceae	**Bromus catharticus*	prairie grass		x	
Poaceae	*Bothriochloa* sp.		x		
Poaceae	*Chloris* sp.		x		
Poaceae	*Cymbopogon refractus*	barbed wire grass	x		
Poaceae	*Cynodon dactylon*	common couch	x	x	x
Poaceae	*Digitaria diffusa*	open summer grass	x		
Poaceae	*Digitaria* sp.		x		
Poaceae	*Echinopogon ovatus*	forest hedgehog grass	x	x	

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
Poaceae	**Ehrharta erecta*	panic veldtgrass	x	x	
Poaceae	*Eragrostis brownii*		x	x	
Poaceae	*Eragrostis* sp.	a lovegrass	x	x	
Poaceae	*Imperata cylindrica* var. *major*	blady grass	x	x	
Poaceae	*Microlaena stipoides* var. *stipoides*	weeping grass	x	x	X
Poaceae	*Oplismenus aemulus*	Australian basket grass		x	
Poaceae	*Oplismenus imbecilis*	creeping beard grass			X
Poaceae	*Panicum* sp.			x	
Poaceae	**Paspalum dilatatum*	paspalum	x		x
Poaceae	*Paspalum distichum*	water couch		x	
Poaceae	*Paspalum* sp.				x
Poaceae	**Pennisetum clandestinum*	kikuyu grass	x		
Poaceae	*Poa affinis*		x		
Poaceae	*Rytidosperma* sp.		x	x	
Poaceae	**Setaria gracilis*	pigeon grass	x	x	
Poaceae	**Setaria parviflora*				x
Poaceae	*Setaria* sp.	pigeon grass	x		
Poaceae	*Sporobolus creber*	slender rats tail grass	x		
Poaceae	**Stenotaphrum secundatum*	buffalo grass	x		
Poaceae	*Themeda triandra*	kangaroo grass	x	x	
Potamogetonaceae	*Potamogeton cheesemanii*			x	
Typhaceae	*Typha domingensis*	narrow-leaved cumbungi	x	x	
Xanthorrhoeaceae	*Xanthorrhoea* sp.		x		

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
MAGNOLIOPSIDA (FLOWERING PLANTS) – MAGNOLIIDAE (DICOTS)					
Acanthaceae	*Brunoniella australis*	blue trumpet	x		
Alismataceae	*Alisma plantago-aquatica*	water plantain	x		
Amaranthaceae	*Alternanthera denticulata*	lesser joyweed			x
Apiaceae	*Centella asiatica*	pennywort	x	x	
Apiaceae	**Cyclospermum leptophyllum*	slender celery	x	x	
Apiaceae	*Platysace ericoides*			x	
Apocynaceae	*Parsonsia straminea*	common silkpod	x		
Araliaceae	*Hydrocotyle laxiflora*	stinking pennywort			x
Araliaceae	*Hydrocotyle tripartita*	pennywort			x
Asteraceae	**Ambrosia* sp.	a lacy ragweed	x		
Asteraceae	**Bidens pilosa*	cobblers pegs	x		
Asteraceae	*Chrysocephalum apiculatum*		x	x	
Asteraceae	*Chrysocephalum* sp.		x	x	
Asteraceae	**Cirsium vulgare*	spear thistle	x		
Asteraceae	**Conyza bonariensis*	fleabane	x	x	
Asteraceae	*Cymbonotus lawsonianus*	bears-ear	x	x	
Asteraceae	*Epaltes australis*	spreading nut heads		x	
Asteraceae	**Gamochaeta* sp.	cudweed	x	x	
Asteraceae	*Euchiton involucratus*		x		
Asteraceae	**Hypochaeris radicata*	catsear	x	x	x
Asteraceae	*Lagenophora* sp.		x		
Asteraceae	*Lagenophora stipitata*		x		
Asteraceae	*Ozothamnus diosmifolius*	rice flower	x	x	
Asteraceae	***Rutidosis heterogama***	**heath wrinklewort**	**x**	**x**	
Asteraceae	**Senecio*	fireweed	x	x	x

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
	madagascariensis				
Asteraceae	**Silybum marianum*	variegated thistle	x	x	
Asteraceae	*Solenogyne bellioides*		x		
Asteraceae	**Soliva sesilis*	Lawn burrweed	x		
Asteraceae	**Sonchus oleraceus*	common sowthistle	x	x	
Asteraceae	**Taraxacum officinale*	dandelion	x		
Brassicaceae	**Lepidium africanum*		x		
Campanulaceae	*Wahlenbergia communis*		x		
Campanulaceae	*Wahlenbergia gracilis*		x		
Campanulaceae	*Wahlenbergia* sp.		x	x	
Caryophyllaceae	**Cerastium glomeratum*	mouse-ear chickweed	x		
Caryophyllaceae	*Polycarpon tetraphyllum*	four-leaved allseed		x	
Caryophyllaceae	**Petrorhagia nanteuilii*		x		
Caryophyllaceae	**Stellaria media*	common chickweed	x		
Casuarinaceae	*Casuarina cunninghamiana*	river oak	x		
Casuarinaceae	*Casuarina glauca*	swamp oak	x	x	X
Celastraceae	*Denhamia silvestris*	narrow-leaved orangebark	x		
Chenopodiaceae	*Einadia hastata*	berry saltbush	x		
Clusiaceae	*Hypericum gramineum*	small St Johns wort	x	x	
Convolvulaceae	*Dichondra repens*	kidney weed	x	x	x
Crassulaceae	*Crassula sieberiana*	Australian stonecrop	x		
Dilleniaceae	*Hibbertia aspera*	rough guinea flower	x		
Dilleniaceae	*Hibbertia obtusifolia*	hoary guinee flower	x		
Dilleniaceae	*Hibbertia pedunculata*		x		
Dilleniaceae	*Hibbertia sp.*		x	x	
Droseraceae	*Drosera peltata*		x		

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
Ericaceae (Epacridoideae)	*Leucopogon juniperinus*	Prickly beard heath		x	
Ericaceae (Styphelioideae)	*Lissanthe strigosa*	peach heath	x		
Ericaceae (Styphelioideae)	*Styphelia triflora*	pink five corners		x	
Ericaceae (Styphelioideae)	*Styphelia viridis*	Green five-corners	x		
Fabaceae (Faboideae)	*Daviesia ulicifolia*	gorse bitter pea	x	x	
Fabaceae (Faboideae)	*Desmodium varians*	slender tick-trefoil	x	x	
Fabaceae (Faboideae)	*Dillwynia retorta*		x		
Fabaceae (Faboideae)	*Glycine clandestina*	twining glycine	x	x	
Fabaceae (Faboideae)	*Glycine microphylla*		x		
Fabaceae (Faboideae)	*Glycine tabacina*	variable glycine	x		x
Fabaceae (Faboideae)	*Hardenbergia violacea*	false sarsparilla	x		
Fabaceae (Faboideae)	*Indigofera australis*	Australian indigo	x		
Fabaceae (Faboideae)	*Jacksonia scoparia*	dogwood	x		
Fabaceae (Faboideae)	**Medicago polymorpha*	burr medic	x		
Fabaceae (Faboideae)	*Mirbelia rubiifolia*	heathy mirbelia	x		
Fabaceae (Faboideae)	*Pultenaea retusa*	notched bush-pea	x		
Fabaceae (Faboideae)	*Pultenaea villosa*	hairy bush-pea	x		

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
Fabaceae (Faboideae)	**Trifolium dubium*	yellow suckling clover		x	
Fabaceae (Mimosoideae)	*Acacia brownii*	prickly Moses	x		
Fabaceae (Mimosoideae)	*Acacia dealbata*	silver wattle		x	
Fabaceae (Mimosoideae)	*Acacia falcata*	hickory wattle		x	
Fabaceae (Mimosoideae)	*Acacia filicifolia*	fern-leaved wattle		x	
Fabaceae (Mimosoideae)	*Acacia longifolia* var. *longifolia*	Sydney golden wattle	x		
Fabaceae (Mimosoideae)	*Acacia parvipinnula*	silver-stemmed wattle		x	
Fabaceae (Mimosoideae)	*Acacia ulicifolia*	prickly Moses wattle	x		
Geraniaceae	*Geranium homeanum*		x	x	x
Goodeniaceae	*Goodenia hederacea*	ivy goodenia	x	x	
Goodeniaceae	*Goodenia rotundifolia*	a goodenia	x	x	
Haloragaceae	*Gonocarpus tetragynus*	Poverty raspwort	x		
Lamiaceae	*Ajuga australis*	Austral bugal	x		
Lauraceae	**Cinnamomum camphora*	camphor laurel	x		x
Lobeliaceae	*Pratia concolor*	poison pratia	x	x	
Lobeliaceae	*Pratia purpurascens*	whiteroot	x		x
Loranthaceae	*Amyema gaudichaudii*		x		
Malvaceae	**Modiola caroliniana*	red-flowered mallow		x	
Malvaceae	**Sida rhombifolia*	Paddys lucerne	x	x	
Menispermaceae	*Stephania japonica*	snake vine		x	
Myrtaceae	*Angophora costata*	smooth-barked apple	x		
Myrtaceae	*Angophora floribunda*	rough-barked apple	x	x	

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
Myrtaceae	***Callistemon linearifolius***	**netted bottlebrush**	**x**		
Myrtaceae	*Callistemon linearis*	narrow-leaved bottlebrush		x	
Myrtaceae	*Callistemon rigidus*	stiff bottle brush	x		
Myrtaceae	*Callistemon salignus*	willow bottlebrush	x		
Myrtaceae	*Corymbia maculata*	spotted gum	x	x	
Myrtaceae	*Eucalyptus acmenoides*	white mahogany	x	x	
Myrtaceae	*Eucalyptus amplifolia*	Ccabbage gum	x	x	X
Myrtaceae	*Eucalyptus fibrosa*	red ironbark	x	X	
Myrtaceae	*Eucalyptus longifolia*	woollybutt	x		
Myrtaceae	*Eucalyptus moluccana*	grey box	x	x	
Myrtaceae	*Eucalyptus punctata*	grey gum	x	X	
Myrtaceae	*Eucalyptus tereticornis*	forest red gum	x		
Myrtaceae	*Leptospermum polygalifolium*	tantoon	x	x	
Myrtaceae	*Leptospermum* sp.		x		
Myrtaceae	*Melaleuca thymifolia*	thyme honey-myrtle	x		
Myrtaceae	*Melaleuca linariifolia*	flax-leaved paperbark	x	x	
Myrtaceae	*Melaleuca nodosa*	ball honeymyrtle	x		
Oleaceae	*Notelaea longifolia*	mock-olive		x	
Oxalidaceae	*Oxalis* sp.		x	x	
Oxalidaceae	*Oxalis perennans*			x	x
Onagraceae	*Ludwigia peploides*	water primrose		x	
Phyllanthaceae	*Phyllanthus gunnii*	Scrubby Spurge		x	
Pittosporaceae	*Billardiera scandens*	hairy apple berry	x		
Pittosporaceae	*Bursaria spinosa* var. *spinosa*	blackthorn	x	x	x
Plantaginaceae	**Plantago lanceolata*	lambs tongues	x	x	

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
Plantaginaceae	*Veronica plebeia*	trailing speedwell		x	
Plantaginaceae	*Plantago* sp.		x		
Polygonaceae	*Persicaria decipiens*	slender knotweed		x	
Polygonaceae	*Rumex brownii*	swamp dock	x		x
Polygonaceae	**Rumex crispus*	curled dock	x		
Proteaceae	*Banksia spinulosa*	hairpin banksia	x		
Proteaceae	*Grevillea montana*		x	x	
Proteaceae	***Grevillea parviflora* subsp. *parviflora***	**small-flower grevillea**	**x**	**x**	
Proteaceae	*Hakea sericea*	needle bush		x	
Proteaceae	*Persoonia linearis*	narrow-leaved geebung	x	x	
Primulaceae	**Anagallis arvensis*	scarlet/blue pimpernel	x	x	
Ranunculaceae	*Clematis glycinoides*	headache vine	x	x	
Ranunculaceae	*Ranunculus inundatus*	river buttercup	x	x	x
Rosaceae	**Rubus fruticosus* sp. agg.	blackberry complex	x	x	
Rosaceae	*Rubus parviflora*	native raspberry		x	
Rubiaceae	*Galium binifolium*				x
Rubiaceae	*Galium propinquum*	Maori bedstraw		x	
Rubiaceae	**Richardia* sp.		x	x	
Rubiaceae	*Pomax umbellata*			x	
Rutaceae	*Geijera salicifolia*	brush wilga	x		
Sapindaceae	*Dodonaea triquetra*	large-leaf hop-bush	x		
Scrophulariaceae	*Myoporum montanum*	western boobialla	x		
Solanaceae	**Cestrum parqui*	green cestrum		x	x
Solanaceae	*Duboisia myoporoides*	corkwood		x	
Solanaceae	**Solanum mauritianum*	wild tobacco bush	x	X	x
Solanaceae	**Solanum nigrum*	black-berry nightshade	x		

Family/Sub Family	Scientific Name	Common Name	2015	2016	2017
Solanaceae	**Solanum pseudocapsicum*	madeira cherry	x		
Solanaceae	*Solanum prinophyllum*	forest nightshade		x	
Solanaceae	*Solanum* sp.		x		
Stackhousiaceae	*Stackhousia viminea*	slender stackhousia	x	x	
Thymelaeaceae	*Pimelea linifolia*	slender rice flower	x		
Ulmaceae	*Trema tomentosa*	poison peach		x	
Verbenaceae	**Lantana camara*	Lantana		x	
Verbenaceae	**Verbena bonariensis*	purpletop	x	x	x
Violaceae	*Viola hederacea*	Ivy-leaved violet		x	

APPENDIX C

Fauna Species List

The following list was developed from surveys as detailed in **Section 4** of the main report. It includes all fauna species observed by Umwelt in the LWB4-B7 Modification Area. This is not an exclusive list, and it is likely that further species are present that were not identified at the time of survey.

All threatened species are indicated in **bold** type.

The following abbreviations or symbols are used in the list:

asterisk (*) denotes species not indigenous to the Stage LWB4-B7 Modification Area;

def	call was identified to a definite level of confidence based on characteristics;
MIG	Listed migratory species under the EPBC Act;
prob	call was identified to a probable level of confidence based on characteristics; and
V	Vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995* (TSC Act).

Birds recorded were identified using descriptions in Slater *et al.* (2003) and the scientific and common name nomenclature of BirdLife Australia. Reptiles recorded were identified using keys and descriptions in Cogger (2000), Swan *et al*. (2004) and Wilson and Swan (2010) and the scientific and common name nomenclature of Cogger (2000).

Amphibians recorded were identified using keys and descriptions in Cogger (2000) and Robinson (2002) and the scientific and common name nomenclature of Cogger (2000). Mammals recorded were identified using keys and descriptions in Van Dyke and Strahan (2008), Churchill (2008) and Menkhorst and Knight (2011) and the scientific and common name nomenclature of Van Dyke and Strahan (2008).

Table 1 Fauna Species Recorded within the LWB4-B7 Modification Area

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
BIRDS					
Anatidae					
Chenonetta jubata	Australian wood duck			✓	✓
Anas superciliosa	Pacific black duck			✓	
Ardeidae					
Ardea ibis	cattle egret			✓	
Egretta novaehollandiae	white-faced heron			✓	
Nycticorax caledonicus	nankeen night heron			✓	
Threskiornithidae					
Threskiornis molucca	Australian white ibis			✓	
Accipitridae					
Haliaeetus leucogaster	**white-bellied sea-eagle**	**V**		✓	✓
Haliastur sphenurus	whistling kite				✓
Falconidae					
Falco cenchroides	nankeen kestrel			✓	
Falco berigora	brown falcon			✓	
Rallidae					
Porphyrio porphyrio	purple swamphen			✓	✓
Charadriidae					
Vanellus miles	masked			✓	✓

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
	lapwing				
Columbidae					
Macropygia amboinensis	brown cuckoo-dove				✓
Ocyphaps lophotes	crested pigeon			✓	✓
Geopelia humeralis	bar-shouldered dove			✓	✓
Leucosarcia melanoleuca	wonga pigeon			✓	✓
Cuculidae					
Chalcites minutillus	little bronze-cuckoo				✓
Cacomantis flabelliformis	fan-tailed cuckoo			✓	
Eudynamis scolopacea	common koel				✓
Cacatuidae					
Cacatua roseicapilla	galah			✓	✓
Cacatua sanguinea	little corella				✓
Psittacidae					
Trichoglossus haematodus	rainbow lorikeet				✓
Platycercus eximius	eastern rosella			✓	✓
Strigidae					
Ninox noveseelandiae	southern boobook			✓	
Podargidae					

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
Podargus strigoides	tawny frogmouth			✓	✓
Alcedinidae					
Ceyx azurea	azure kingfisher				✓
Halcyonidae					
Dacelo novaeguineae	laughing kookaburra			✓	✓
Todiramphus macleayii	forest kingfisher				✓
Todiramphus sancta	sacred kingfisher				✓
Ptilonorhynchidae					
Ptilonorhynchus violaceus	satin bowerbird			✓	✓
Coraciidae					
Eurystomus orientalis	dollarbird				✓
Climacteridae					
Cormobates leucophaea	white-throated treecreeper				✓
Climacteris affinis	white-browed treecreeper				✓
Maluridae					
Malurus cyaneus	superb fairy-wren			✓	✓
Acanthizidae					
Sericornis frontalis	white-browed scrubwren				✓

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
Gerygone albogularis	white-throated gerygone				✓
Acanthiza lineata	striated thornbill				✓
Acanthiza chrysorrhoa	yellow-rumped thornbill				✓
Pardalotidae					
Pardalotus punctatus	spotted pardalote				✓
Pardalotus striatus	striated pardalote			✓	
Meliphagidae					
Acanthorhynchus tenuirostris	eastern spinebill				✓
Meliphaga lewinii	Lewin's honeyeater				✓
Lichenostomus chrysops	yellow-faced honeyeater			✓	✓
Entomyzon cyanotis	blue-faced honeyeater			✓	
Anthochaera carunculata	red wattlebird			✓	
Lichenostomus penicillatus	white-plumed honeyeater				
Manorina melanocephala	noisy miner			✓	✓
Phylidonyris niger	white-cheeked honeyeater				✓
Philemon corniculatus	noisy friarbird			✓	✓

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
Petroicidae					
Petroica rosea	rose robin			✓	
Pomatostomidae					
Pomatostomus temporalis temporalis	**grey-crowned babbler (eastern subspecies)**	**V**		✓	✓
Eupetidae					
Psophodes olivaceus	eastern whipbird			✓	✓
Neosittidae					
Daphoenositta chrysoptera	**varied sittella**	**V**		✓	
Pachycephala rufiventris	rufous whistler			✓	✓
Pachycephala pectoralis	golden whistler			✓	✓
Campephagidae					
Coracina novaehollandiae	black-faced cuckoo-shrike				✓
Corcoracidae					
Corcorax melanorhamphos	white-winged chough			✓	✓
Monarchidae					
Grallina cyanoleuca	magpie-lark			✓	✓
Rhipiduridae					
Rhipidura albiscapa	grey fantail			✓	✓

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
Rhipidura leucophrys	willie wagtail			✓	✓
Oriolidae					
Oriolus sagittatus	olive-backed oriole				✓
Artamidae					
Cracticus torquatus	grey butcherbird			✓	✓
Cracticus nigrogularis	pied butcherbird				✓
Gymnorhina tibicen	Australian magpie			✓	✓
Strepera graculina	pied currawong				✓
Corvidae					
Corvus coronoides	Australian raven			✓	✓
Monarchidae					
Myiagra cyanoleuca	satin flycatcher				✓
Nectariniidae					
Dicaeum hirundinaceum	mistletoebird				✓
Estrilidae					
Neochmia temporalis	red-browed finch			✓	✓
Cisticolidae					
Cisticola exilis	golden-headed cisticola				✓
Acrocephalidae					

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
Acrocephalus australis	Australian reed-warbler				
Timaliidae					
Zosterops lateralis	silvereye				✓
Hirundinidae					
Hirundo neoxena	welcome swallow			✓	
Hirundo ariel	fairy martin				✓
REPTILES					
Cheloniidae					
Chelodina longicollis	snake-necked turtle				✓
Agamidae					
Amphibolurus muricatus	Jacky lizard			✓	✓
Physignathus lesueurii ssp. *lesueurii*	eastern water dragon				✓
Pogona barbata	eastern bearded dragon			✓	
Scincidae					
Eulamprus quoyii	eastern water skink			✓	✓
Lampropholis delicata	grass skink				✓
Lampropholis guichenoti	garden skink				✓
Carlia tetradactyla	southern rainbow skink			✓	✓

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
Saiphos equalis	three-toed skink			✓	
Varanidae					
Varanus varius	lace monitor			✓	
Elapidae					
Pseudechis porphyriacus	red-bellied black snake				✓
AMPHIBIANS					
Myobatrachidae					
Crinia signifera	brown froglet			✓	
Limnodynastes fletcheri	barking marsh frog			✓	
Limnodynastes tasmaniensis	spotted marsh frog			✓	
Limnodynastes peronii	striped marsh frog			✓	✓
Uperoleia laevigata	smooth toadlet			✓	
Hylidae					
Litoria dentata	bleating tree frog				✓
Litoria fallax	dwarf tree frog			✓	✓
Litoria latopalmata	broad-palmed frog			✓	✓
Litoria peronii	Peron's tree frog			✓	✓
Litoria tyleri	Tyler's tree frog				✓
Litoria verreauxii	Verreauxs			✓	

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
	tree frog				
MAMMALS					
Vombatidae					
Vombatus ursinus	common wombat			✓	
Tachyglossidae					
Tachyglossus aculeatus	echidna			✓	
Petauridae					
Petaurus breviceps	sugar glider				✓
Petaurus norfolcensis	**squirrel glider**	**V**		✓	
Petaurus sp.	unidentified glider			✓	
Phalangeridae					
Trichosurus vulpecula	common brushtail possum			✓	✓
Pseudocheiridae					
Pseudocheirus peregrinus	common ringtail possum			✓	✓
Macropodidae					
Macropus giganteus	eastern grey kangaroo			✓	✓
Macropus rufogriseus	red-necked wallaby				✓
Wallabia bicolor	swamp wallaby				✓
Pteropodidae					

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
Pteropus poliocephalus	grey-headed flying-fox	V	V		✓
Emballonuridae					
***Saccolaimus flaviventris* (prob)**	**yellow-bellied sheathtail-bat**	**V**			✓
Molossidae					
***Mormopterus norfolkensis* (def)**	**East-coast - freetail-bat**	**V**			✓
Mormopterus ridei (def)	Ride's freetail-bat				✓
Mormopterus planiceps (def)	southern freetail-bat				✓
Nyctinomus australis (def)	white-striped freetail-bat				✓
Scotorepens balstoni (sg)	inland broad-nosed bat				✓
Scotorepens orion (sg)	eastern broad-nosed bat				✓
Vespertilionidae					
***Miniopterus australis* (prob)**	**little bentwing-bat**	**V**			✓
Nyctophilus gouldi (sg)	Gould's long-eared bat				✓
Nyctophilus geoffroyi	lesser long-eared bat			✓	
***Chalinolobus dwyeri* (def)**	**large-eared pied bat**	**V**	**V**	✓	
Chalinolobus gouldii (def)	Gould's wattled bat			✓	✓

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
Chalinolobus morio (def)	chocolate wattled bat			✓	✓
Scoteanax rueppellii **(prob)**	**greater broad-nosed bat**	**V**		✓	
Falsistrellus tasmaniensis **(sg)**	**eastern falsistrelle**	**V**			✓
Miniopterus schreibersii oceanensis **(sg)**	**eastern bentwing-bat**	**V**			✓
Myotis macropus **(sg)**	**southern myotis**	**V**			✓
Vespadelus troughtoni **(sg)**	**eastern cave bat**	**V**			✓
Vespadelus darlingtoni (sg)	Large forest bat				✓
Vespadelus pumilus (sg)	Eastern forest bat				✓
Vespadelus regulus (sg)	Southern forest bat				✓
Vespadelus vulturnus (sg)	Little forest bat				✓
Canidae					
**Vulpes vulpes*	fox			✓	✓
Leporidae					
**Oryctolagus cuniculus*	rabbit			✓	✓
Bovidae					
**Bos taurus*	cow			✓	
Cervidae					
**Dama dama*	fallow deer				✓

Scientific Name	Common Name	Conservation Status		LW B1-B3 Modification (2015)	LW B4-B7 Modification (2016)
		TSC Act	EPBC Act		
**Cervus timoriensis*	rusa deer				✓
Equidae					
**Equus caballus*	horse			✓	

APPENDIX D

Aquatic Survey Results

This appendix provides the results of the aquatic assessment undertaken as provided within **Section 4.4** of the Ecological Assessment. **Table 1** provides the results of the Habitat Assessments undertaken at the five separate aquatic habitat assessment locations shown on **Figure 2.3**:

- Quorrobolong Creek above LWB6 in the far north of the LWB4-B7 Modification Area
- Unnamed tributary of Quorrobolong Creek above LWB3, north of Sandy Creek Road
- Unnamed tributary of Quorrobolong Creek south of Sandy Creek Road above LWB1.

Table 2 provides a summary of the Riparian Channel and Environmental Inventory (RCE) categorisation undertaken at these sites. Both sets of data are qualitative in nature and were collected to inform the likelihood of occurrence of significant aquatic ecological values base on habitat.

Table 1 Aquatic Habitat Attributes

		2016	2015	2015	2017	2017
Habitat Attribute		**Quorrobolong Creek (North) centre LWB6**	**Unnamed Tributary of Quorrobolong Creek – North of Sandy Creek Rd (LWB3)**	**Unnamed Tributary of Quorrobolong Creek – South of Sandy Creek Rd (LWB1)**	**Quorrobolong Creek (west most of Study Area)**	**Quorrobolong Creek (Base of LW B7)**
Easting		344640.4	345397.3	345008.8	344110	344188
Northing		6356720	6356328	6355259	6356879	6356810
Bank height (m)		0.5	0.5	1.8	0.5*	0.8
Bank full width (m)		4.5m	>5m	10	5*	5
Length of reach (m)		200m	300m	500m	200m	200m
Stream width (m)	minimum	2	0.5	0.5	1.5*	2
	maximum	4	3	3	3*	3
	mode	2.5	1.5	1	2*	2.5
Riffle		Absent	Absent	Small amount of riffling present at man-made weir. Very slow moving.	None identified	Very small amount of riffling present due to fallen logs/branches
Pool %		20	Absent	10	10*	10
Run %		80	100%	90	90*	90
Macrophyte		Absent	Absent	Small amounts of water ribbons	Absent	Absent
Riparian zone width (m)	left	>50m	3m	3m	>50m	>50m
	right	>50m	3m	3m	>50m	>50m
% cover of riparian zone	trees (>10 m)	10	15	15	30%*	25%
	trees (<10 m)	20	40	15	15%*	10%
	shrubs	40		0	30%*	50%
	grasses/ferns/ sedges	95	90	80	80%*	60%
Vegetation description		Riparian Swamp Oak Open Forest	Riparian Swamp Oak Open Forest (dominated by planted *Casuarina cunninghamiana*)	Riparian Swamp Oak Open Forest – Eucalypt Dominant Variant	Riparian Swamp Oak Open Forest	Riparian Swamp Oak Open Forest
Shading of river%		60	90	80	70%	70%
Vegetation %	native	95	50	80	60	60
	exotic	5	50	20	20	40
Water odour		nil	nil	nil	nil	nil

Habitat Attribute		2016 Quorrobolong Creek (North) centre LWB6	2015 Unnamed Tributary of Quorrobolong Creek – North of Sandy Creek Rd (LWB3)	2015 Unnamed Tributary of Quorrobolong Creek – South of Sandy Creek Rd (LWB1)	2017 Quorrobolong Creek (west most of Study Area)	2017 Quorrobolong Creek (Base of LW B7)
Water oils (natural or manmade)		None	nil	None. Small level of tannins	Yes-slight	Yes-slight
Turbidity		Moderate	nil	low	low	low
Plume		Nil	nil	nil	nil	nil
Sediment oils		Nil	nil	nil	nil	nil
Sediment odours		nil	Could not be identified as could not access water course	nil	nil	nil
Flow level		Not flowing	Low	Moderate	Moderate	Moderate
Bare ground above water mark (%)	left	10	5	5	5	10
	right	10	5	5	5	10
Are the undersides of stones that are not deeply embedded black?		No	No -not stony	No	No -not stony	No -not stony
Sediment deposits		Very little	None observed	Very little	Minor	Minor
Local catchment erosion		Minor	Minor	Minor	Minor	Minor
Local point source pollution		Agriculture	Agriculture	Agriculture	Agriculture	Agriculture
Local non-point source pollution		None likely	None likely	None likely – maybe small amount of road runoff and waste from grazing cattle	None likely	None likely
Dams/barriers		None identified	None identified	Culvert to north from Sandy Creek Road Crossing and small weir. Does not appear to be impeding flow.	None identified	None identified
River braiding		nil	nil	nil	nil	nil
Land use Left bank		Remnant	Fenced and protected	Grazing	Remnant	Remnant
Land use Right bank		Remnant	Fenced and protected	Grazing	Remnant	Remnant
Bars		Some minor sand bar occurrences	Nil	Nil	Nil	Nil

Habitat Attribute		2016 Quorrobolong Creek (North) centre LWB6	2015 Unnamed Tributary of Quorrobolong Creek – North of Sandy Creek Rd (LWB3)	2015 Unnamed Tributary of Quorrobolong Creek – South of Sandy Creek Rd (LWB1)	2017 Quorrobolong Creek (west most of Study Area)	2017 Quorrobolong Creek (Base of LW B7)
Reach: substratum description (% cover)	bedrock	0	0	0	0	0
	boulder	0	0	0	0	0
	cobble	10	0	0	0	0
	pebble	10	0	0	1	0
	gravel	5	0	0	1	0
	sand	75	0	80	20	20
	silt	0	80 (based on observation- could not access)	10	70	70
	clay	0	20 (based on observation- could not access)	10	8	10
Organic substratum	detritus (sticks, wood)	5%	15%	<5%	10	5
	muck/mud	Nil	Could not be observed as could not access	Nil	0	0
Percent of reach covered by	periphyton	0	0	5	0	0
	moss	0	0	0	0	0
	filamentous algae	0	0	10	0	0
	macrophytes	0	0	5	0	0
Macrophytes	submerged/floating	0	<5	5 (water ribbons)	0	0
	emergent	*0*	0	0	15	15

Note many of these factors such as presence of riffles and runs are likely to be dependent on the presence and level of water flow occurring in the tributary at the time of survey

* not documented and subsequently data has been extrapolated based upon photography

Table 2 AUSRIVAS Physical and Chemical Assessment Habitat Attributes (low gradient streams)

Habitat variable	Quorrobolong Creek (North) centre LWB6		Unnamed Tributary of Quorrobolong Creek – North of Sandy Creek Rd (LWB3)		Unnamed Tributary of Quorrobolong Creek – South of Sandy Creek Rd (LWB1)		Quorrobolong Creek (west most of Study Area)		Quorrobolong Creek (Base of LW B7)	
Bottom substrate/available cover	Sub-optimal (13)		Sub-optimal (14)		Sub-optimal (11)		Poor (5)		Sub-optimal (13)	
Pool Substrate Characterisation	Sub-optimal (12)		Sub-optimal (11)		Sub-optimal (11)		Poor (5)		Poor (5)	
Pool Variability	Marginal (10)		Marginal (6)		Marginal (8)		Marginal (10)		Marginal (10)	
Sediment Deposition	Optimal (15)		Optimal (18)		Optimal (16)		Optimal (20)		Optimal (19)	
Channel flow status	Poor (3)		Optimal (18)		Optimal (17)		Optimal (20)		Optimal (19)	
Channel Alteration	Optimal (19)		Sub-optimal (16)		Optimal (17)		Optimal (20)		Optimal (19)	
Channel Sinuosity	Sub-optimal (15)		Marginal (7)		Marginal (9)		Marginal (10)		Optimal (18)	
Bank Stability	Optimal (9)	Optimal (9)	Optimal (9)	Optimal (9)	Sub-optimal (8)	Sub-optimal (8)	Sub-optimal (8)	Sub-optimal (8)	Good (6)	Good (7)
Vegetation Protection	Optimal (8)	Optimal (8)	Optimal (9)	Optimal (9)	Marginal (5)	Marginal (4)	Marginal (4)	Sub-optimal (8)	Optimal (9)	Optimal (9)
Riparian Zone	Optimal (10)	Optimal (10)	Marginal (5)	Marginal (5)	Poor (2)	Marginal (3)	Optimal (10)	Optimal (10)	Optimal (10)	Optimal (10)
Total Score	**141**		**136**		**119**		**138**		**154**	

APPENDIX E

Seven Part Test of Significance under the Environmental Planning and Assessment Act 1979

Assessments of significance have been used to determine potential impacts as a result of the proposed modification. The tables presented in **Appendix A** are intended to streamline the impact assessment process, ensuring that only those species with reasonable potential to occur in the LWB4-B7 Modification Area and with reasonable potential to be impacted by the proposed modification are assessed under a 7 part test.

A 7 part test of significance was prepared in accordance with the requirements of Section 5A of the EP&A Act for each threatened species, population or EECs potentially impacted as a result of the proposed modification. As discussed in **Section 4** of the Ecological Assessment, biodiversity values have the potential to be directly impacted by subsidence related surface cracking, and by any associated remediation of surface cracking post mining. Secondary impacts associated with hydrological changes are also possible and typically impact greatest on riparian areas. Such secondary impacts could include:

- changes to runoff and flow volumes through subsidence induced changes to catchment boundaries
- changes to bank stability and channel alignment
- changes to in-channel and out of channel ponding through changes to the bed profile of the creeks which may result in drying or waterlogging of root systems
- loss of water to near-surface groundwater flows due to subsidence-induced cracks occurring beneath a stream or other surface water body (valley closure)
- increased ponding.

Due to the depth of mining within the proposed modification area (minimum 400 metres), and the small magnitude of predicted ground curvatures and strains, the potential for surface cracking is low. This is supported by monitoring evidence within the Stage 2, Stage 3 and LWB1-B3 mining areas, where there has been no significant or visible surface cracking above previously extracted longwalls A3 to A8 or LWB2. Any surface cracking that does occur is expected to be minor and isolated and unlikely to directly or adversely impact site vegetation communities and fauna habitat.

Based on previous experience within the Austar Coal Mine, remediation of surface cracking is unlikely to be required within the LWB4-B7 Modification Area.

Flood modelling indicates that the potential for secondary impacts such as increased erosion of the landscape as a result of the proposed modification is also expected to be minimal.

Based on the preliminary impact assessment detailed in **Appendix A**, further assessment is required for the following EECs and species:

- River-flat Eucalypt Forest EEC
- Lower Hunter Spotted Gum – Ironbark Forest EEC
- potential Quorrobolong Scribbly Gum Woodland EEC
- netted bottle-brush (*Callistemon linearifolius*)
- heath wrinklewort (*Rutidosis heterogama*)

- small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*)
- green-thighed frog (*Litoria brevipalmata)*
- green and golden bell frog (*Litoria aurea*)
- Australasian bittern (*Botaurus poiciloptilus*)
- black bittern (*Ixobrychus flavicollis*)
- black-necked stork (*Ephippiorhynchus asiaticus*)
- Australia painted snipe (*Rostratula australis*)
- freckled duck (*Stictonetta naevosa*)
- swift parrot (*Lathamus discolor*)
- white-bellied sea eagle (*Haliaeetus leucogaster*)
- regent honeyeater (*Anthochaera phrygia*)
- grey-crowned babbler (*Pomatostomus temporalis temporalis*)
- varied sittella (*Daphoenositta chrysoptera*)
- grey-headed flying fox (*Pteropus poliocephalus*)
- squirrel glider (*Petaurus norfolcensis*)
- koala (*Phascolarctos cinereus*)
- large-eared pied bat (*Chalinolobus dwyeri*)
- southern myotis (*Myotis macropus*)
- east-coast freetail bat (*Mormopterus norfolkensis*)
- little bentwing-bat (*Miniopterus australis*)
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*)
- greater broad-nosed bat (*Scoteanax rueppellii*)
- yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*)
- eastern falsistrelle (*Falsistrellus tasmaniensis*)
- eastern cave bat (*Vespadelus troughtoni*).

Below is a 7 part test of significance for each of these, which is prepared in accordance with the requirements of the EP&A Act.

River-flat Eucalypt Forest EEC

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

A total of 56.7 hectares of River-Flat Eucalypt Forest EEC occurs within the LWB4-B7 Modification Area. The potential for surface cracking or significant deformation of the ground surface within the LWB4-B7 Modification Area as a result of subsidence is expected to be minimal and therefore very little disturbance of surface and groundwater flow patterns is predicted. Some minor ponding is proposed to occur within this vegetation community over approximately 4.4 hectares. This increased ponding duration and frequency is likely to gradually alter the composition of the understorey of this small area of vegetation; however not to the extent that the vegetation type is likely to change and become incompatible with that of this EEC

Based on the subsidence predictions summarised in **Section 4**, it is not likely that the proposed modification will result in the loss or substantial modification of any areas of River-flat Eucalypt Forest EEC and therefore the local occurrence of the community will not be placed at risk of extinction.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

The proposed modification is predicted to have very minor surface impacts and minor impacts on surface and groundwater flows. The proposed ponding impacts may alter the understory composition so that it contains species that are more capable of coping with longer periods of water inundation such as sedges and rushes, however such changes would remain compatible with this EEC. Based on the subsidence predictions, it is not likely that the proposed modification will adversely modify the composition of the River-flat Eucalypt Forest EEC such that its local occurrence will be placed at risk of extinction.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal of habitat for the River-flat Eucalypt Forest EEC; however is likely to alter the composition of the understory vegetation of approximately 4.4 ha of this EEC. It is predicted that the proposed modification will result in negligible changes to the habitat characteristics of the EEC in the LWB4-B7 Modification Area.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification does not involve any clearing of vegetation that would result in the fragmentation or isolation of any areas of the River-flat Eucalypt Forest EEC, within or adjacent to the LWB4-B7 Modification Area.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises approximately 56.7 hectares of River-flat Eucalypt Forest, which also occurs in several other locations within the locality. Bell and Driscoll (2008) identify approximately 1531.31 hectares of this EEC within the Cessnock-Kurri Region. The remnants of River-flat Eucalypt Forest within the LWB4-B7 Modification Area are in moderate condition, with evidence of historic clearing, fragmentation and ongoing grazing management practices, and are regarded to have moderate conservation significance.

Given that the proposed modification will not involve the removal or modification of any areas of this EEC, there will be no impact on the long-term viability of this EEC within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this EEC or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this EEC and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this EEC.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant.

Lower Hunter Spotted Gum – Ironbark Forest EEC

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Approximately 104.2 hectares of Lower Hunter Spotted Gum – Ironbark Forest EEC occurs in the LWB4-B7 Modification Area, where it occupies lower slopes. Large areas of this EEC are protected in the nearby Werakata SCA and elsewhere in the locality and region.

The potential for surface cracking or significant deformation of the ground surface within the LWB4-B7 Modification Area as a result of subsidence is expected to be minimal and therefore very little disturbance of surface and groundwater flow patterns is predicted. The secondary impacts of subsidence (decreased creek bank stability, hydrological changes, tree fall etc.) typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor.

As a consequence of the above there is very low potential for this EEC to be impacted. Based on the subsidence predictions summarised in **Section 4** and in the main EA, it is not likely that the proposed modification will result in the loss or modification of any areas of the Lower Hunter Spotted Gum - Ironbark EEC and therefore the local occurrence of the community will not be placed at risk of extinction.

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

The proposed modification is predicted to have very minor surface impacts and minor impacts on surface and groundwater flows. Based on the subsidence predictions, it is not likely that the proposed modification will adversely modify the composition of the Lower Hunter Spotted Gum – Ironbark Forest EEC such that its local occurrence will be placed at risk of extinction.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of habitat for the Lower Hunter Spotted Gum – Ironbark Forest EEC. It is predicted that the proposed modification will result in negligible changes to the floristic composition or extent of this EEC.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification does not involve any clearing of vegetation that would result in the fragmentation or isolation of any areas of Lower Hunter Spotted Gum – Ironbark Forest EEC, within or adjacent to the LWB4-B7 Modification Area.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises approximately 104.2 hectares of the Lower Hunter Spotted Gum – Ironbark Forest EEC that is in moderate condition. High conservation value examples of this community are protected widely within the Werakata State Conservation Area which occurs in proximity to the LWB4-B7 Modification Area.

Given that the proposed modification will not involve the removal or modification of any areas of the Lower Hunter Spotted Gum – Ironbark Forest EEC, there will be no impact on the long-term viability of this EEC within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the Lower Hunter Spotted Gum – Ironbark Forest EEC or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to the Lower Hunter Spotted Gum – Ironbark Forest EEC or the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this EEC.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant to this community.

Potential Quorrobolong Scribbly Gum EEC

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Approximately 1.6 hectares of potential Quorrobolong Scribbly Gum Woodland EEC occurs in the LWB4-B7 Modification Area, where it occupies lower slopes in the north-west. The known geographic distribution if this community is highly restricted.

The potential for surface cracking or significant deformation of the ground surface within the LWB4-B7 Modification Area as a result of subsidence is expected to be minimal and therefore very little disturbance of surface and groundwater flow patterns is predicted. The secondary impacts of subsidence (decreased creek bank stability, hydrological changes, tree fall etc.) typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. Therefore there is very low potential for this potentially occurring EEC to be impacted.

Based on the subsidence predictions summarised in **Section 4** and in the main EA, it is not likely that the proposed modification will result in the loss or modification of any areas of the potential Quorrobolong Scribbly Gum Woodland EEC and therefore the local occurrence of the community will not be placed at risk of extinction.

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

The proposed modification is predicted to have very minor surface impacts and minor impacts on surface and groundwater flows. Based on the subsidence predictions, it is not likely that the proposed modification will adversely modify the composition of the potential Quorrobolong Scribbly Gum Woodland EEC such that its local occurrence will be placed at risk of extinction.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of habitat for the potential Quorrobolong Scribbly Gum Woodland EEC. It is predicted that the proposed modification will result in negligible changes to the floristic composition or extent of this EEC.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification does not involve any clearing of vegetation that would result in the fragmentation or isolation of any areas of potential Quorrobolong Scribbly Gum Woodland EEC, within or adjacent to the LWB4-B7 Modification Area.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises approximately 1.6 hectares of potential Quorrobolong Scribbly Gum Woodland EEC that is in moderate condition. The other known occurrences of this EEC are more consistent with the determination and contain greater biodiversity value than the extent present in the LWB4-B7 Modification Area.

Given that the proposed modification will not involve the removal or modification of any areas of the potential Quorrobolong Scribbly Gum Woodland EEC, there will be no impact on the long-term viability of this EEC within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the potential Quorrobolong Scribbly Gum Woodland EEC or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to the potential Quorrobolong Scribbly Gum Woodland EEC or the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this EEC.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant to this community.

Netted bottlebrush (*Callistemon linearifolius*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Netted bottlebrush (*Callistemon linearifolius*) was identified within the eastern part of the LWB4-B7 Modification Area. Approximately 30 individuals were recorded. This threatened flora species is also known to occur within the proximate Werakata State Conservation Area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor.

There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats. Therefore there is very low potential for an impact on this species which occurs in dry habitats on slopes and ridges. The proposed modification will not have an adverse effect on the life cycle of any netted bottlebrush (*Callistemon linearifolius*) such that a viable local population of the species is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

Known and potential habitat for the netted bottlebrush (*Callistemon linearifolius*) within the LWB4-B7 Modification Area will not be removed or modified as a result of the proposed modification.

There is no potential for the habitats this species occurs within to be impacted by the proposed modification.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

As there will be no removal or modification of habitat for the netted bottlebrush (*Callistemon linearifolius*) within the LWB4-B7 Modification Area, there is no potential for habitats to be fragmented or isolated.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

Known and potential habitat for the netted bottlebrush (*Callistemon linearifolius*) occurs in the areas of remnant vegetation in the LWB4-B7 Modification Area. Known and potential habitat for netted bottlebrush (*Callistemon linearifolius*) also occurs widely within the locality, including within Werakata State Conservation Area which occurs in proximity to the LWB4-B7 Modification Area. The habitats present in the LWB4-B7 Modification Area are not considered to be important for the long-term survival of the species in the local area.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species or the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being ‘Alterations due to subsidence associated with longwall mining’ and ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant to this species.

Heath wrinklewort (*Rutidosis heterogama*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Approximately 500 heath wrinklewort (*Rutidosis heterogama*) were identified within the middle part of the LWB4-B7 Modification Area in the vicinity of LWB4 and LWB5, and it is considered likely that more than this is present. This threatened flora species is also known to be widespread within the large remnant of the proximate Werakata State Conservation Area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor.

There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats. The proposed modification will not have an adverse effect on the life cycle of any occurring or potentially occurring heath wrinklewort (*Rutidosis heterogama*) such that a viable local population of the species is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

Approximately 500 heath wrinklewort (*Rutidosis heterogama*) were identified within the LWB4-B7 Modification Area, in addition 162.5 ha of potential habitat was identified comprising areas of forest vegetation. Neither known nor potential habitat will be removed or modified as a result of the proposed modification. It is unlikely that the heath wrinklewort will be adversely affected by the proposed modification.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

As there will be no removal or modification of known or potential habitat for the heath wrinklewort (*Rutidosis heterogama*) within the LWB4-B7 Modification Area, there is no potential that any habitats will be fragmented or isolated.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The heath wrinklewort (*Rutidosis heterogama*) occurs in the remnant vegetation in the north-west of the LWB4-B7 Modification Area. Known and potential habitat for heath wrinklewort (*Rutidosis heterogama*) occurs widely within the locality, including within Werakata State Conservation Area which occurs in proximity to the LWB4-B7 Modification Area. The habitats present in the LWB4-B7 Modification Area are not considered to be important for the long-term survival of the species in the local area.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species or the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant to this species.

Small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Small-flower grevillea (*Grevillea parviflora* subsp*. parviflora*) was identified within the middle part of the LWB4-B7 Modification Area in the vicinity of LWB4 and LWB5. Approximately 86 individuals were identified and it is anticipated that more occur in this area. This threatened flora species is also known to be widespread within the large remnant of the proximate Werakata State Conservation Area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor.

There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats. The proposed modification will not have an adverse effect on the life cycle of any potentially occurring small-flower grevillea (*Grevillea parviflora* subsp*. parviflora*) such that a viable local population of the species is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

Approximately 86 individuals of this species were identified in the north-west of the LWB4-B7 Modification Area. Known and potential habitat will not be removed or modified as a result of the proposed modification. It is unlikely that the small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) will be adversely affected by the proposed modification.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

As there will be no removal or modification of known or potential habitat for the small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) within the LWB4-B7 Modification Area, there is no potential that any habitats will be fragmented or isolated.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) occurs in the remnant vegetation in the north-west of the LWB4-B7 Modification Area in moderate numbers. Known and potential habitat for small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) occurs widely within the locality, including within Werakata State Conservation Area which occurs in proximity to the LWB4-B7 Modification Area. The habitats present in the LWB4-B7 Modification Area are not considered to be important for the long-term survival of the species in the local area.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species or the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Green-thighed frog (*Litoria brevipalmata*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Although not identified, there is a low possibility that the riparian habitats of the LWB4-B7 Modification Area provide potential habitat for the green-thighed frog (*Litoria brevipalmata*).

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

Based on the subsidence predictions summarised in **Section 4**, it is not likely that the proposed modification will result in the loss or modification of any areas of potential habitat for the green-thighed frog (*Litoria brevipalmata*) and therefore a viable local population of the species will not be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the green-thighed frog (*Litoria brevipalmata*). It is expected that the proposed modification will result in negligible changes to the habitat characteristics available to this species.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the potential habitat for the green-thighed frog (*Litoria brevipalmata*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The riparian habitats of the LWB4-B7 Modification Area comprise potential habitat for the green-thighed frog (*Litoria brevipalmata*), with most areas of potential habitat being disturbed or modified. The likelihood of this species occurring within these habitats is regarded to be low.

Given that the proposed modification will not involve the removal or modification to any areas of potential habitat for the green-thighed frog (*Litoria brevipalmata*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor and are not predicted to result in changes to surface water flows, the implications of these KTPs are not considered significant.

Green and golden bell frog (*Litoria aurea*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Although not identified, there is a low possibility that the riparian habitats of the LWB4-B7 Modification Area provide potential habitat for the green and golden bell frog (*Litoria aurea*). The last record of this species from the local area was made at Ellalong Lagoon approximately 2.5km west in 1993. Although it is unlikely that an extant population of this species persists, there is potential that this species could occur due to the presence of appropriate habitat.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

Based on the subsidence predictions summarised in **Section 4**, it is not likely that the proposed modification will result in the loss or modification of any areas of potential habitat for the green and golden bell frog (*Litoria aurea*) and therefore a viable local population of the species will not be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the green and golden bell frog (*Litoria aurea*). It is expected that the proposed modification will result in negligible changes to the habitat characteristics available to this species.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the potential habitat for the green and golden bell frog (*Litoria aurea*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The riparian habitats of the LWB4-B7 Modification Area comprise potential habitat for the green and golden bell frog (*Litoria aurea*), with most areas of potential habitat being disturbed or modified. The likelihood of this species occurring within these habitats is regarded to be low.

Given that the proposed modification will not involve the removal or modification to any areas of potential habitat for the green and golden frog (*Litoria aurea*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Draft Recovery Plan for the Green and Golden Bell Frog Litoria aurea (NSW DEC 2015) identifies the following as being the man threatening processes interfering with the recovery of this species:

- Habitat loss, habit modification and disturbance
- Fragmentation and isolation of habitat
- Predation by introduced fish
- Disease
- Water quality and pollution
- Predation of introduced terrestrial fauna.

The project will not result in direct habitat clearing and impacts of subsidence are not predicted to result in the modification of any of the water bodies that would be likely to be utilised by this species if it were present. In addition, the project will not cause any disturbance that would lead to an increase in predation by introduced fish or terrestrial fauna, or disease (particularly chytridomycosis) or that would modify water quality or cause water pollution.

Based on the former, the Project is not in contravention with any of the management objectives for this species.

There is also a draft Management Plan- Green and Golden Bell Frog Population Middle Hunter (DECC 2007) which identifies Ellalong Lagoon as one of its target locations (in spite of the lack of recent records). The identified threats to this species in the Middle Hunter are similar to those of the Draft Recovery Plan:

- The small population sizes
- Loss of habitat
- Disease
- Habitat degradation
- Introduced predators
- Native predators
- Water quality
- Anthropogenic climate change

The Project will not cause any population bottlenecking that would interfere with any potentially present local populations. As above no habitats will be removed and water bodies are not likely to be modified. Water quality will not be altered and the project will not result in substantial local anthropogenic climate change impacts that would be likely to interfere with any potentially present local populations

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor and are not predicted to result in changes to surface water flows, the implications of these KTPs are not considered significant.

Australasian bittern (*Botaurus poiciloptilus*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Although this species was not recorded, the LWB4-B7 Modification Area provides potential habitat for the Australasian bittern (*Botaurus poiciloptilus*) in the aquatic habitats with dense fringing vegetation, particularly in the north of the LWB4B7 Modification Area. There is one record of this species within 10km of the LWB4-B7 Modification Area from 2015 at Pokolbin to the north-west.

Moderate to high conservation value habitat for this species also occurs in the nearby Ellalong Lagoon which is a protected offset area for Port Waratah Coal Services.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas and waterbodies, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of habitats for this species. As such, there is very low potential for an impact on the Australasian bittern (*Botaurus poiciloptilus*).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the Australasian bittern (*Botaurus poiciloptilus*). It is expected that the proposed modification will result in negligible changes to the habitat characteristics available to this species.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the potential habitat for the Australasian bittern (*Botaurus poiciloptilus*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides 6.5 ha of moderate conservation value habitat for the Australasian bittern (*Botaurus poiciloptilus*). Known and potential habitat for the Australasian bittern (*Botaurus poiciloptilus*) is moderately widespread within the locality, including within Ellalong Lagoon which occurs within 2.5 km west of the LWB4-B7 Modification Area.

There are a number of areas of high conservation habitat within the region, only some of which are conserved. The LWB4-B7 Modification Area is not considered to provide important habitat for this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the Australasian bittern (*Botaurus poiciloptilus*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in Section 4.6 of the main report. Given that the predicted surface impacts of the proposed modification will be very minor and are not predicted to result in changes to surface water flows, the implications of these KTPs are not considered significant.

Black bittern (*Ixobrychus flavicollis*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Although this species was not recorded, the LWB4-B7 Modification Area provides potential habitat for the black bittern (*Ixobrychus flavicollis*) in the aquatic habitats with dense fringing vegetation, particularly in the north of the LWB4B7 Modification Area. There is one record of this species within 10km of the LWB4-B7 Modification Area from 2005 within Werakata National Park near Lovedale, NSW.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas and waterbodies, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of habitats for this species. As such, there is very low potential for an impact on the black bittern (*Ixobrychus flavicollis*).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

There will be no vegetation loss as a result of direct clearing, or as a result of subsidence impacts associated with the proposed modification. There will be no removal or modification of potential habitats for the black bittern (*Ixobrychus flavicollis*).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the potential habitat for the black bittern (*Ixobrychus flavicollis*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides 6.5 ha moderate conservation value habitat for the black bittern (*Ixobrychus flavicollis*). Known and potential habitat for the black bittern (*Ixobrychus flavicollis*) is moderately widespread within the locality, including within Ellalong Lagoon which occurs within 2.5 km west of the LWB4-B7 Modification Area.

There are a number of areas of high conservation habitat within the region, only some of which are conserved. The LWB4-B7 Modification Area is not considered to provide important habitat for this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the black bittern (*Ixobrychus flavicollis*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being ‘Alterations due to subsidence associated with longwall mining’ and ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’. Several other KTPs were considered for their relevance to the project: these are discussed in Section 4.6 of the main report. Given that the predicted surface impacts of the proposed modification will be very minor and are not predicted to result in changes to surface water flows, the implications of these KTPs are not considered significant.

Black-necked stork (*Ephippiorhynchus asiaticus*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Although this species was not recorded, the LWB4-B7 Modification Area provides potential habitat for the black-necked stork (*Ephippiorhynchus asiaticus*) in the aquatic habitats with dense fringing vegetation, particularly in the north of the LWB4B7 Modification Area. There is one record of this species within 10km of the LWB4-B7 Modification Area from 1993 from Weston near Kurri Kurri, NSW.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas and waterbodies, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of habitats for this species. As such, there is very low potential for an impact on the black-necked stork (*Ephippiorhynchus asiaticus*).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

There will be no vegetation loss as a result of direct clearing, or as a result of subsidence impacts associated with the proposed modification. There will be no removal or modification of potential habitats for the black-necked stork (*Ephippiorhynchus asiaticus*).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the potential habitat for the black-necked stork (*Ephippiorhynchus asiaticus*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides 6.5 ha moderate conservation value habitat for the black-necked stork (*Ephippiorhynchus asiaticus*). Known and potential habitat for the black-necked stork (*Ephippiorhynchus asiaticus*) is moderately widespread within the locality, including within Ellalong Lagoon which occurs within 2.5 km west of the LWB4-B7 Modification Area.

There are a number of areas of high conservation habitat within the region, only some of which are conserved. The LWB4-B7 Modification Area is not considered to provide important habitat for this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the black-necked stork (*Ephippiorhynchus asiaticus*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in Section 4.6 of the main report. Given that the predicted surface impacts of the proposed modification will be very minor and are not predicted to result in changes to surface water flows, the implications of these KTPs are not considered significant.

Australian painted snipe (*Rostratula australis*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Although this species was not recorded, the LWB4-B7 Modification Area provides potential habitat for the Australian painted snipe (*Rostratula australis*) in the aquatic habitats with dense fringing vegetation, particularly in the north of the LWB4B7 Modification Area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas and waterbodies, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of habitats for this species. As such, there is very low potential for an impact on the Australian painted snipe (*Rostratula australis*).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

There will be no vegetation loss as a result of direct clearing, or as a result of subsidence impacts associated with the proposed modification. There will be no removal or modification of potential habitats for the Australian painted snipe (*Rostratula australis*).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the potential habitat for the Australian painted snipe (*Rostratula australis*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides 6.5 ha moderate conservation value habitat for the Australian painted snipe (*Rostratula australis*). Other potential habitat for the Australian painted snipe (*Rostratula australis*) is moderately widespread within the locality, including within Ellalong Lagoon which occurs within 2.5 km west of the LWB4-B7 Modification Area.

There are a number of areas of high conservation habitat within the region, only some of which are conserved. The LWB4-B7 Modification Area is not considered to provide important habitat for this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the Australian painted snipe (*Rostratula australis*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in Section 4.6 of the main report. Given that the predicted surface impacts of the proposed modification will be very minor and are not predicted to result in changes to surface water flows, the implications of these KTPs are not considered significant.

Freckled duck (*Stictonetta naevosa*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Although this species was not recorded, the LWB4-B7 Modification Area provides potential habitat for the freckled duck (*Stictonetta naevosa*) in the aquatic in the north of the LWB4-B7 Modification Area. There is one record of this species within 10km of the LWB4-B7 Modification Area from 1983 from Ellalong Lagoon, approximately 2.5km west.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas and waterbodies, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of habitats for this species. As such, there is very low potential for an impact on the freckled duck (*Stictonetta naevosa*).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

There will be no vegetation loss as a result of direct clearing, or as a result of subsidence impacts associated with the proposed modification. There will be no removal or modification of potential habitats for the freckled duck (*Stictonetta naevosa*).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the potential habitat for the freckled duck (*Stictonetta naevosa*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides 6.5 ha moderate conservation value habitat for the freckled duck (*Stictonetta naevosa*). Other potential habitat for the freckled duck (*Stictonetta naevosa*) is moderately widespread within the locality, including within Ellalong Lagoon which occurs within 2.5 km west of the LWB4-B7 Modification Area.

There are a number of areas of high conservation habitat within the region, only some of which are conserved. The LWB4-B7 Modification Area is not considered to provide important habitat for this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the freckled duck (*Stictonetta naevosa*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in Section 4.6 of the main report. Given that the predicted surface impacts of the proposed modification will be very minor and are not predicted to result in changes to surface water flows, the implications of these KTPs are not considered significant.

Swift parrot (*Lathamus discolor*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The LWB4-B7 Modification Area provides potential habitat for the swift parrot (*Lathamus discolor*), in particular within the Lower Hunter Spotted Gum – Ironbark Forest and the Riparian Cabbage Gum Open Forest which both support winter flowering tree species that are known to be used by this species in the local area. Moderate to high conservation value habitat for this species also occurs in the nearby Werakata State Conservation Area. This highly mobile species is known to forage at a number of suitable locations within the local area in the cooler months; however it has not been recorded in the LWB4-B7 Modification Area. There are over 40 records of this species within 10km of the LWB4-B7 Modification Area, including within the township of Ellalong less than 1.5km away.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats. As such, there is very low potential for an impact on the swift parrot (*Lathamus discolor*).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

There will be no vegetation loss as a result of direct clearing, or as a result of subsidence impacts associated with the proposed modification. There will be no removal or modification of potential habitats for the swift parrot (*Lathamus discolor*).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the potential habitat for the swift parrot (*Lathamus discolor*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides moderate conservation value habitat for the swift parrot (*Lathamus discolor*). Known and potential habitat for the swift parrot (*Lathamus discolor*) is moderately widespread within the locality, including within Werakata State Conservation Area which occurs within 2 km of the LWB4-B7 Modification Area. There are a number of areas of high conservation habitat within the region, only some of which are conserved. The LWB4-B7 Modification Area is not considered to provide important habitat for this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the swift parrot (*Lathamus discolor*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The key actions from the swift parrot recovery plan (Swift Parrot Recovery Team 2001) are summarised below:

- Identify and map priority foraging habitats and to identify important breeding sites.
- Implement a strategy to protect priority sites and habitats.
- Identify degraded habitats that have potential to benefit the recovery of the swift parrot.
- Monitor collisions and collision hazards, particularly during the breeding season.
- Monitor the density of the breeding population and the extent and quality of habitat.
- Increase public awareness about the recovery program.
- Involve the community in the recovery.

None of the above recovery actions would be compromised as a result of the proposed modification.

The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant.

White-bellied sea eagle (Haliaeetus leucogaster)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The LWB4-B7 Modification Area provides known habitat for the white-bellied sea-eagle (*Haliaeetus leucogaster*), including breeding habitats as nesting was identified in tall canopy vegetation adjacent to the large water body in the north. Moderate to high conservation value habitat for this species also occurs in the nearby Werakata State Conservation Area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats. As such, there is very low potential for an impact on the white-bellied sea eagle (*Haliaeetus leucogaster*).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

There will be no vegetation loss as a result of direct clearing, or as a result of subsidence impacts associated with the proposed modification. There will be no removal or modification of known or potential habitats for the white-bellied sea eagle (*Haliaeetus leucogaster*).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the habitats for the white-bellied sea eagle (*Haliaeetus leucogaster*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides moderate conservation value habitat for the white-bellied sea eagle (*Haliaeetus leucogaster*). Known and potential habitat for the white-bellied sea eagle (*Haliaeetus leucogaster*) is moderately widespread within the locality, including within Werakata National Park and Ellalong Lagoon which occurs within 2.5 km of the LWB4-B7 Modification Area. There are a number of areas of high conservation habitat within the region, only some of which are conserved. The LWB4-B7 Modification Area is not considered to provide important habitat for this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the white-bellied sea eagle (*Haliaeetus leucogaster*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant.

Regent honeyeater (*Anthochaera phrygia*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The LWB4-B7 Modification Area provides suitable habitat for the regent honeyeater (*Anthochaera phrygia*), in particular within the Lower Hunter Spotted Gum – Ironbark Forest and the Riparian Cabbage Gum Open Forest which both support winter flowering tree species that are known to be used by this species. Moderate to high conservation value habitat for this species also occurs in the large remnant of the nearby Werakata State Conservation Area. This highly mobile species is known to forage at a number of suitable locations within the local area in the cooler months.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats. As such, there is very low potential for an impact on the regent honeyeater (*Anthochaera phrygia*).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

There will be no vegetation loss as a result of direct clearing, or as a result of subsidence impacts associated with the proposed modification. There will be no removal or modification of potential habitats for the regent honeyeater (*Anthochaera phrygia*).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the potential habitat for the regent honeyeater (*Anthochaera phrygia*). Areas of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides moderate conservation value habitat for the regent honeyeater (*Anthochaera phrygia*). Known and potential habitat for the regent honeyeater (*Anthochaera phrygia*) is moderately widespread within the locality, including within Werakata State Conservation Area which occurs within 3 kilometres of the LWB4-B7 Modification Area. There are a number of areas of high conservation habitat within the region, only some of which are conserved. It is not considered that the habitats provided by the LWB4-B7 Modification Area are of particular importance to this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the regent honeyeater (*Anthochaera phrygia*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The specific recovery actions from the Regent Honeyeater Recovery Plan (Department of Natural Resources and Environment 1999) are:

- effectively organise and administer the recovery effort
- maintain and enhance habitat
- monitor trends in population size and range
- facilitate strategic research
- maintain and increase community awareness, understanding and involvement and
- maintain the captive population.

None of the above recovery actions would be compromised as a result of the proposed modification.

The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant.

Grey-crowned babbler (*Pomatostomus temporalis temporalis*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The LWB4-B7 Modification Area provides known habitat and a likely resident population of the grey-crowned babbler (*Pomatostomus temporalis temporalis*) within remnant vegetation areas. Moderate to high conservation value habitat for this species also occurs in the large remnant of the nearby Werakata State Conservation Area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance to surface and groundwater flow. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is not likely that subsidence will lead to loss of vegetation or modification of habitats. As such, there is very low potential for an adverse impact on grey-crowned babbler (*Pomatostomus temporalis temporalis*) such that a viable local population of the species is placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

There will be no vegetation loss as a result of direct clearing, or as a result of subsidence impacts associated with the proposed modification. There will be no removal or modification of habitats for the grey-crowned babbler (*Pomatostomus temporalis temporalis*).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the habitat required for the grey-crowned babbler (*Pomatostomus temporalis temporalis*). Areas of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides moderate conservation value habitat for the grey-crowned babbler (*Pomatostomus temporalis temporalis*). Known and potential habitat for the grey-crowned babbler (*Pomatostomus temporalis temporalis*) is widespread within the locality, including within Werakata State Conservation Area which occurs within 3km of the LWB4-B7 Modification Area. As such the LWB4-B7 Modification Area is not considered of particular importance to this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for the grey-crowned babbler (*Pomatostomus temporalis temporalis*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being ‘Alterations due to subsidence associated with longwall mining’ and ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant.

Varied sittella (*Daphoenositta chrysoptera*)

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The LWB4-B7 Modification Area provides known habitat for the varied sittella (*Daphoenositta chrysoptera*), in particular within the areas of remnant vegetation. The LWB4-B7 Modification Area is likely to provide habitat for a resident population of the varied sittella (*Daphoenositta chrysoptera*) given the relatively sedentary nature of this species compared to other birds. Moderate to high conservation value habitat for this species also occurs in the large remnant of the Werakata State Conservation Area which is within 3 km of the LWB4-B7 Modification Area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance to surface and groundwater flow. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats. As such, there is very low potential for an impact on varied sittella (*Daphoenositta chrysoptera*).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

There will be no vegetation loss as a result of direct clearing, or as a result of subsidence impacts associated with the proposed modification. There will be no removal or modification of habitat available to this species in the LWB4-B7 Modification Area as a result of the proposed modification.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to have only very minor surface impacts, and will not result in the disturbance to any characteristics of the required habitat for the varied sittella (*Daphoenositta chrysoptera*). Areas of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area provides moderate conservation value habitat for the varied sittella (*Daphoenositta chrysoptera*). Known and potential habitat for the varied sittella (*Daphoenositta chrysoptera*) is widespread within the locality, including within Werakata State Conservation Area which occurs within 3 km of the LWB4-B7 Modification Area. As such the LWB4-B7 Modification Area is not considered of particular importance to this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for varied sittella (*Daphoenositta chrysoptera*) or any other threatened species or populations.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Grey-headed flying-fox (*Pteropus poliocephalus*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The grey-headed flying-fox (*Pteropus poliocephalus*) was recorded in the LWB4-B7 Modification Area and potentially forages within the riparian habitats during periods of eucalypt flowering. No camps that provide breeding habitat for the species were identified during surveys and record comprised lone individuals.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance to surface and groundwater flow. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats. The proposed modification will therefore not affect the life-cycle of the grey-headed flying-fox (*Pteropus poliocephalus*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the grey-headed flying-fox (*Pteropus poliocephalus*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area as a result of the proposed modification.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance to potential habitat for the grey-headed flying-fox (*Pteropus poliocephalus*). As such, an area of potential habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises suitable foraging habitat for the grey-headed flying-fox (*Pteropus poliocephalus*). This species could utilise this site for foraging, however suitable breeding and roosting habitat was not identified. It is not considered that the habitats provided are important for this species.

Given that the proposed modification will not involve the removal or modification to any areas of potential habitat for the grey-headed flying-fox (*Pteropus poliocephalus*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The Draft National Recovery Plan for the Grey-Headed Flying-Fox (Department of Environment, Climate Change and Water 2009) lists the following priority actions:

- identify and protect foraging habitat critical to the survival of grey-headed flying-foxes
- enhance winter and spring foraging habitat for grey-headed flying-foxes
- identify, protect and enhance roosting habitat critical to the survival of grey-headed flying-foxes
- significantly reduce levels of deliberate grey-headed flying-fox destruction associated with commercial horticulture
- provide information and advice to managers, community groups and members of the public that are involved with controversial flying-fox camps
- produce and circulate educational resources to improve public attitudes toward grey-headed flying-foxes, promote the recovery program to the wider community and encourage participation in recovery actions
- monitor population trends for the grey-headed flying-fox
- assess the impacts on grey-headed flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts

- oversee a program of research to improve knowledge of the demographics and population structure of the grey-headed flying-fox and
- maintain a National Recovery Team to oversee the implementation of the grey-headed flying-fox National Recovery Plan.

None of the above recovery actions would be compromised as a result of the proposed modification.

The proposed modification is additionally not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Squirrel glider (*Petaurus norfolcensis*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The squirrel glider (*Petaurus norfolcensis*) was recorded in the LWB4-B7 Modification Area, and it is considered that a resident population is likely present, utilising the habitats of the LWB4-B7 Modification Area as part of a wider habitat range in surrounding areas of vegetation. This species could be denning in hollow-bearing tree present.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of the squirrel glider (*Petaurus norfolcensis*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of habitat for the squirrel glider (*Petaurus norfolcensis*). There will be no removal or modification of habitat for this species in the LWB4-B7 Modification Area a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance to any characteristics of habitats available for the squirrel glider (*Petaurus norfolcensis*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises known foraging habitat and potential denning habitat for the squirrel glider (*Petaurus norfolcensis*).

Given that the proposed modification will not involve the removal or modification to any areas of habitat for the squirrel glider (*Petaurus norfolcensis*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

As part of the Saving Our Species program for this species currently listed on the OEH website (OEH 2016), protection of known occurrences and habitat are recommended management actions. However as no habitats for this species will be removed, the proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Koala (*Phascolarctos cinereus*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

There is an existing Atlas record of the koala (*Phascolarctos cinereus*) from the LWB4-B7 Modification Area as well as over 50 records of this species within 10km. The record occurring within the LWB4-B7 Modification Area (if accurate as the Atlas data indicates that the accuracy was within 1000 metres off the coordinates provided (BioNet 2016)) likely represents a dispersing individual, as a resident population of the species (or signs of presence) was not recorded during surveys and potential foraging resources for the species were low.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of the koala (*Phascolarctos cinereus*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of habitat for the koala (*Phascolarctos cinereus*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance of habitat for the koala (*Phascolarctos cinereus*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises a small amount of low to moderate quality foraging habitat for the koala (*Phascolarctos cinereus*) and a resident population was not identified. Given that the proposed modification will not involve the removal or modification to any areas of habitat for the koala (*Phascolarctos cinereus*) there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The 'Recovery plan for the koala (*Phascolarctos cinereus*)' (DECC 2008) is relevant to this species. The proposed action does not contravene with any of the objective or actions listed within this recovery plan. No threat abatement plans are pertinent to this threatened species. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Large-eared pied bat (*Chalinolobus dwyeri*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The large-eared pied bat (*Chalinolobus dwyeri*) was recorded in the LWB4-B7 Modification Area. Due to an absence of appropriate roosting habitat (as a cave-roosting species), it is considered that this species would only be utilising the habitats available as part of a larger foraging range.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of large-eared pied bat (*Chalinolobus dwyeri*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of foraging or roosting habitat for the large-eared pied bat (*Chalinolobus dwyeri*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance of foraging or roosting habitat for the large-eared pied bat (*Chalinolobus dwyeri*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises foraging habitat for the large-eared pied bat (*Chalinolobus dwyeri*). Given that the proposed modification will not involve the removal or modification to any areas of habitat for the large-eared pied bat (*Chalinolobus dwyeri*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The only current relevant recovery plan for this species is the National Recovery plan for the Large-eared Pied Bat Chalinolobus dwyeri (Department of Environment and Resource Management 2011). Specific objectives of this plan are:

- Identify priority roost and maternity sites for protection
- Implement conservation and management strategies for priority sites
- Educate the community and industry to understand and participate in the conservation of the large-eared pied bat
- Research the large-eared pied bat to augment biological and ecological data to enable conservation management
- Determine the meta-population dynamics throughout the distribution of the large-eared pied bat

As this species would not be roosting in the LWB4-B7 Modification Area, this site would not be considered as a priority roost and maternity site for protection. All the subsequent actions are flow on points from this. The project des not contravene any of these objectives.

The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Southern myotis (*Myotis macropus*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The southern myotis (*Myotis macropus*) was identified as potentially present as it was recorded as part of a species group during Anabat echolocation surveys. This species potentially forages and roosts within the riparian habitats present. There is potential that a local population is present that utilises the habitats present as part of a wider area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of southern myotis (*Myotis macropus*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the southern myotis (*Myotis macropus*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance of potential habitat for the southern myotis (*Myotis macropus*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises potential foraging and roosting habitat for the southern myotis (*Myotis macropus*).

Given that the proposed modification will not involve the removal or modification to any areas of habitat for the southern myotis (*Myotis macropus*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

East-coast freetail-bat (*Mormopterus norfolkensis*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The east-coast freetail-bat (*Mormopterus norfolkensis*) was recorded in the LWB4-B7 Modification Area, and potentially forages and roosts (tree-hollow roosting species) within the woodland habitats present.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of east-coast freetail bat (*Mormopterus norfolkensis*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of habitat for the east-coast freetail bat (*Mormopterus norfolkensis*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area as a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance to potential habitat for the east-coast freetail bat (*Mormopterus norfolkensis*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises potential foraging and roosting habitat for east-coast freetail bat (*Mormopterus norfolkensis*). Given that the proposed modification will not involve the removal or modification to any areas of habitat for the east-coast freetail bat (*Mormopterus norfolkensis*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being ‘Alterations due to subsidence associated with longwall mining’ and ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Little bentwing-bat (*Miniopterus australis*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The little bentwing-bat (*Miniopterus australis*) was identified in the LWB4-B7 Modification Area, and potentially forages and roosts within the habitats present. This species roosts in tree-hollows and caves however no cave habitats were present in the LWB4-B7 Modification Area. There is potential that a local population is present however it is most likely that this species would utilise the habitats present as part of a wider area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance to surface and groundwater flow. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of the little bentwing-bat (*Miniopterus australis*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the little bentwing-bat (*Miniopterus australis*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area as a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance to potential habitat for the little bentwing-bat (*Miniopterus australis*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises potential foraging and roosting habitat for the little bentwing-bat (*Miniopterus australis*).

Given that the proposed modification will not involve the removal or modification to any areas of habitat for the little bentwing-bat (*Miniopterus australis*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Eastern bentwing-bat (*Miniopterus schreibersii oceanensis*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The eastern bentwing-bat (*Miniopterus schreibersii oceanensis*) was possibly recorded within the LWB4-B7 Modification Area as part of a species group. However for the purposes of this impact assessment this species has been assumed to occur. Although this species could be foraging in the LWB4-B7 Modification Area, there are no cave habitats present that could be utilised by this species for roosting. There is potential that a local population is present that utilises the habitats present as part of a wider area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance to surface and groundwater flow. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of the eastern bentwing-bat (*Miniopterus australis*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the eastern bentwing-bat (*Miniopterus schreibersii oceanensis*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area as a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance to potential habitat for the eastern bentwing-bat (*Miniopterus schreibersii oceanensis*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises potential foraging and roosting habitat for the eastern bentwing-bat (*Miniopterus schreibersii oceanensis*).

Given that the proposed modification will not involve the removal or modification to any areas of habitat for the eastern bentwing-bat (*Miniopterus schreibersii oceanensis*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Greater broad-nosed bat (*Scoteanax rueppellii*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The greater broad-nosed bat (*Scoteanax rueppellii*) was recorded in the LWB4-B7 Modification Area, and potentially forages and roosts (tree-hollow roosting species) within the woodland habitats present.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance to surface and groundwater flow. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of the greater broad-nosed bat (*Scoteanax rueppellii*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of habitat for the greater broad-nosed bat (*Scoteanax rueppellii*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area as a result of the proposed modification.

ii) **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and**

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance to foraging or roosting habitat for the greater broad-nosed bat (*Scoteanax rueppellii*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii) **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality**

The LWB4-B7 Modification Area comprises foraging and potential roosting habitat for the greater broad-nosed bat (*Scoteanax rueppellii*). Given that the proposed modification will not involve the removal or modification to any areas of habitat for the greater broad-nosed bat (*Scoteanax rueppellii*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Yellow bellied sheathtail-bat (*Saccolaimus flaviventris*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The yellow bellied sheathtail-bat (*Saccolaimus flaviventris*) was identified in the LWB4-B7 Modification Area, and potentially forages and roosts within the habitats present. There is potential that a viable population exists, but it is unlikely that it would be exclusively dependent on the habitats provided by the LWB4-B7 Modification Area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of yellow bellied sheathtail-bat (*Saccolaimus flaviventris*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the yellow bellied sheathtail-bat (*Saccolaimus flaviventris*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance of potential habitat for the yellow bellied sheathtail-bat (*Saccolaimus flaviventris*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises potential foraging and roosting habitat for the yellow bellied sheathtail-bat (*Saccolaimus flaviventris*). Given that the proposed modification will not involve the removal or modification to any areas of habitat for the yellow bellied sheathtail-bat (*Saccolaimus flaviventris*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant to this species.

Eastern falsistrelle (*Falsistrellus tasmaniensis*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The eastern falsistrelle (*Falsistrellus tasmaniensis*) was possibly recorded within the LWB4-B7 Modification Area as part of a species group. However for the purposes of this impact assessment this species has been assumed to occur. Although this species could be foraging in the LWB4-B7 Modification Area, there are no cave habitats present that could be utilised by this species for roosting. The eastern falsistrelle (*Falsistrellus tasmaniensis*) potentially occurs in the LWB4-B7 Modification Area, and potentially forages and roosts (tree-hollow roosting species) within the habitats present. There is potential that a local population is present that utilises the habitats present as part of a wider area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of the eastern falsistrelle (*Falsistrellus tasmaniensis*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the eastern falsistrelle (*Falsistrellus tasmaniensis*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance of potential habitat for the eastern falsistrelle (*Falsistrellus tasmaniensis*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises potential foraging and roosting habitat for the eastern falsistrelle (*Falsistrellus tasmaniensis*).

Given that the proposed modification will not involve the removal or modification to any areas of habitat for the eastern falsistrelle (*Falsistrellus tasmaniensis*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being ‘Alterations due to subsidence associated with longwall mining’ and ‘Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant.

Eastern cave bat (*Vespadelus troughtoni*)

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The eastern cave bat (*Vespadelus troughtoni*) was possibly recorded within the LWB4-B7 Modification Area as part of a species group. However for the purposes of this impact assessment this species has been assumed to occur. Although this species could be foraging in the LWB4-B7 Modification Area, there are no cave habitats present that could be utilised by this species for roosting. There is potential that a local population is present that utilises the habitats present as part of a wider area.

Subsidence modelling and predictions indicate that the potential for surface cracking and significant deformation of the ground surface is minimal, and therefore the proposed modification will cause very little disturbance of surface and groundwater flow patterns. The secondary impacts (decreased creek bank stability, hydrological changes, tree fall etc.) of subsidence typically have greatest impact on riparian areas, and these secondary impacts are also predicted to be minor. There will be no loss of vegetation as a result of direct clearing, and it is very unlikely that subsidence will lead to loss of vegetation or modification of habitats.

It is not likely that proposed modification will result in the loss or modification of any areas of habitat for this species. The proposed modification will not affect the lifecycle of the eastern cave bat (*Vespadelus troughtoni*) such that a viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

Not applicable.

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed

The proposed modification will not lead to the removal or modification of any areas of potential habitat for the eastern cave bat (*Vespadelus troughtoni*). There will be no removal or modification of habitat characteristics available to this species in the LWB4-B7 Modification Area a result of the proposed modification.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

The proposed modification is expected to result in negligible surface impacts, and will not result in the disturbance of potential habitat for the eastern cave bat (*Vespadelus troughtoni*). As such, an area of habitat for this species will not become fragmented or isolated from other areas of habitat (known or potential) as a result of the proposed modification.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The LWB4-B7 Modification Area comprises potential foraging habitat for the eastern cave bat (*Vespadelus troughtoni*).

Given that the proposed modification will not involve the removal or modification to any areas of habitat for the eastern cave bat (*Vespadelus troughtoni*); there will not be an impact on the long-term viability of this species within the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The LWB4-B7 Modification Area does not support any critical habitat for this species or any other threatened species, populations or EECs.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There is not currently a recovery plan or threat abatement plan which relates to this species and the proposed modification. The proposed modification is not in contravention of the Saving Our Species program for this threatened species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

There are two KTPs most relevant to the proposed modification, being 'Alterations due to subsidence associated with longwall mining' and 'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. Several other KTPs were considered for their relevance to the project: these are discussed in **Section 4.6** of the main report. Given that the predicted surface impacts of the proposed modification will be very minor, the implications of these KTPs are not considered significant for this species.

Conclusion

The proposed modification will not result in a significant impact on any threatened species, populations or EECs recorded or potentially occurring within the LWB4-B7 Modification Area.

APPENDIX F

Assessments of Significance under the Environment Protection Biodiversity Conservation Act 1999

A search of the Department of the Environment (DotE) Protected Matters Database identified threatened and migratory species (EPBC Act listed) known to occur or considered likely to occur, on the basis of habitat modelling, within a 10 kilometre radius of the LWB4-B7 Modification Area. No EPBC Act listed endangered populations or threatened ecological communities (TECs) are known or have potential to occur within the LWB4-B7 Modification Area.

Given that the proposed modification comprises underground mining that is predicted to have very minor impacts on surface habitats, an assessment was only undertaken for those species regarded to have reasonable potential to occur and reasonable potential to be impacted by the proposed modification. Consequently, six threatened species and one migratory species require assessment. An assessment of the potential impacts of the proposed modification on these species is provided below.

The aim of this assessment is to determine whether the proposed modification is likely to have a significant impact on any EPBC Act matters of national environmental significance (MNES). In this instance, MNES with potential to occur within the LWB4-B7 Modification Area include:

- listed threatened species (including critically endangered, endangered and vulnerable species)
- listed migratory species.

Each category is addressed separately below.

Endangered and Critically Endangered Species

The following EPBC Act listed endangered and critically endangered species respectively are considered in this assessment:

- swift parrot (*Lathamus discolor*)
- regent honeyeater (*Anthochaera phrygia*)
- Australian painted snipe (*Rostratula australis*)
- Australasian bittern (*Botaurus poiciloptilus*)

An assessment in accordance with the DotE principal significant impact guidelines (DotE 2013) is provided below for these species.

In this case, a *population* means:

- a geographically distinct regional population, or collection of local populations
- a regional population, or collection of local populations, that occurs within a particular bioregion.

The swift parrot (*Lathamus discolor*) and regent honeyeater (*Anthochaera phrygia*) are not known to occur in the LWB4-B7 Modification Area, however have potential to occur due to the presence of winter flowering eucalypt species and the presence of local records. Both are migratory species, and are known to occur in the locality in the cooler months where they forage on winter-flowering resources such as spotted gum (*Corymbia maculata*) and ironbarks (primarily broad-leaved ironbark (*Eucalyptus fibrosa*)). It is considered that the habitats provided by the LWB4-B7 Modification Area provide only moderate quality habitat for these species due to the fragmented and modified nature of the woodland habitat available as a result of historic clearing and ongoing grazing practices.

The swift parrot occurs as a single population, although it migrates annually from breeding grounds in Tasmania to the winter foraging grounds on the coastal plains and slope woodlands of mainland eastern Australia (Saunders 2002). Approximately 200 mature birds (10 per cent of the total estimated population) are known to over-winter in the Lower Hunter Region of New South Wales (Saunders 2002). The Modification Area is considered to form part of a regional dispersal route close to important winter foraging areas in the lower Hunter Valley.

Although there appears to be minor behavioural differences between regent honeyeaters in the three main areas inhabited by the species (the Bundarra-Barraba area in NSW, the Capertee Valley in NSW, and north-eastern Victoria), the direction and extent of movements, including evidence of movement between breeding sites, and a lack of discernible genetic differences between the sites suggest that the regent honeyeater occurs as a single, contiguous population (Garnett and Crowley 2000).

The Australian painted snipe and Australasian bittern were not identified in the LWB4-B7 Modification Area however have potential (albeit low) to occur in the large waterbody in the north. If these species were to occur, it would be unlikely that it would be exclusively reliant on the habitats present, particularly given the proximity to known area of higher quality and more appropriate habitat provided by Ellalong Lagoon. Based on the former definition, it is unlikely that the LWB4-B7 Modification Area supports a population of these species.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- **lead to a long-term decrease in the size of a *population*; or**

Neither the swift parrot or regent honeyeater were recorded within the LWB4-B7 Modification Area, however there is potential for these species to occur, in particular in the Lower Hunter Spotted Gum – Ironbark Forest community and to a lesser extent the Riparian Cabbage Gum Forests, Coastal Foothills Transition Forest and Melaleuca Shrubland with Emergent Eucalypts. As these species are winter migrants, they would utilise the resources of the LWB4-B7 Modification Area as part of a wider foraging range at appropriate times of the year. The proposed modification will not result in the loss of vegetation as a result of direct clearing or in relation to secondary impacts related to subsidence. The subsidence predictions indicate that any modifications to surface habitats resulting would be minor. As such, there is no potential for the proposed modification to lead to a long-term decrease in the size of a population of swift parrot or regent honeyeater.

Neither the Australian painted snipe nor Australasian bittern were recorded within the LWB4-B7 Modification Area, however there is potential for these species to occur, in the large water body in the north of the LWB4-B7 Modification Area. It is likely that they would utilise the habitats present as part of a wider range. The proposed modification will not result in the loss of vegetation as a result of direct clearing or in relation to secondary impacts related to subsidence. The subsidence predictions indicate that any modifications to surface habitats resulting would be minor. As such, there is no potential for the proposed modification to lead to a long-term decrease in the size of a population of Australian painted snipe or Australasian bittern.

- **reduce the area of occupancy of the species; or**

Neither the swift parrot, regent honeyeater, Australian painted snipe or Australasian bittern were recorded within the LWB4-B7 Modification Area, however it does support potential habitat for them to occur. Given that surface impacts will be minor, the proposed modification will not reduce the area of potential habitat for these species, and sizeable areas of similar potential habitats for these species are protected within the nearby (within 3 km) Werakata State Conservation Area and Ellalong Lagoon.

- **fragment an existing *population* into two or more populations; or**

Neither the swift parrot, regent honeyeater, Australian painted snipe or Australasian bittern were recorded within the LWB4-B7 Modification Area, however potential habitat for these species is present. The proposed modification will not result in the loss of vegetation as a result of direct clearing or in relation to secondary impacts related to subsidence. The subsidence predictions indicate that any modifications to surface habitats resulting would be minor. As such, there is no potential for the proposed modification to lead to the fragmentation of an existing population of the swift parrot, regent honeyeater, Australian painted snipe or Australasian bittern into two or more populations.

- **adversely affect habitat critical to the survival of a species; or**

Neither the swift parrot, regent honeyeater, Australian painted snipe or Australasian bittern were recorded within LWB4-B7 Modification Area. The LWB4-B7 Modification Area is not known to support any areas of critical habitat for either species. The proposed modification will not adversely affect habitat critical to the survival of these species.

- **disrupt the breeding cycle of a population; or**

Potential habitat for the swift parrot, regent honeyeater, Australian painted snipe or Australasian bittern occurs within the LWB4-B7 Modification Area; however there is no known breeding habitat. The proposed modification does not involve any clearing or fragmentation of habitats. As such, the proposed modification will not disrupt the breeding cycle of any population of any endangered species.

- **modify, destroy, remove isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline; or**

Potential foraging habitat for the swift parrot and regent honeyeater occurs within the LWB4-B7 Modification Area, in particular within the Lower Hunter Spotted Gum – Ironbark Forest community. The proposed modification is underground and will result in minor surface disturbances that are not expected to alter the habitats of these two critically endangered species.

Potential habitat for the Australian painted snipe and Australasian bittern occurs within the LWB4-B7 Modification Area, in the large water body in the north. The proposed modification is underground and will result in minor surface disturbances (including water bodies) that are not expected to alter the habitats of the two endangered species.

Consequently, the proposed modification will not modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that these critically endangered and endangered species are likely to decline.

- **result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat; or**

Given that the proposed modification comprises underground mining and will have minimal surface impacts, it is not expected to result in the establishment of invasive species that are harmful to these critically endangered and endangered species.

- **Interfere with the recovery of the species.**

The proposed modification will not lead to the loss, alteration or fragmentation of known or potential habitats for the swift parrot, regent honeyeater, Australian painted snipe or Australasian bittern. As such, the proposed modification will not interfere with the recovery of these species.

Vulnerable Flora Species

The following EPBC Act listed vulnerable flora species are considered in this assessment:

- heath wrinklewort (*Rutidosis heterogama*)
- small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*)

An assessment in accordance with the DotE principal significant impact guidelines (DotE (2013) is provided below for these species.

In this case, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity
- populations that are near the limit of the species range.

Approximately 500 heath wrinklewort (*Rutidosis heterogama*) and 86 small-flower grevillea (*Grevillea parviflora* subsp. *parviflora*) were recorded in the LWB4-B7 Modification Area. Although these are likely to comprise viable local populations, based upon the above definitions, these would not comprise *important populations*. These species are known to occur in substantial numbers throughout the Quorrobolong area, particularly within the nearby Werakata SCA. Based on the above definition, it is not considered that the LWB4-B7 Modification Area supports an important population of heath wrinklewort (*Rutidosis heterogama*) or small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- **lead to a long-term decrease in the size of an *important population* of a species; or**

The LWB4-B7 Modification Area supports known habitat for heath wrinklewort (*Rutidosis heterogama*) and small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*), however it does not support an important population of either of these species. The proposed modification involves underground mining and as such there will be only minor surface impacts. Based on subsidence modelling and predictions, there will be no alteration to potential habitats of the heath wrinklewort (*Rutidosis heterogama*) or small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*). As such, there is no potential for the proposed modification to lead to a long-term decrease in the size of an important population of these species.

- **reduce the area of occupancy of an *important population*; or**

As described above, the proposed modification will not involve any activities that would alter the known or potential habitats of the heath wrinklewort (*Rutidosis heterogama*) or small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*). As such, there is no potential for the proposed modification to lead to a reduction in the area of occupancy of a population of these species.

- **fragment an existing important population into two or more populations; or**

Given that any surface disturbances associated with the proposed modification would only be minor; there is no potential for known or potential populations of heath wrinklewort (*Rutidosis heterogama*) or small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*) within the LWB4-B7 Modification Area to become fragmented or isolated.

- **adversely affect habitat critical to the survival of a species; or**

The LWB4-B7 Modification Area does not contain any habitats that are critical to the survival of heath wrinklewort (*Rutidosis heterogama*) or small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*). Regardless, there will not be any modifications to the habitats of these species as a result of the proposed modification.

- **disrupt the breeding cycle of an important population; or**

The proposed modification does not comprise any actions that would disrupt the breeding cycle of heath wrinklewort (*Rutidosis heterogama*) or small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*).

- **modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline; or**

The LWB4-B7 Modification Area supports known habitat for heath wrinklewort (*Rutidosis heterogama*) and small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*), however it does not support an important population of either of these species. The proposed modification involves underground mining and as such there will be only minor surface impacts. Based on subsidence modelling and predictions, there will be no alteration to known or potential habitats of the heath wrinklewort (*Rutidosis heterogama*) or small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*). As such, there is no potential for the proposed modification to modify, destroy, remove, isolate or decrease the availability or quality of habitat for these species to the extent that they would be likely to decline.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or**

Given that the proposed modification is underground and will have minimal surface impacts, it is not expected to result in the establishment of invasive species that are harmful to these species.

- **interfere substantially with the recovery of the species.**

The proposed modification will not lead to the loss, alteration or fragmentation of potential habitats for heath wrinklewort (*Rutidosis heterogama*) or small-flower grevillea (*Grevillea parviflora* susbp. *parviflora*). As such, the proposed modification will not interfere with the recovery of these species.

Vulnerable Fauna Species

An assessment in accordance with the DotE principal significant impact guidelines (DotE 2013) is provided below for the green and golden bell frog (*Litoria aurea*), koala (*Phascolarctos cinereus*), large-eared pied bat (*Chalinolobus dwyeri*) and grey-headed flying-fox (*Pteropus poliocephalus*).

In this case, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity
- populations that are near the limit of the species range.

Koala (*Phascolarctos cinereus*)

There is one NSW Atlas of NSW Wildlife record of the koala (*Phascolarctos cinereus*) from within the LWB4-B7 Modification Area, from 2006 that has an accuracy of 1000m (BioNet 2015). Based on the habitats provided by the LWB4-B7 Modification Area it is considered that this record (if accurate); likely comprised a single individual passing through the LWB4-B7 Modification Area to a more appropriate area of habitat. No actual koalas or evidence of koalas (sightings, scats, scratchings) were observed during surveys undertaken by Umwelt for this assessment. Potential food resources were identified for this species, however these were typically only in low densities (except in areas of Riparian Cabbage Gum Forest).

The Assessment of Significance for the koala has been prepared with consideration of the EPBC Act Referral Guidelines for the Vulnerable Koala (DoE 2014).

The Referral Guidelines advise that the assessment of significant impacts on the koala is undertaken primarily through the assessment of habitat critical to the survival of the koala and actions that interfere substantially with the recovery of the koala. This approach aims to avoid and address habitat loss as well as promote a streamlined assessment and approval process.

In accordance with the Referral Guidelines, the habitat assessment tool was applied to determine the extent of vegetation that contains at least one known koala food tree within the Central Coast Koala Management Area (Phillips 2000). Koala feed trees for the Central Coast Koala Management Area (OEH 2014) that occur in the LWB4-B7 Modification Area include:

Primary Food Tree Species:

- Cabbage gum (*Eucalyptus amplifolia*).
- Forest red gum (*Eucalyptus tereticornis*)

Secondary Food Tree Species:

- Grey box (*Eucalyptus moluccana*)
- Grey gum (*Eucalyptus punctata*)

These species predominantly occur in the Riparian Cabbage Gum Open Forest and to a lesser extent in the Spotted-Gum Ironbark Forest, Coastal Foothills Transition Forest and Melaleuca Shrublands with Emergent Eucalypts. Together these areas comprise 163.8 ha of habitat. Although at least one primary food tree species and at least one secondary food tree species were present in the LWB4-B7 Modification Area.

Table 1 below applies the Koala Habitat Assessment Tool as outlined in Table 3 of the Referral Guidelines.

Table 1 Assessment of Koala Habitats

Koala Habitat Assessment Tool (Table 3 from DoE 2014)			LWB4-B7 Modification Area Assessment	
Attribute	**Score**	**Coastal**	**Allocated Score**	**Score Justification**
Koala occurrence	+2 (high)	Evidence of one or more koalas within the last 2 years.	**0**	Atlas of NSW Wildlife point buffer search identified 1 koala records within the LWB4-B7 Modification Area from 9 years ago. No evidence of the koala was recorded during the Umwelt surveys (call playback, SATT assessment, searches for signs of presence and spotlighting) of the LWB4-B7 Modification Area in 2015 or 2016.
	+1 (medium)	Evidence of one or more koalas within 2 km of the edge of the impact area within the last 5 years.		
	0 (low)	None of the above.		
Vegetation composition	+2 (high)	Has forest or woodland with 2 or more known koala food tree species, OR 1 food tree species that alone accounts for >50% of the vegetation in the relevant strata.	**+2**	This Referral Area contains known koala feed trees for the Hunter-Central Rivers region including cabbage gum (*Eucalyptus amplifolia*), forest red gum (*Eucalyptus tereticornis*), grey gum (*Eucalyptus punctata*) and grey box (*Eucalyptus moluccana*).
	+1 (medium)	Has forest or woodland with only 1 species of known koala food tree present.		
	0 (low)	None of the above.		
Habitat connectivity	+2 (high)	Area is part of a contiguous landscape ≥ 500 ha.	**+2**	The north-west areas of the LWB4-B7 Modification Area are connected to the higher quality habitats of Werakata State Conservation Area in the north. Potential habitat within the LWB4-B7 Modification Area for this species will not be removed by works and subsidence will not substantially impact these habitats.
	+1 (medium)	Area is part of a contiguous landscape < 500 ha, but ≥ 300 ha.		
	0 (low)	None of the above.		

Koala Habitat Assessment Tool (Table 3 from DoE 2014)			LWB4-B7 Modification Area Assessment	
Attribute	**Score**	**Coastal**	**Allocated Score**	**Score Justification**
Key existing threats	+2 (low)	Little or no evidence of koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for koala occurrence.	**1**	One BioNet Wildlife Atlas record notes two koala road mortalities since 2002 within 10km of the LWB4-B7 Modification Area It is expected that any local koala populations are substantially affected by the agricultural land uses in the locality that would likely expose any local koala population to dog attack.
	+1 (medium)	Evidence of infrequent or irregular koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for koala occurrence, OR areas which score 0 for koala occurrence are likely to have some degree of dog or vehicle threat present.		
	0 (high)	Evidence of frequent or regular koala mortality from vehicle strike or dog attack in the study area at present, OR areas which score 0 for koala occurrence and have a significant dog or vehicle threat present.		
Recovery value	+2 (high)	Habitat is likely to be important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1.	**0**	Table 1 of the Draft Referral Guidelines (DoE 2014) prescribes, that for coastal areas, the interim recovery objective(s) are to: *"Protect and conserve large, connected areas of koala habitat, particularly large, connected areas that support koalas that are:-of sufficient size to be genetically robust/operate as a viable sub-population OR free of disease or have a low incidence of disease OR breeding and to maintain corridors and connective habitat that allow movement of koalas between large areas of habitat."* The habitats of the LWB4-B7 Modification Area are of a lower quality (subject to grazing, clearing etc.) compared to connected vegetation in Werakata State Conservation Area to the north-west which would provide preferential
	+1 (medium)	Uncertainty exists as to whether the habitat is important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1.		
	0 (low)	Habitat is unlikely to be important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1.		

Koala Habitat Assessment Tool (Table 3 from DoE 2014)			LWB4-B7 Modification Area Assessment	
Attribute	**Score**	**Coastal**	**Allocated Score**	**Score Justification**
				habitat for this species. No clearing of this potential koala habitat is proposed. Subsequently the proposed modification will not cause fragmentation of retained habitats and is not likely to influence the interim recovery objectives. Preferred/primary koala habitat will not be directly impacted by the Project.
TOTAL SCORE			**5**	**≥ 5 indicates habitat critical for the survival of the koala.**

As the habitats identified in the LWB4-B7 Modification Area scored five using the Referral Guidelines habitat assessment tool, the LWB4-B7 Modification Area is considered to contain habitat critical to the survival of the koala (DoE 2014). However these guidelines state that:

> *the actions are likely to have a significant impact on a vulnerable species if they <u>adversely effect</u> habitat critical to the survival of the species*

As the impacts of underground mining are not predicted to cause substantial impacts as a result of subsidence, the project is not anticipated to adversely effect these areas of identified critical habitat. The modifications are not expected to result in substantial inference to the recovery of the koala. Further consideration of the impacts of the Proposed Action is detailed in the Assessment of Significance below.

In this case, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity
- populations that are near the limit of the species range.

The koala is known to occur in eucalypt woodlands and forests from north-eastern Queensland, along the eastern coast of NSW, to the south-east corner of South Australia. The vulnerable listing for the koala extends from north-eastern Queensland to the Victoria border. In the Central-Hunter Rivers Catchment of NSW, the koala population is predominantly centred in the Port Stephens LGA, with scattered records located elsewhere throughout the catchment. One single unconfirmed record of this species has been recorded in the LWB4-B7 Modification Area; however the species has been recorded elsewhere in the locality. This one record from 2006 was recorded by way of community wildlife surveys and its accuracy was very low (i.e. 1000 metres). No evidence of the koala (sightings, scats, scratchings) were recorded in the LWB4-B7 Modification Area during the surveys undertaken for this assessment during 2015, 2016 or 2017.

Atlas records indicate approximately 80 known records within 10 kilometres of the LWB4-B7 Modification Area, primarily in areas that provide higher habitat value (due to higher levels of connectivity, less fragmentation and greater diversity and abundance of feed tree species) than that of the LWB4-B7 Modification Area.

The known records surrounding the LWB4-B7 Modification Area (in higher quality habitats) are unlikely to be key source populations for breeding or dispersal, necessary for maintaining genetic diversity or at the limit of the known range of the species. It is unlikely that any potential population occurring in the LWB4-B7 Modification Area constitutes part of an important population that occurs in the Hunter-Central Rivers CMA.

An action has, will have, or is likely to have a significant impact on threatened species if it does, will, or is likely to:

- **lead to a long-term decrease in the size of an important population of a species;**

The Proposed Action will not result in the loss of any of the moderate quality habitat available to this species. Evidence of their previous or current occupation, such as scratches and scats, were not recorded in the LWB4-B7 Modification Area. It is considered that the LWB4-B7 Modification Area contains some moderate habitat for the species, however it is not known to be regularly utilised by the individuals that may occur in the locality. The proposed modification is not expected to lead to a long-term decrease in the size of an important population of the species.

- **reduce the area of occupancy of an important population, or;**

The Proposed Action will not result in the loss of any of the moderate quality habitat available to this species. Evidence of their current occupation, such as scratches and scats, were not recorded in the LWB4-B7 Modification Area. It is considered that the LWB4-B7 Modification Area contains some moderate habitat for the species, however it is not known to be utilised by the individuals that may occur in the locality. The proposed modification is not expected to reduce the area of occupancy of an important population of the species.

- **fragment an existing important population into two or more populations, or;**

The proposed modification will not result in the loss of any of the moderate quality habitat available to this species. Evidence of their previous or current occupation, such as scratches and scats, were not recorded in the LWB4-B7 Modification Area. It is considered that the LWB4-B7 Modification Area contains some marginal habitat for the species, however it is not known to be utilised by the individuals that may occur in the locality.

The proposed modification will not fragment any areas of potential or known habitat for this species.

- **adversely affect habitat critical to the survival of a species, or;**

The proposed modification will not result in the loss of any of the moderate quality potential habitat for the koala. Although using the Koala Habitat Assessment Tool outlined in the Koala Draft Referral Guidelines (DoE 2014) (refer to **Table 1** above) identified that the habitats present were consistent with critical habitat for the koala, the proposed modification will not affect habitat critical to the survival of the species.

- **disrupt the breeding cycle of an important population, or;**

No koalas or evidence of koalas were been recorded in the LWB4-B7 Modification Area during targeted surveys and therefore there is no evidence of breeding or territorial behaviour to indicate the LWB4-B7 Modification Area is important for the breeding cycle of an important population of the koala. It is likely that surrounding records are dispersing individuals from other quality habitats in the wider locality including within Werakata SCA. The proposed modification will not alter habitat available for this species and is subsequently unlikely to disrupt the breeding cycle of an important population of the species.

- **modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or;**

The proposed modification will not modify or destroy any of the available koala habitats in the LWB4-B7 Modification Area. The koala (if present) would be expected to occur in low densities while dispersing and subsequently the proposed modification is considered unlikely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;**

No invasive species are likely to become established as a result of the proposed modification that may impact upon any habitat relevant to the koala.

- **introduce disease that may cause the species to decline; or**

The koala is known to contract strains of *Chlamydia* and the koala retrovirus. Chlamydia infections are known to cause reduced female fertility and are expected to reduce the reproductive potential of koala populations. There is potential that at least some of the Hunter-Central Rivers population is infected with Chlamydia. The koala retrovirus can cause a range of conditions including leukaemia and immunodeficiency syndrome. It is estimated that up to 100 per cent of koala populations in Queensland and New South Wales have the koala retrovirus (TSSC 2012).

The proposed modification does not involve any processes that are likely to introduce a disease on site for the koala or that may cause this species to decline.

- **interfere substantially with the recovery of the species.**

The Approved Recovery Plan for the Koala (DECC 2008) contains specific recovery objectives and performance criteria including maintaining existing populations, improving the extent and quality of priority habitat areas, increasing numbers of breeding females, increasing the health of individuals in the wild, expanding the distribution of the species and increasing community reports of sightings.

The proposed modification will not result in the loss of any of the moderate quality habitat provided by the LWB4-B7 Modification Area, which is not an area known to contain a population of the species. No significant effect on the recovery of the koala is expected to occur as a result of the proposed modification.

Conclusion

The proposed modification is unlikely to result in a significant impact on an important population of koala as the proposed modification will not impact habitat critical to the survival for the species as described in the Referral Guidelines (DoE 2014) or as presented in the assessment of significance under the EPBC Act.

Green and golden bell frog, Grey-headed Flying-Fox and Large-eared Pied Bat

The green and golden bell frog was not identified in the LWB4-B7 Modification Area however has potential (albeit low) to occur in the large waterbody in the north. The most recent record of this species in the local area was at Ellalong Lagoon from 1993. It is unlikely that this species persists as an extant population in his area. Based on the former definition, as this species was not identified, it is unlikely that the LWB4-B7 Modification Area supports an important population of this species.

The grey-headed flying-fox was identified as lone individuals in the LWB4-B7 Modification Area, and this species potentially forages in riparian habitats. No roost sites for this species occur were identified or are likely to occur in the LWB4-B7 Modification Area. Based on the definition described above, the LWB4-B7 Modification Area does not support an important population of this species. It is expected that individuals of this highly mobile species would utilise the resources of the LWB4-B7 Modification Area as part of a wider foraging range, and no populations would rely exclusively on the resources identified in the LWB4-B7 Modification Area.

The large-eared pied bat was recorded using an Anabat Echolocation Detector in the western habitats of the LWB4-B7 Modification Area. No roosting sites (cave roosting species) for this species occur, however there are appropriate foraging habitats available. This species is likely to be utilising the habitats present in the LWB4-B7 Modification Area as part of a much larger area of habitat. It is subsequently not considered that the LWB4-B7 Modification Area supports an important population of this species.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- **lead to a long-term decrease in the size of an *important population* of a species; or**

The LWB4-B7 Modification Area provides potential habitat for the green and golden bell frog, grey-headed flying-fox and known foraging habitat for the large-eared pied bat, however it does not support an important population of these species under the former definition.

The proposed modification involves underground mining and subsidence predictions indicate that there will be minor surface impacts. Any potential loss of foraging resources for the green and golden bell frog, grey-headed flying-fox or large-eared pied bat is expected to be very minor and would not have potential to lead to a decrease in the size of a population of these species.

- **reduce the area of occupancy of an *important population*; or**

The proposed modification will not disturb or modify any areas of habitat for the green and golden bell frog, grey-headed flying fox or the large-eared pied bat. The LWB4-B7 Modification Area does not comprise an important population for these species.

The proposed modification involves underground mining and subsidence predictions indicate that there will be minor surface impacts from subsidence. Any potential loss of habitat for the green and golden bell frog, grey-headed flying-fox or large-eared pied bat is expected to be very minor and would not have potential to lead to a reduction in the area of occupancy of these species.

- **fragment an existing important population into two or more populations; or**

Given that surface disturbances associated with the proposed modification are expected to be minor, there is no potential for any potentially existing population of green and golden bell frog, grey-headed flying-fox or large-eared pied bat to become fragmented or isolated.

- **adversely affect habitat critical to the survival of a species; or**

The LWB4-B7 Modification Area does not contain any habitats that are critical to the survival of the green and golden bell frog, grey-headed flying-fox or large-eared pied bat. The nearby (within 3 km) Werakata State Conservation Area and Ellalong Lagoon protect larger areas of higher quality habitats compared to those present within the LWB4-B7 Modification Area.

- **disrupt the breeding cycle of an important population; or**

The LWB4-B7 Modification Area does not support any important population for the green and golden bell frog, grey-headed flying-fox or large-eared pied bat. Breeding sites/ camps/roosting habitat of the green and golden bell frog, grey-headed flying-fox and large-eared pied bat respectively were not recorded during surveys and the proposed modification is not expected to result in any actions that would disrupt the breeding cycle of these species.

- **modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline; or**

The LWB4-B7 Modification Area provides potential habitat for the green and golden bell frog, as well as known habitat for the grey-headed flying-fox and large-eared pied bat, however it does not support an important population of these species under the above definition.

The proposed modification involves underground mining and subsidence predictions indicate that there will be minor surface impacts. There is no potential for the proposed modification to modify, destroy, remove, isolate, or decrease the availability or quantity of habitat for green and golden bell frog, grey-headed flying-fox or large-eared pied bat to the extent that the species are likely to decline.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or**

Given that the proposed modification comprises underground mining and is predicted to have minimal surface impacts, it is not expected to result in the establishment of invasive species that are harmful to these vulnerable species.

- **interfere substantially with the recovery of the species.**

The potential habitats for the green and golden bell frog, grey-headed flying-fox and known foraging habitats for the large-eared pied bat identified within the LWB4-B7 Modification Area are smaller and of a lower quality than those protected in nearby Ellalong Lagoon and Werakata State Conservation Area. Due to the very minor surface impacts predicted, the proposed modification will not interfere substantially with the recovery of the green and golden bell frog, grey-headed flying-fox or large-eared pied bat.

Migratory Species

Three migratory species, the Japanese snipe (*Gallinago hardwickii*), sharp-tailed sandpiper (*Calidiris acuminata*) and common greenshank (*Tringa nebularia*) have been considered in this assessment.

An assessment in accordance with the DotE principal significant impact guidelines (DotE 2013) is provided below for these species.

An area of important habitat is:

- habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species
- habitat utilised by a migratory species which is at the limit of the species range
- habitat within an area where the species is declining.

None of these species were recorded during surveys of the LWB4-B7 Modification Area; however all have been identified within a 10km radius, including at the nearby Ellalong Lagoon. Potential habitat is present for each of them to occur and forage in the habitats provide by the large waterbody in the north. However, based on the above definition, the LWB4-B7 Modification Area is not regarded to be *important habitat* for these species based on the above definition.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

- **substantially modify (including fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;**

The proposed modification will not result in the loss of vegetation due to direct clearing or as a result of secondary impacts relating to subsidence. The subsidence predictions indicate that any modifications to surface habitats would be minor. There is no potential for the proposed modification to result in a substantial modification, destruction or isolation of habitats for these migratory species.

- **result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or**

Given that the proposed modification relates to underground mining that is predicted to have minimal surface impacts, it is not expected to result in the establishment of invasive species that are harmful to these migratory species.

- **seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species**

The nature of the proposed modification is such that there will be very minor disturbances to surface vegetation and habitats within the LWB4-B7 Modification Area. As such, there is no potential that the lifecycle of these migratory species could be seriously disrupted. There is no potential that an ecologically significant proportion of the population of these migratory species could be affected by the proposed modification.

Conclusion

The proposed modification will not result in a significant impact on any EPBC Act listed threatened species or migratory species.

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APPENDIX 6

Aboriginal Cultural Heritage and Archaeological Assessment

Inspired people | Dedicated team
Quality outcomes

LWB4-B7 MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT REPORT

Austar Coal Mine

FINAL

May 2017

LWB4-B7 MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT REPORT

Austar Coal Mine

FINAL

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Report No.	3900/R04/FINAL
Date:	May 2017

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Quality
ISO 9001

This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	**Date**	**Name**	**Date**
Final	N Roche	26/05/17	B Crossley	26/05/17

Acknowledgement

Umwelt (Australia) Pty Limited (Umwelt), Yancoal Australia Limited (Yancoal) and Austar Coal Mine Pty Ltd (Austar) would like to acknowledge the traditional custodians of the Quorrobolong Valley and pay respect to their cultural heritage, beliefs and continuing relationship with the land.

Umwelt, Yancoal and Austar would also like to acknowledge the post-contact experiences of Aboriginal people who have attachment to the Quorrobolong Valley.

We pay our respect to the Elders – past, present and future – for they hold the memories, traditions, culture and hopes of Aboriginal people in the area.

Executive Summary

Austar Coal Mine Pty Ltd (Austar) is seeking to modify development consent DA29/95 (the Bellbird South Consent) to permit the transfer and processing of coal from four proposed longwall panels. This modification is referred to as the LWB4-B7 Modification and is sought under section 75W of the *Environmental Planning and Assessment Act 1979*.

The LWB4-B7 Modification seeks to extend the Bellbird South consent area to cover the four proposed longwall panels. No other changes to the approved mining operations associated surface facilities or production rates are proposed as part of the modification.

Austar engaged Umwelt (Australia) Pty Ltd (Umwelt) to work with the registered Aboriginal parties to complete an Aboriginal Cultural Heritage Assessment for the proposed modification. This report has been prepared in accordance with *The Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010). The Aboriginal Cultural Heritage Assessment Report (ACHAR) will inform the Environmental Assessment for the proposed modification to development consent DA 29/95.

The potential impacts of the proposed LWB4-B7 Modification on Aboriginal archaeology and cultural heritage have been assessed within the 20 millimetre subsidence contour for LWB4-B7. This area is referred to as the 'LWB4-B7 Modification Area'. The LWB4-B7 Modification Area incorporates portions of the previously assessed LWB1-B3 Modification Area (Umwelt 2015), therefore the archaeological survey and cultural heritage assessment findings from the LWB1-B3 Modification have been considered in this assessment where appropriate.

A search of the Aboriginal Heritage Management System and a targeted pedestrian survey of the LWB4-B7 Modification Area identified one existing and thirteen new archaeological sites, one of which was located outside the LWB4-B7 Modification Area. These sites consisted of isolated artefacts and artefact scatters, with only two sites (ACM38 and ACM40) containing more than five artefacts. The distribution and contents of these sites is relatively comparable to the outcomes of previous archaeological investigations within the Austar Coal Mine and surrounds. No grinding grooves or scarred trees were identified within the LWB4-B7 Modification Area and no areas of outcropping sandstone were present within Quorrobolong Creek.

Registered Aboriginal parties who participated in the survey identified that Quorrobolong Creek is a key water resource within the area and has high cultural value for both its natural aspects and its association with archaeological evidence. Maintaining the health of watercourses within the LWB4-B7 Modification Area was seen as very important to ensure protection of natural and cultural values.

The registered Aboriginal party representatives indicated general agreement with the identification of areas of archaeological potential in association with Quorrobolong Creek and the elevated landform in the north-western portion of the LWB4-B7 Modification Area. The registered Aboriginal party representatives indicated that the identified archaeological sites have inherent Aboriginal cultural value. It was identified by one of the registered Aboriginal party representatives that the sites or areas of potential where there is an increased likelihood that deposits will retain integrity are of greater value as the interpretation of these sites/deposits could provide more specific information about the Aboriginal occupation of the area and how this may have changed over time.

Based on the criteria for the assessment of archaeological potential, the majority of the LWB4-B7 Modification Area has low archaeological potential. The exceptions to this are the valley flats bordering Quorrobolong Creek (moderate potential), slopes within 100 metres of the main channel of Quorrobolong Creek and identified overflow channels and the spur crest in Survey Unit 9 (all of which have low to moderate archaeological potential).

The archaeological significance of the identified sites was assessed as low, with the exception of sites ACM38 and ACM40, which were assessed as having low-moderate archaeological significance, largely based on their research potential. Cultural information provided by registered Aboriginal parties confirmed the cultural significance of the local landscape and any sites (recorded and unrecorded) within the surrounding area. Quorrobolong Creek was considered to hold high importance and cultural significance to the Aboriginal community. Specific reference was also made to the cultural values associated with Ellalong Lagoon (which is outside the LWB4-B7 Modification Area).

The proposed modification does not involve any additional surface development and therefore will have no direct impact on Aboriginal archaeological sites as a result of land clearing. The potential impact of the proposed modification on archaeological sites is therefore limited to indirect impacts associated with subsidence, including the potential for surface cracking and changes to hydrology (including ponding or alterations to creekline morphology). Based on the outcomes of assessments undertaken by MSEC (2017) and Umwelt (2017c), the proposed LWB4-B7 Modification is unlikely to result in direct or indirect impacts to the identified archaeological sites or on the identified areas of low-moderate or higher archaeological potential.

The following recommendations have been developed in light of the outcomes of consultation with the registered Aboriginal parties, the archaeological context of the LWB4-B7 Modification Area; the findings of the current survey and the previous survey of the LWB1-B3 Modification Area; the low likelihood of impact of the proposed modification on identified archaeological sites and areas of archaeological potential and current cultural heritage legislation:

- Austar Coal Mine should continue to implement the management strategies currently in place at the Austar Coal Mine, including those in the Austar Aboriginal Cultural Heritage Management Plan (ACHMP). Consistent with existing management strategies, in the unlikely event that subsidence remediation works are required that will impact on the identified sites or areas of low-moderate or higher archaeological potential, an Aboriginal Heritage Impact Permit (AHIP) will be sought for the portion of the site or area of potential to be impacted prior to the commencement of any remediation works in proximity to the recorded site or area of potential (noting that, in some instances, it may be necessary to undertake test excavation to inform the requirement for an AHIP). Appropriate mitigation measures for the site or area of potential to be impacted by the remediation works will be developed as part of the AHIP application process in consultation with the registered Aboriginal parties and in accordance with OEH requirements.

- The Austar ACHMP should be reviewed to incorporate the outcomes of this assessment and to include provisions for the monitoring of identified archaeological sites within the LWB4-B7 Modification Area in accordance with the management strategies currently implemented within the Austar Coal Mine.

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Figures

Tables

Appendices

1.0 Introduction

Austar Coal Mine Pty Ltd (Austar), a subsidiary of Yancoal Australia Limited (Yancoal) operates the Austar Coal Mine, an underground coal mine located approximately 10 kilometres south of Cessnock in the Lower Hunter Valley in NSW (refer to **Figure 1.1**). The Austar Coal Mine incorporates the former Pelton, Ellalong, Cessnock No. 1 (Kalingo) and Bellbird South Collieries and includes coal extraction, handling, processing and rail and road transport facilities.

Austar is proposing to modify development consent DA 29/95 (the Bellbird South Consent) under section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The modification is required to permit the transfer and processing of coal from four (4) additional longwall panels (LW) B4 to B7 via the existing Bellbird Mains and to extend the development consent area to encompass the four proposed longwall panels (refer to **Figure 1.2** and **Figure 1.3**). There will be no change to surface facilities, approved rates of mining, coal processing and handling or product transport rates as a result of the modification.

Austar engaged Umwelt (Australia) Pty Ltd (Umwelt) to work with the registered Aboriginal parties to complete an Aboriginal Cultural Heritage Assessment for the proposed modification. Umwelt and Austar recognise that the registered Aboriginal parties have primary responsibility for assessing the cultural significance of the lands for which they are traditional custodians and/or to which they have contemporary connection and all comments and feedback provided by Aboriginal parties are documented in this report.

This Aboriginal cultural heritage assessment report (ACHAR) has been prepared in accordance with the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011), with all consultation undertaken in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010a) (the consultation requirements), as documented in **Appendix 1**. An archaeological technical report (ATR) for the proposed modification was prepared in accordance with *The Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b) (the Code of Practice) and is provided in **Appendix 2**. This ACHAR will inform the Environmental Assessment (EA) for the proposed modification to the Bellbird South Consent.

1.1 Austar Coal Mine Background

Extensive mining has been undertaken within the Austar Coal Mine since 1916. Historical mining was predominantly via bord and pillar mining and more recently via conventional longwall mining and Longwall Top Coal Caving (LTCC) methods. Mining within the Bellbird South areas (Southland, Stage 1 and Stage 2 refer to **Figure 1.2**) was approved by the Minister for Urban Affairs and Planning in 1996 under DA 29/95 (the Bellbird South Consent), while mining of Stage 3 was approved by the Minister for Planning in 2009 under Project Approval 08_0111. Longwall mining commenced in the Ellalong Colliery area in 1983 and has subsequently progressed into the Bellbird South and the Stage 3 areas.

Mining is currently being undertaken in the LWB1-B3 mining area in accordance with the Bellbird South Consent. A review of accessible coal resources within the Bellbird South/Ellalong Colliery areas has identified the potential for four additional longwall panels (LWB4-B7) adjacent to LWB3 (refer to **Figure 1.3**). It is noted that the impacts of mining LWB1-B3 on Aboriginal cultural heritage was assessed in 2015 (Umwelt 2015) as part of a previous modification of the Bellbird South Consent.

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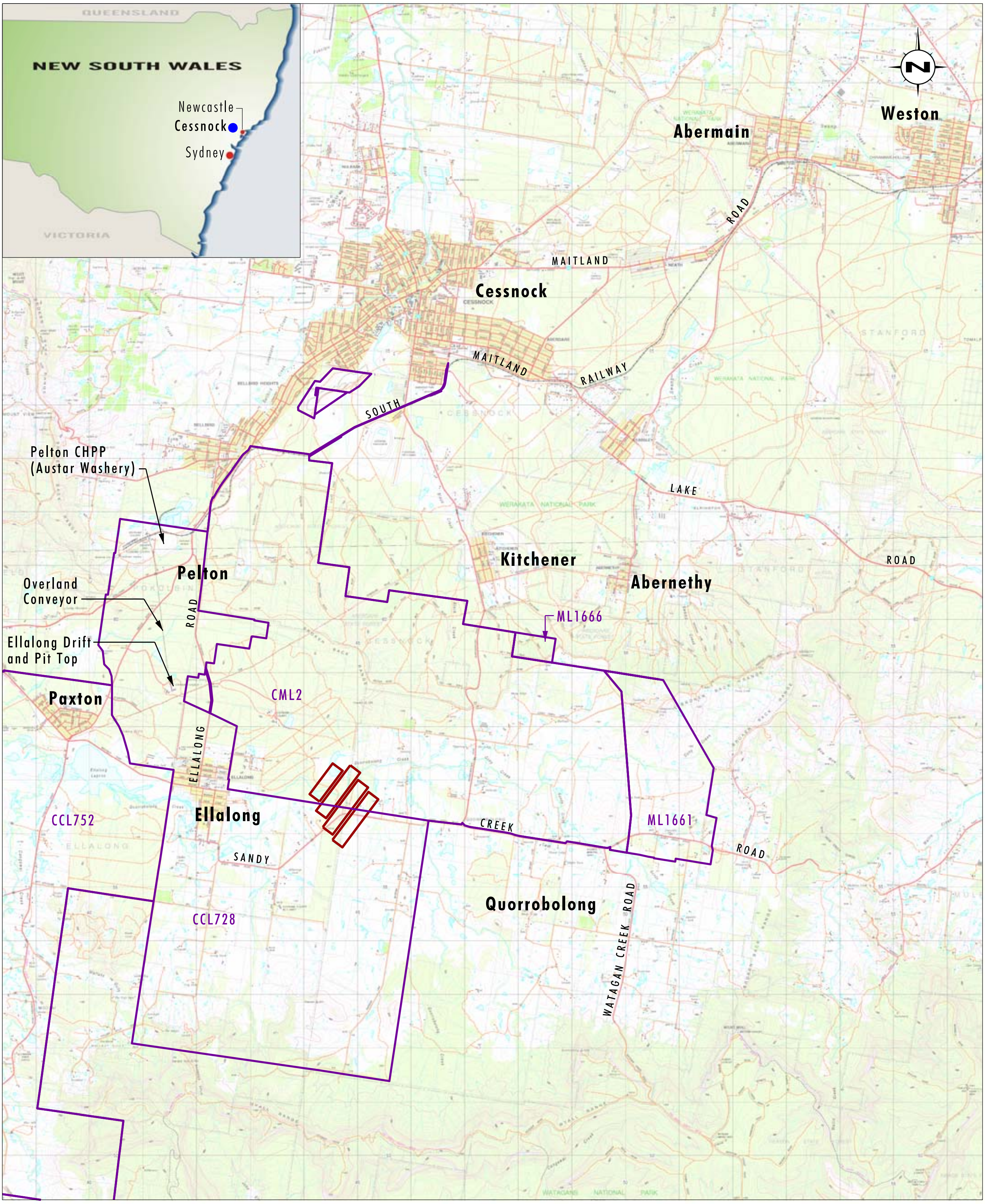

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

Legend

- Proposed LWB4-B7 Longwall Panels
- Mining Lease Boundary

FIGURE 1.1

Locality Plan

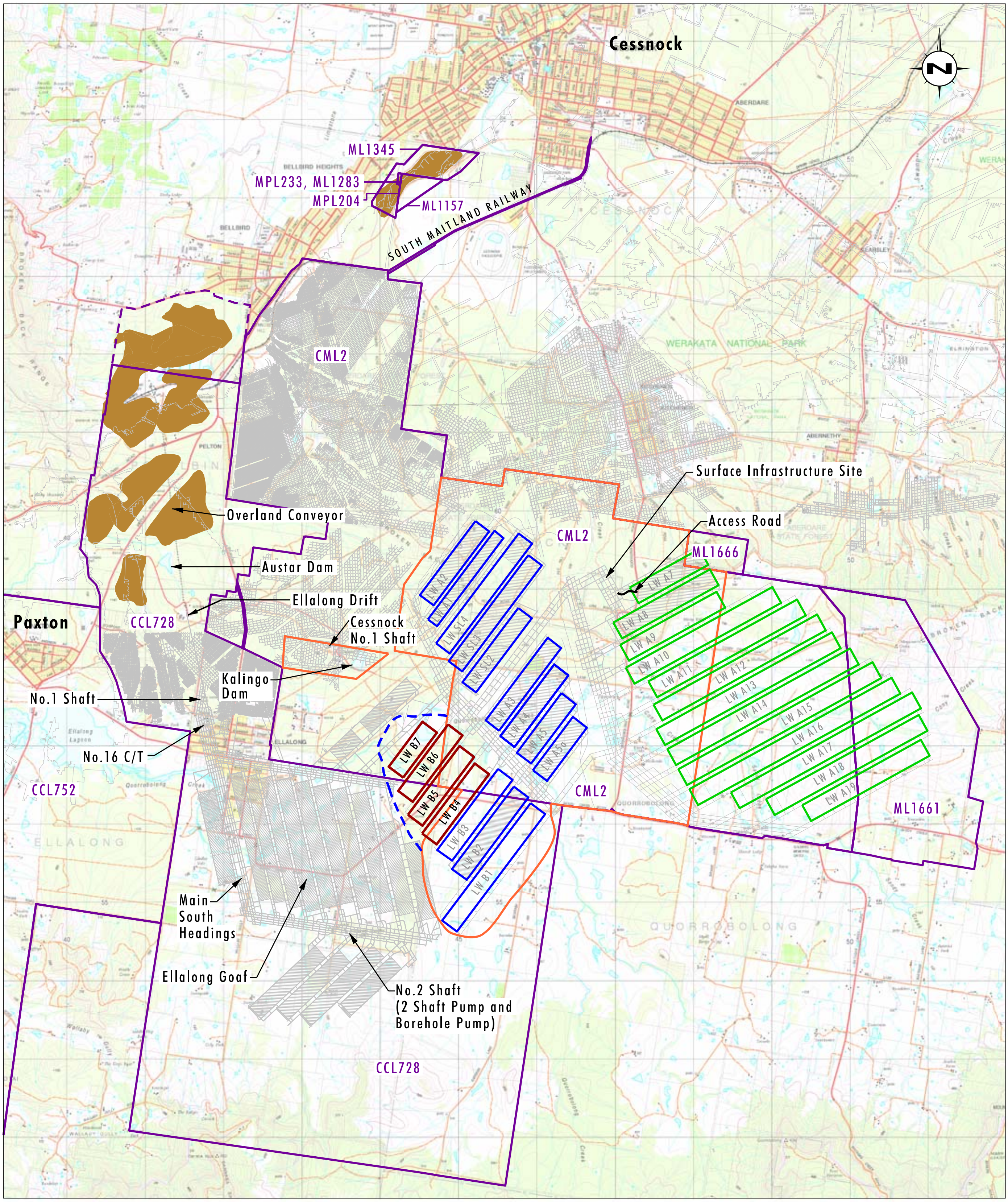

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

0 1 2 3km
1:70 000

Legend

- Bellbird South Stage 1, Stage 2, Southland and LWB1-B3 Longwall Panels (DA 29/95)
- Proposed LWB4-B7 Longwall Panels (DA 29/95)
- Stage 3 Longwall Panels (PA08_0111)
- DA 29/95 Bellbird South Consent Area (Subsurface) - As Approved
- DA 29/95 Bellbird South Consent Area (Subsurface) - Proposed Extension
- Approved Reject Emplacement Areas
- Completed Underground Workings
- Mining Lease Boundary
- Austar owned CHPP Land

FIGURE 1.2

Austar Coal Mine and Proposed LWB4-B7

File Name (A4): R04/3900_077.dgn
20170424 12.07

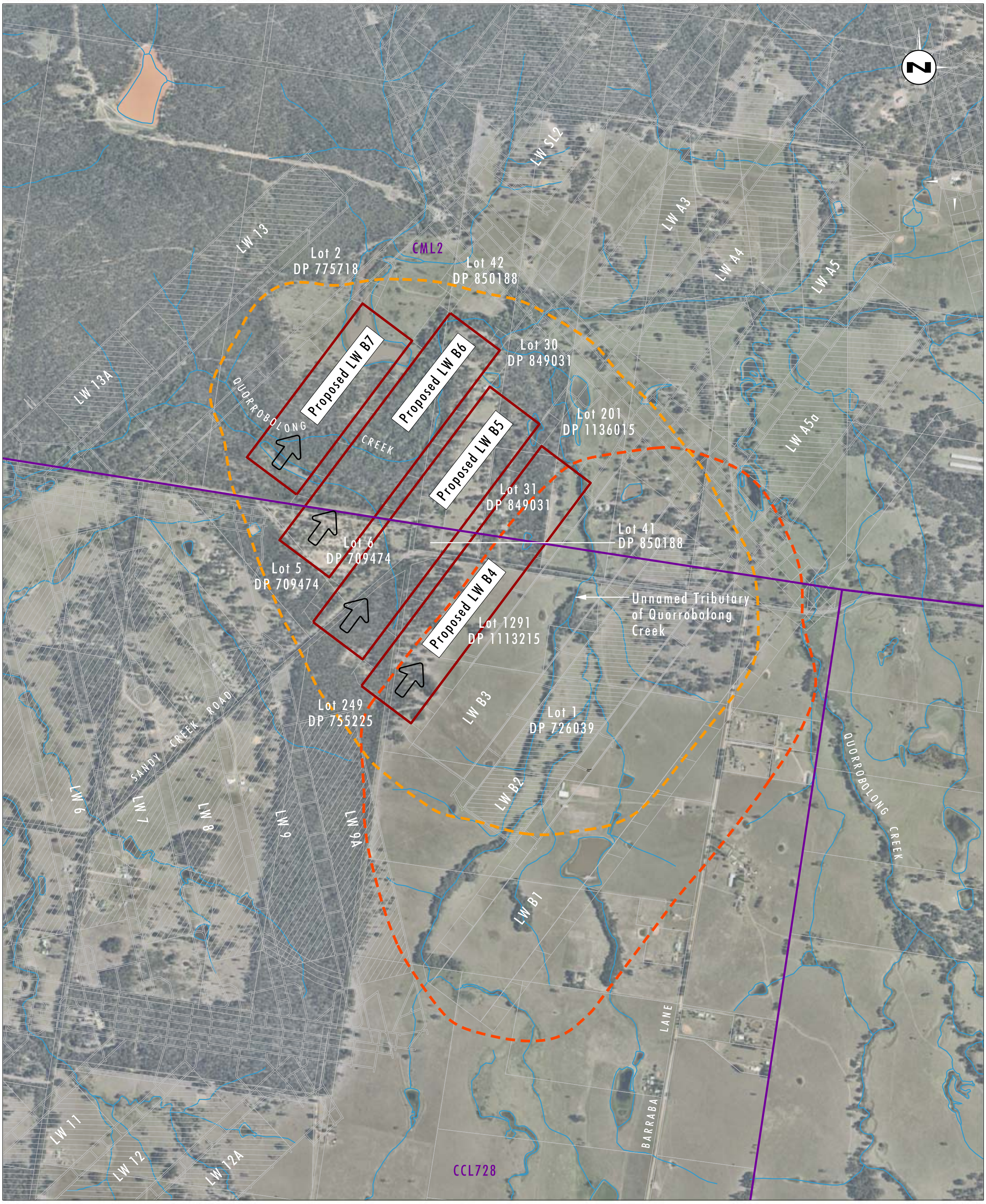

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- LWB1-B3 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Direction of Mining
- Drainage Line

FIGURE 1.3

Proposed LWB4-B7 Modification

File Name (A4): R04/3900_078.dgn
20170516 12.56

The potential impacts of the proposed LWB4-B7 Modification on Aboriginal archaeology and cultural heritage have been assessed within the 20 millimetre subsidence contour for LWB4-B7. This area is referred to as the 'LWB4-B7 Modification Area' and is shown on **Figure 1.3.** The 20 millimetre subsidence contour is considered the vertical limit of subsidence. The LWB4-B7 Modification Area incorporates portions of the previously assessed LWB1-B3 Modification Area (Umwelt 2015), therefore the archaeological survey and cultural heritage assessment findings from the LWB1-B3 Modification have been used to supplement this assessment where appropriate. The detailed survey data from the assessment of the LWB1-B3 Modification is not repeated within this report but the outcomes of the previous assessment are used to inform the current assessment (including the location of site #37-6-3398).

The LWB4-B7 Modification Area is located entirely within the Austar mining authorities CCL728 and CML 2 and no change to Austar's existing mining authorities would be required to accommodate the LWB4-B7 Modification.

1.2 Modification Description

Austar proposes to modify the Bellbird South consent to:

- permit the transfer and processing of coal from LWB4-B7 via the existing Bellbird mains
- extend the development consent area to encompass the four proposed longwall panels (refer to **Figure 1.3**).

Coal will be extracted from LWB4-B7 using conventional longwall mining techniques. The existing Austar Coal Mine infrastructure is sufficient to support the mining of the four proposed longwalls and there will be no change to surface facilities, approved rates of mining, coal processing and handling or product transport rates as a result of the modification.

The proposed modification does not involve any additional surface development and therefore will have no direct impact on Aboriginal archaeological sites as a result of land clearing. The potential impact of the proposed modification on archaeological sites is therefore limited to potential indirect impacts associated with subsidence, including surface cracking and changes to hydrology (including ponding or alterations to creekline morphology). The potential impacts of subsidence are discussed in detail in **Section 7.0**. However, it is noted that the predicted levels of subsidence within the LWB4-B7 Modification Area are lower than those that have occurred in the previously approved Stage 2 and Stage 3 mining areas (refer to **Figure 1.2**), where there has been no significant or visible surface cracking observed and no requirement for remediation of any ground surface cracking (MSEC 2017).

1.3 Legislative and Approvals Context

The following section provides an overview of the legislative frameworks relating to the protection and management of the Aboriginal cultural heritage within the LWB4-B7 Modification Area. The management and conservation of Aboriginal cultural heritage is subject to a range of statutory provisions under the NSW state government legislation. Key pieces of legislation with reference to the current assessment are the *Environmental Planning and Assessment Act 1979* (the EP&A Act) and the *National Parks and Wildlife Act 1974* (the NPW Act).

1.3.1 Environmental Planning and Assessment Act 1979

The EP&A Act is the main system of land use planning and development regulation legislation in NSW. The EP&A Act requires that consideration be given to potential environmental impacts during the planning process including the potential impact on Aboriginal cultural heritage.

The Bellbird South Consent was granted by the Minister for Urban Affairs and Planning under Part 4 of the EP&A Act in 1996 prior to the commencement of the (now repealed) Part 3A provisions. For the purposes of this modification, however, the consent is considered a transitional Part 3A project and Section 75W is the appropriate approval pathway for the proposed LWB4-B7 Modification.

Despite being assessed under Section 75W, the proposed modification to the Bellbird South Consent will remain an approval under Part 4 of the EP&A Act. Therefore the exemptions which apply to approved Part 3A projects relating to permits under Section 87 or consents under Section 90 of the NPW Act do not apply.

1.3.1.1 Cessnock Local Environmental Plan 2011

The proposed LWB4-B7 Modification Area is located within the Cessnock Local Government Area. The Cessnock Local Environmental Plan (LEP) 2011 is a planning instrument established under the EP&A Act. Section 5.10 of the Cessnock LEP contains provisions for heritage conservation, including the conservation of Aboriginal objects and Aboriginal places of heritage significance. Clause 8 of Section 5.10 further specifies that an assessment of 'the effect of the proposed development on the heritage significance of the place and any Aboriginal object known or reasonably likely to be located at the place' and includes requirements for consultation with Aboriginal parties.

1.3.2 National Parks and Wildlife Act 1974

The Office of Environment and Heritage (OEH) is primarily responsible for regulating the management of Aboriginal cultural heritage in New South Wales under the *National Parks and Wildlife Act 1974* (the NPW Act). The NPW Act is accompanied by the *National Parks and Wildlife Regulation 2009* (the Regulation) and a range of codes and guides including the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011), the consultation requirements and the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b).

The NPW Act defines an Aboriginal object as:

> *..any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises New South Wales.*

Under Section 84 of the NPW Act, an Aboriginal Place must be declared by the Minister as a place that, in the opinion of the Minister, is or was of special significance with respect to Aboriginal culture. Section 86(4) of the NPW Act states that a person must not harm or desecrate an Aboriginal place.

In accordance with Section 86(1) of the NPW Act, it is an offence to harm or desecrate a known Aboriginal object, whilst it is also an offence to harm an Aboriginal object under Section 86(2). Harm to an object or place is defined as any act or omission that:

- *destroys, defaces or damages an object or place, or*
- *in relation to an object – moves the object from the land on which it had been situated, or*
- *is specified by the regulations, or*
- *causes or permits the object or place to be harmed in a manner referred to in paragraph (a), (b) or (c),*

but does not include any act or omission that:

- *desecrates the object or place (noting that desecration constitutes a separate offence to harm), or*
- *is trivial or negligible, or*
- *is excluded from this definition by the regulations.*

Section 87(1) of the NPW Act specifies that it is a defence to prosecution under Section 86(1) and Section 86(2) if the harm or desecration of an Aboriginal object was authorised by an Aboriginal Heritage Impact Permit (AHIP) and the activities were carried out in accordance with that AHIP.

1.4 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) includes provisions for the protection of Aboriginal cultural heritage. To determine if there were any federally listed Aboriginal heritage sites or places present within the proposal site, an updated search was undertaken of the EPBC Act Protected Matters Search Tool on 7 April 2017 (refer to **Appendix 2**, Attachment 1). No World Heritage Properties, National Heritage Places or other protected matters were identified within the search area including the LWB4-B7 Modification Area.

1.5 Report Authorship

During the process of the development of this report, information relevant to the assessment of the Aboriginal cultural heritage values of the LWB4-B7 Modification Area was provided by all representatives of registered Aboriginal parties who participated in the survey. Additional correspondence pertaining to this assessment methodology was provided by Peter Townsend (Awabakal Local Aboriginal Land Council), Tracey Skene (Culturally Aware), Arthur Fletcher (Kauwal) and Jakub Czastka (Tocomwall). Correspondence and comments provided by Aboriginal parties are included in **Section 3**.

Nicola Roche (Umwelt Manager Cultural Heritage) was the primary author of the ATR (**Appendix 2**) and compiled this ACHAR. Nicola was assisted by Joshua Madden and Alison Lamond (Umwelt Senior Archaeologists). This ACHAR was reviewed on behalf of Umwelt by Barbara Crossley (Managing Director).

1.6 Objectives of this Assessment

The key objective of this assessment is to ensure that the Aboriginal cultural values of the LWB4-B7 Modification Area are appropriately assessed with reference to the approach specified in the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011) and the consultation requirements. In order to achieve this it is emphasised that Aboriginal people are the primary determinants of the cultural significance of their heritage and this ACHAR is primarily prepared to ensure that the information provided by registered Aboriginal parties is documented and presented in a manner that informs decision making on the management of Aboriginal cultural heritage within the LWB4-B7 Modification Area.

2.0 Description of the Modification Area

The LWB4-B7 Modification Area is illustrated in **Figure 1.1**, **Figure 1.2** and **Figure 1.3**, which show its boundaries with reference to key topographic features and cadastral information. As identified in **Section 1.3.1.1**, the LWB-B7 Modification Area is within the Cessnock Local Government Area and is within the parishes of Ellalong and Quorrobolong in the County of Northumberland.

As part of this assessment, the following key information is provided for the LWB4-B7 Modification Area:

- A description of land where Aboriginal objects and places of Aboriginal significance have been identified, both as a result of previous assessments (**Section 4.2.5**) and as part of this assessment (**Section 5.0**). Information on the nature of potential impacts (or harm) to these objects and places of significance is provided in **Section 7.0**.

- A description of the environment as relevant to the modification area (refer to **Section 4.1**), including photographs and mapping of land units (refer to **Section 5.0**).

- A description of other information relevant to Aboriginal peoples past use of the LWB4-B7 Modification Area and surrounds including key landscape features and resource availability (refer to **Section 4.1** and **Section 5.0**).

3.0 Consultation Process

Consultation with Aboriginal parties is an integral part of identifying and assessing the significance of Aboriginal objects and/or places, and determining and carrying out appropriate strategies to mitigate impacts upon Aboriginal heritage. In accordance with current requirements and expectations, consultation with Aboriginal parties regarding the proposal was undertaken in accordance with the relevant aspects of Part 8A, Clause 80C of the NPW Regulation and the *Aboriginal cultural heritage consultation requirements for proponents* (DECCW 2010). The documentation of the outcomes of Aboriginal party consultation in this report reflects the requirements of the *Guide to investigating assessing and reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011).

3.1 Identification of Registered Aboriginal Parties

Consultation with Aboriginal parties in relation to approved activities at Austar Coal Mine and the development of Aboriginal cultural heritage management plans has been ongoing since 2007 and has been undertaken in accordance with all relevant requirements and to the satisfaction of the regulatory authorities. At the commencement of the current assessment, Umwelt contacted the Office of Environment and Heritage (OEH) and identified that consultation with the registered Aboriginal parties participating in previous assessments for Austar had been consistent and ongoing, including consultation regarding the ACHMP (Austar 2017), which occurred in October/November 2016. OEH advised that Austar could continue to consult with the existing group of registered Aboriginal parties for the LWB4-B7 Modification and was not required to undertake a further public notification and registration process (refer to email correspondence provided in **Appendix 1**).

Twenty Aboriginal parties registered an interest in ongoing consultation regarding the Austar Coal Mine and were consulted regarding this modification (previous consultation is detailed in the Aboriginal Cultural Heritage Management Plan: Austar Coal Mine, Austar 2017).

The registered Aboriginal parties are:

- Aboriginal Native Title Consultants
- Awabakal Local Aboriginal Land Council
- Culturally Aware
- Deslee Talbott Consultant
- Giwiirr Consultants
- Hunter Valley Cultural Consultants
- Hunter Valley Cultural Surveying
- Lower Hunter Wonnarua Council
- Lower Wonnarua Tribal Consultancy
- Mindaribba Local Aboriginal Land Council
- Mingga Consultants

- The Awabakal and Guringai People
- Tocomwall Pty Ltd
- Upper Hunter Heritage Consultants
- Wanaruah Custodians
- Wattaka Wonnarua Cultural Consultants Services
- Wonn 1 Contracting
- Wonnarua Culture Heritage
- Wonnarua Elders Council Inc.
- Yinarr Cultural Service.

In relation to the registered Aboriginal parties listed above, it is noted that the area subject to the Austar ACHMP (Austar 2017) includes lands within the boundaries of two registered native title claims. These are NC2013/006 (Scott Franks and Anor on behalf of the Plains Clan of the Wonnarua People) and NCS2013/002 (Awabakal and Guringai People). However, the LWB4-B7 Modification Area specifically falls within the boundaries of the registered claim of the Scott Franks and Anor on behalf of the Plains Clan of the Wonnarua People (refer to **Figure 3.1**). The Chief Executive Officer of Tocomwall, Mr Scott Franks, is listed as an applicant on claim NC2013/006.

The LWB4-B7 Modification Area includes land within the boundaries of both the Mindaribba Local Aboriginal Land Council and the Awabakal Local Aboriginal Land Council, as shown in **Figure 3.2**.

3.2 Consultation regarding Assessment Methodology

A draft methodology for the ACHAR was provided to all registered Aboriginal parties on 5 January 2017. It was requested that all Aboriginal parties provide comment on the proposed assessment methodology. Particular emphasis was placed on comments relating to the Aboriginal cultural values of the modification area and the way in which the assessment may or may not contribute to documenting these values and assisting in their management. Copies of all communication regarding the draft methodology are provided in full in **Appendix 1** and summarised in **Table 3.1** below.

Nine Aboriginal parties did not provide any response to the draft methodology. Three Aboriginal parties (Awabakal Local Aboriginal Land Council, Culturally Aware and Wonn1 Contracting) responded to the draft methodology and did not identify any concerns or issues with the draft methodology but did not provide any additional information on cultural values. An additional seven registered Aboriginal parties did not provide a specific response regarding the draft methodology but submitted an Expression of Interest for participation in the survey of the LWB4-B7 Modification Area.

Tocomwall provided detailed comments on the methodology raising a number of issues with the methodology by email on 6 February 2017 (refer to **Appendix 1**). Umwelt provided a response to the comments on 7 February 2017 (refer to **Appendix 1**). Tocomwall requested further clarification on 9 February 2017 and Austar responded on 8 March 2017, including further technical response provided by Umwelt, and a further offer for Tocomwall to participate in a survey of the area.

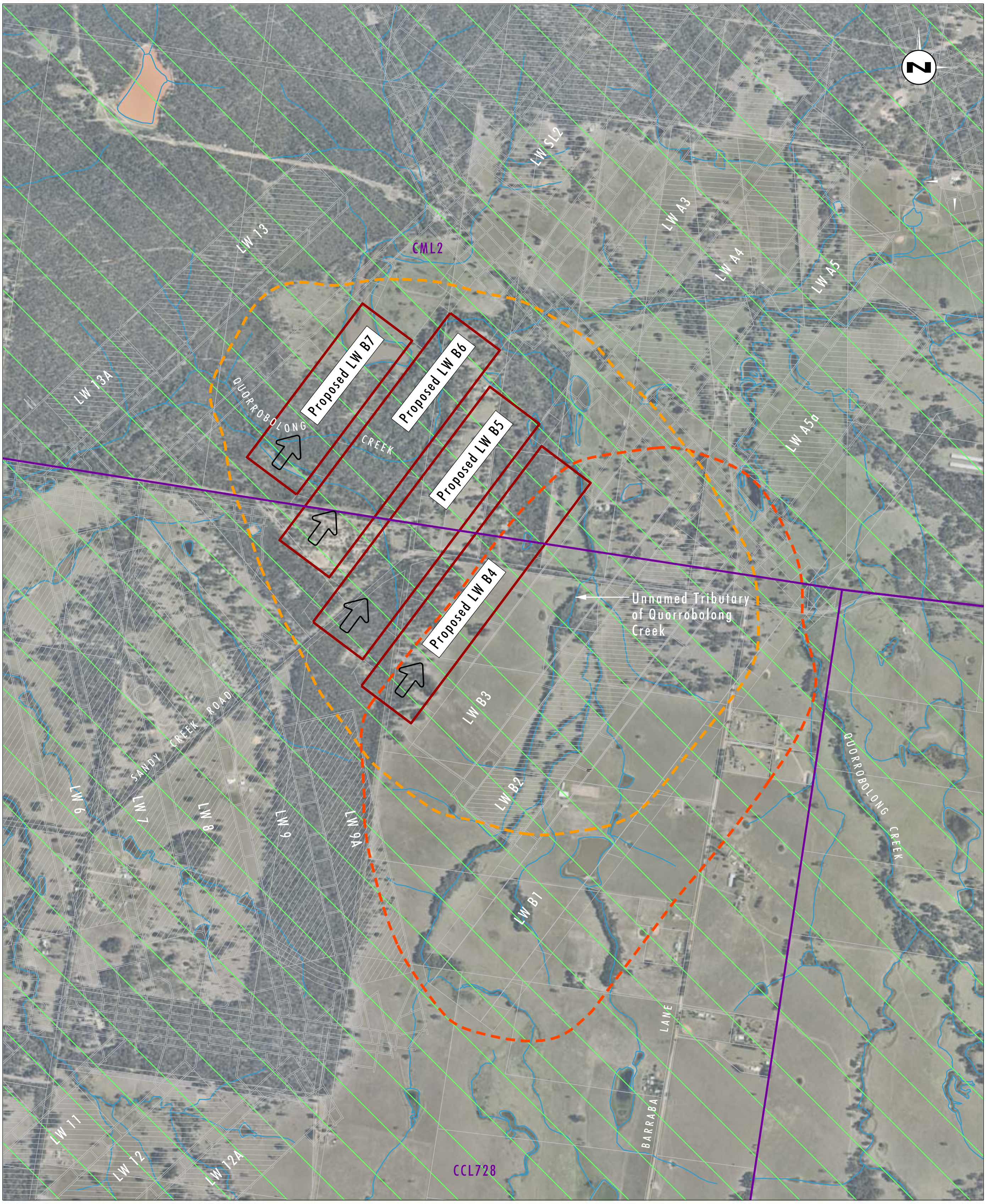

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

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Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- LWB1-B3 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Direction of Mining
- Drainage Line
- Scott Franks and Anor on behalf of the Plains Clans of the Wonnarua People

FIGURE 3.1

Location of Native Title Claim Boundaries

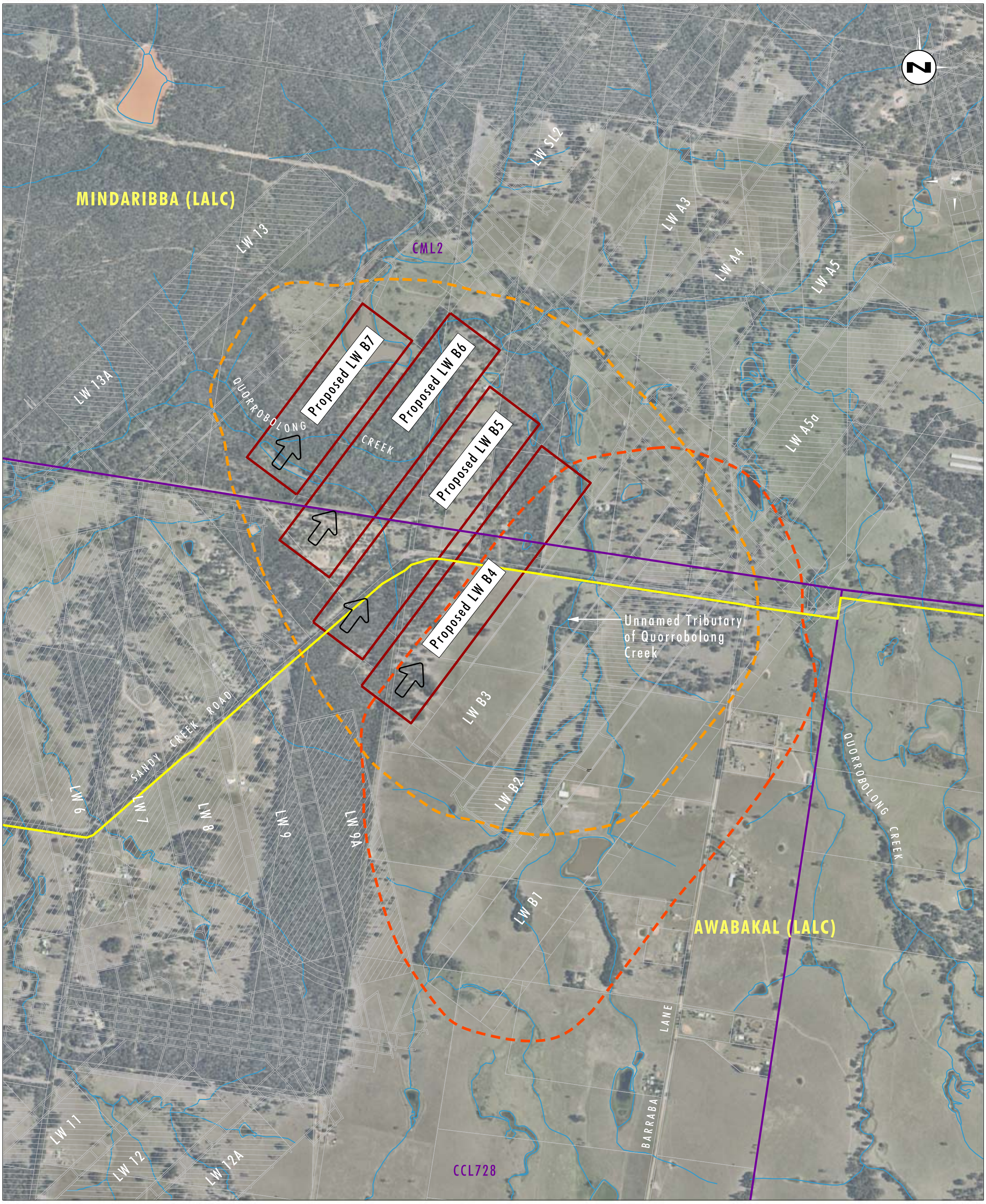

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- LWB1-B3 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Direction of Mining
- Drainage Line
- Local Aboriginal Land Council (LALC) Boundary

FIGURE 3.2

Location of LALC boundaries

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Table 3.1 Summary of Aboriginal Party Consultation

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
05/01/2017	Provision of assessment methodology to RAPs for review and comment. Correspondence re-sent with the inclusion of relevant figures and signature provided 19/01/17	Aboriginal Native Title Consultants	No response.
		Awabakal Local Aboriginal Land Council	Response provided by email on 17/01/17 stating satisfaction with the proposed methodology.
		Culturally Aware	Response provided by email on 16/01/17 stating no issues or concerns with the proposed methodology.
		Deslee Talbott Consultant	No response.
		Giwiirr Consultants	No response.
		Hunter Valley Cultural Consultants	No response.
		Hunter Valley Cultural Surveying	EOI for fieldwork provided by email 24/01/17.
		Lower Hunter Wonnarua Council	EOI for fieldwork provided by email 31/01/17.
		Lower Wonnarua Tribal Consultancy	EOI for fieldwork provided by email 23/01/17.
		Mindaribba Local Aboriginal Land Council	EOI for fieldwork provided by email 24/01/17.
		Mingga Consultants	No response.
		The Awabakal and Guringai People	No response.
		Tocomwall Pty Ltd	Initial email response received 18/01/17 requesting signed copy of methodology with accompanying figures. Methodology resent 19/01/17. Response received from Tocomwall on 6/02/17 raising a number of concerns with proposed methodology (refer to main text).
		Upper Hunter Heritage Consultants	No response.
		Wanaruah Custodians	No response.

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
		Wattaka Wonnarua Cultural Consultants Services	EOI for fieldwork provided by email 20/01/17.
		Wonn 1 Contracting	Response provided by email on 20/01/17 stating no problems with the proposed methodology.
		Wonnarua Culture Heritage	EOI for fieldwork provided via email on 16/01/17.
		Wonnarua Elders Council Inc.	No response.
		Yinarr Cultural Services	EOI for fieldwork provided by email 24/01/17.
7/02/2017	Response provided to Tocomwall regarding comments on draft methodology	Tocomwall Pty Ltd	Further comments received from Tocomwall (by email 9/2/2017) noting remaining concerns regarding the methodology.
9/02/2017	Telephone conversation between Nicola Roche and Jakub Czatska	Tocomwall Pty Ltd	During telephone conversation, Jakub advised that due to outstanding concerns regarding the assessment methodology, Tocomwall would not be attending the survey. Nicola and Jakub discussed that consultation regarding the matter would remain ongoing.
9/02/2017	Email from Gary Mulhearn (Austar)	Tocomwall Pty Ltd	In response to provision of letter noting remaining concerns regarding the methodology, Austar indicated that survey had commenced on 9/02/17 with other Aboriginal parties but that this would not preclude Tocomwall from attending a future survey
9-10/02/2017	Survey of modification area with registered Aboriginal parties that provided EOI	Awabakal Local Aboriginal Land Council	Peter Townsend attended survey.
		Culturally Aware	Maree Waugh attended survey.
		Hunter Valley Cultural Surveying	Luke Hickey attended survey.

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
		Lower Hunter Wonnarua Council	Tom Miller attended survey.
		Lower Wonnarua Tribal Consultancy	Barry Anderson attended survey.
		Mindaribba Local Aboriginal Land Council	Jason Brown attended survey.
		Wattaka Wonnarua Cultural Consultants Services	Rod Hickey attended survey.
		Wonn 1 Contracting	Arthur Fletcher attended survey.
		Wonnarua Culture Heritage	Did not attend survey.
		Yinarr Cultural Services	Kathie Steward Kinchela attended survey on 9/02/17 only.
8/03/2017	Provision of further information requested by Tocomwall regarding assessment methodology	Tocomwall Pty Ltd	Response by email 17/03/17 to schedule survey.
21/03/2017	Survey of modification area undertaken with Tocomwall	Tocomwall Pty Ltd	Attended survey.
26/04/2017	Provision of draft ACHAR to registered Aboriginal parties for review and comment	Aboriginal Native Title Consultants	Verbal response received 16/05/17 (see below).
		Awabakal Local Aboriginal Land Council	Written response received 22/05/17 (see below).
		Culturally Aware	Written response received 26/05/17 (see below).
		Deslee Talbott Consultant	No response received as at 26/05/17
		Giwiirr Consultants	No response received as at 26/05/17
		Hunter Valley Cultural Consultants	No response received as at 26/05/17
		Hunter Valley Cultural Surveying	No response received as at 26/05/17

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
		Lower Hunter Wonnarua Council	No response received as at 26/05/17.
		Lower Wonnarua Tribal Consultancy	Written response received 25/05/17 (see below).
		Mindaribba Local Aboriginal Land Council	Written response received 25/05/17 (see below).
		Mingga Consultants	No response received as at 26/05/17.
		The Awabakal and Guringai People	No response received as at 26/05/17.
		Tocomwall Pty Ltd	No response received as at 26/05/17.
		Upper Hunter Heritage Consultants	No response received as at 26/05/17.
		Wanaruah Custodians	No response received as at 26/05/17.
		Wattaka Wonnarua Cultural Consultants Services	No response received as at 26/05/17.
		Wonn 1 Contracting	Written response received 25/05/17 (see below).
		Wonnarua Culture Heritage	Verbal response received 16/05/17 (see below).
		Wonnarua Elders Council Inc.	No response received as at 26/05/17.
		Yinarr Cultural Services	No response received as at 26/05/17.
26/04/2017	Provision of draft ACHAR to Plains Clan of the Wonnarua People for review and comment	Plains Clan of the Wonnarua People	No response received as at 26/05/17.
16/05/2017	Telephone call reminder of closing date for comment on draft report	Aboriginal Native Title Consultants	Margaret Matthews advised that she did not attend the survey and has not reviewed the report in detail but is happy to endorse it on the strength of previous assessments done at Austar

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
		Awabakal Local Aboriginal Land Council	Peter Townsend advised would submit comment. Response subsequently received (see below)
		Culturally Aware	Left message advising of closing date for comment Response subsequently received (see below).
		Deslee Talbott Consultant	Left message advising of closing date for comment No subsequent response received.
		Giwiirr Consultants	No telephone number available. Sent email advising of closing date for comment No subsequent response received.
		Hunter Valley Cultural Consultants	Left message advising of closing date for comment No subsequent response received.
		Hunter Valley Cultural Surveying	Left message advising of closing date for comment No subsequent response received.
		Lower Hunter Wonnarua Council	Tom Miller advised would email comment to Nicola Roche No subsequent response received.
		Lower Wonnarua Tribal Consultancy	Left message advising of closing date for comment Response subsequently received (see below)
		Mindaribba Local Aboriginal Land Council	Left message advising of closing date for comment Response subsequently received (see below)
		Mingga Consultants	Left message advising of closing date for comment No subsequent response received.

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
		The Awabakal and Guringai People	Peter Leven advised would provide comment Kerrie Brauer advised would provide comment No subsequent response received.
		Tocomwall Pty Ltd	Left message advising of closing date for comment No subsequent response received.
		Upper Hunter Heritage Consultants	Left message advising of closing date for comment No subsequent response received.
		Wanaruah Custodians	No answer and not possible to leave message or send email No subsequent response received.
		Wattaka Wonnarua Cultural Consultants Services	Des Hickey advised would provide comment No subsequent response received.
		Wonn 1 Contracting	Arthur Fletcher advised he will discuss with Suzie Worth and provide comment Response subsequently received
		Wonnarua Culture Heritage	Gordon Griffiths advised that he did not participate in the survey and cannot provide comment
		Wonnarua Elders Council Inc.	Left message advising of closing date for comment No subsequent response received.
		Yinarr Cultural Services	Left message advising of closing date for comment No subsequent response received.

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
22/05/17	Letter from Awabakal Local Aboriginal Land Council	Awabakal Local Aboriginal Land Council	Letter provided indicating agreement with the Austar Coal Aboriginal Cultural Heritage Management Plan. No comment made regarding current document.
25/05/17	Letter from Lower Wonnarua Tribal Consultancy	Lower Wonnarua Tribal Consultancy	Letter provided identifying minor corrections required to this section (adopted) and agreeing with the recommendations provided in Section 8.
25/05/17	Email from Wonn1 Contracting (Kauwal)	Wonn1 Contracting (Kauwal)	Email received from Arthur Fletcher indicating that he had been ill but 'with my limited understanding of it, I will be supporting this one.'
25/05/17	Letter from Mindaribba Local Aboriginal Land Council	Mindaribba Local Aboriginal Land Council	Response provided to Mindaribba Local Aboriginal Land Council by Umwelt addressing matters raised in their response to the draft report.
26/06/17	Email from Culturally Aware	Culturally Aware	Email provided referencing specific cultural values of Ellalong Lagoon, Quorrobolong Creek and the modification area more generally. Monitoring of sites and landscape features identified as appropriate management strategy

3.3 Aboriginal party participation in survey

In conjunction with the provision of the draft assessment methodology, the registered Aboriginal parties were invited to provide expressions of interest in being engaged to undertake the survey work. All eligible Aboriginal parties who submitted a complete Expression of Interest document (including provision of required insurance information) within the required timeframe were invited to participate in the survey. Survey participants are listed in **Table 3.2** below.

Following the completion of the survey on 9-10 February 2017 and on 21 March 2017, a meeting was held with the participants for each survey period, to review the outcomes of the survey, to discuss the LWB4-B7 Modification and to document any further feedback or comments that Aboriginal party representatives wished to make.

Table 3.2 On-site meeting and survey participants

Date	Organisation	Name
9/02/17	Austar	Josh Chadwick
	Umwelt	Nicola Roche
	Umwelt	Joshua Madden
	Culturally Aware	Maree Waugh
	Hunter Valley Cultural Surveying	Luke Hickey
	Wattaka Wonnarua	Rod Hickey
	Lower Hunter Wonnarua Consultancy Services	Tom Miller
	Lower Wonnarua Tribal Consultancy	Barry Anderson
	Mindaribba Local Aboriginal Land Council	Jason Brown
	Awabakal Local Aboriginal Land Council	Peter Townsend
	Kawul TA Wonn1	Arthur Fletcher
	Yinarr Cultural Services	Kathy Steward Kinchela
10/02/17	Austar	Josh Chadwick
	Umwelt	Nicola Roche
	Umwelt	Joshua Madden
	Culturally Aware	Maree Waugh
	Hunter Valley Cultural Surveying	Luke Hickey
	Wattaka Wonnara	Rod Hickey
	Lower Hunter Wonnarua Consultancy Services	Tom Miller

Date	Organisation	Name
	Lower Wonnarua Tribal Consultancy	Barry Anderson
	Mindaribba Local Aboriginal Land Council	Jason Brown
	Awabakal Local Aboriginal Land Council	Peter Townsend
	Kawul TA Wonn1	Arthur Fletcher
21/03/17	Austar	Josh Chadwick
	Umwelt	Nicola Roche
	Tocomwall	Danny Franks

3.3.1 Outcomes of in-field consultation

This section documents specific feedback received from Aboriginal party representatives during the survey and post-survey meetings. It is noted that all recording of Aboriginal archaeological sites during the survey was undertaken in consultation with Aboriginal parties.

In terms of specific feedback, the Aboriginal party representatives present during survey on 9 February 2017 requested that the landform adjoining an exposed artefact scatter be recorded as part of the site. The boundaries for this site (ACM38) were discussed and agreed with the Aboriginal party representatives. Similarly, the Aboriginal party representatives identified that the elevated spur crest in the north-west of the LWB4-B7 Modification Area be recorded as an area of archaeological potential.

During the survey, a large living red gum exhibiting two large scars was identified on the bank of Quorrobolong Creek at MGA E344925 N6357211. One scar is located approximately two metres from the base of the tree, is not symmetrical in shape and exhibits uneven scar margins, as shown in Archaeology Technical Report (ATR – refer to **Appendix 2**, Attachment 2, Plate 56). Based on the lack of symmetry to the scar, the uneven margins, the height of the scar on the tree and the presence of another minor scar higher up the tree that had resulted from limb tear, this scar is considered highly unlikely to be of Aboriginal cultural origin. This conclusion was discussed and agreed with Aboriginal party representatives present during survey.

The second scar on the tree is generally symmetrical (sub-ovoid) in shape, is located approximately 3.5 metres from the base on the tree, exhibits an estimated 15-20 centimetres of callus regrowth (not measurable due to height from ground surface) and is approximately 1.5-2 metres in length by 0.8 metres in width (refer to **Appendix 2**, Attachment 2, Plate 57). No evidence of scarring associated with the cutting of footholds was present on the tree trunk below the scar and there were no disconformities (such as burls) that would render the section of the tree trunk accessible from the ground unsuitable for use. This scar exhibits some characteristics associated with Aboriginal scarred trees (namely that it is a suitable species, is a mature tree, has a scar that is symmetrical and is relatively old based on the extent of callus regrowth). However, the scar is located a considerable distance off the ground surface, meaning that if it was made by an Aboriginal person, he or she would have been required to climb up to 5-5.5 metres to reach the top of the scar. The absence of footmarks in the tree truck indicates that this climbing would have been done by some other means (which is not unknown within accounts of Aboriginal scarring practices). In contrast the tree trunk immediately below the scar and directly accessible from the ground does not exhibit any evidence that it would have been unsuitable for use. In addition, the tree exhibits other clear evidence of damage from limb tears.

Based on the available evidence, this scar does not present sufficient evidence to warrant the recording of the tree as an archaeological site. This conclusion was discussed with the Aboriginal party representatives present during survey. Several of the Aboriginal party representatives indicated that they felt that the scar may be of cultural origin and requested that the above information be included within the report.

During the post-survey meeting on 10 February 2017, Aboriginal party representatives identified that Quorrobolong Creek was an important resource and that maintaining the watercourses within the LWB4-B7 Modification Area is a key aspect of the natural and cultural values of this area. It was noted that feral flora and fauna species were identified during the survey. This included the identification of feral pigs and their traces within Quorrobolong Creek and the presence of a range of weed species within the creek. Aboriginal party representatives indicated that controlling feral species is key to the health of the area and requested that landowners consider the need for weed management and feral animal controls within its landholdings.

The Aboriginal party representatives indicated that they felt that the level of survey coverage was adequate and indicated general agreement with the identification of areas of archaeological potential in association with Quorrobolong Creek and the elevated landform in the north-western portion of the LWB4-B7 Modification Area (as will be discussed further in **Section 5.0**). The Aboriginal party representatives also indicated that the number of sites and artefacts recorded within the LWB4-B7 Modification Area was interesting, being slightly higher than identified in the adjoining LWB1-B3 Modification Area. It was discussed that, based on subsidence predictions, it was unlikely that the identified archaeological sites or areas of archaeological potential would be subject to direct or indirect impact as a result of the proposed modification and that the sites would be subject to ongoing monitoring, consistent with the approach that forms part of the current Austar ACHMP (Austar 2017).

During the post-survey meeting on 21 March 2017, Danny Franks indicated that he was satisfied with the extent of survey undertaken and indicated general agreement with the identification of areas of archaeological potential in association with Quorrobolong Creek and the elevated landform in the north-western portion of the LWB4-B7 Modification Area (as will be discussed further in **Section 5.0**). Danny also indicated that he felt that the sites or areas of potential where there is an increased likelihood that deposits will retain integrity are of greater value as the interpretation of these sites/deposits could provide more specific information about the Aboriginal occupation of the area and how this may have changed over time.

3.3.2 Consultation regarding draft ACHAR

A copy of the draft Aboriginal cultural heritage and archaeological assessment report was provided to all registered Aboriginal parties on 26 April 2017 with an invitation to review and comment on all aspects of the document. All comments received will be documented included in full in **Appendix 1** and summarised in **Table 3.1.** Verbal comment on the draft report was provided by Margaret Matthews (Aboriginal Native Title Consultants) who indicated that she did not participate in the survey and had not reviewed the draft report, but based on her previous experience at Austar, she did not have any major concerns. Verbal comment was also provided by Gordon Griffiths (Wonnaua Culture Heritage) who identified that he had not participated in the survey and therefore could not comment on the draft report.

Written comment was received from Awabakal Local Aboriginal Land Council regarding the Austar Coal Aboriginal Cultural Heritage Management Plan but not specifically regarding this report. Written comment was also received from Arthur Fletcher (Wonn 1 Consulting/Kauwal) who did not raise any concerns regarding the draft report. Barry Anderson (Lower Wonnarua Tribal Consulting) requested some minor corrections to the draft report regarding his organisation’s name (which have been made) and provided agreement with the recommendations in the draft report.

Written response was also received from Mindaribba Local Aboriginal Land Council requesting clarification of aspects of the draft report and the provision of additional information. These comments were addressed via correspondence to Mindaribba Local Aboriginal Land Council, including the provision of some additional information in this report. A copy of the correspondence provided to Mindaribba Local Aboriginal Land Council is included in **Appendix 1**.

Written comment was also received from Tracey Skene (Culturally Aware) referencing the high cultural significance of Ellalong Lagoon and noting that 'the assessment area has a known creek called Quorrobolong Creek, this area may have low scientific value but holds a high importance and cultural significance to the Aboriginal Community'. Ms Skene identified that monitoring of the recorded sites is an adequate management strategy and emphasised the importance of keeping the natural surrounds free from damage.

4.0 Contextual Information

This section presents a review of background information undertaken to gain an initial understanding of the cultural landscape. In order to avoid duplication, this section is cross-referenced with information presented in the ATR provided in **Appendix 2**.

4.1 Physical Setting

The majority of the LWB4-B7 Modification Area can be broadly classified as low relief rolling hills bordering Quorrobolong Creek, which is the main watercourse in the modification area. Based on the available topographic information, provisional landform mapping was undertaken within the LWB4-B7 Modification Area, as shown in **Figure 4.1**. Within the LWB4-B7 Modification Area, Quorrobolong Creek is an ephemeral watercourse with flows only occurring as a result of prolonged or high rainfall periods. Areas of ponding do however occur along its alignment within the modification area. A 4^{th} order unnamed tributary of Quorrobolong Creek flows in a northerly direction through the LWB4-B7 Modification Area above LWB1 to LWB4, converging with Quorrobolong Creek upstream of LWB5. Of these watercourses, Quorrobolong Creek comprises the most reliable source of water and is bordered by relatively broad valley flats formed through alluvial deposition.

Information of the geology and soils of the LWB4-B7 Modification Area is provided in Section 2.1 of **Appendix 2** and is not replicated here other than to note that the depths of topsoil within the area is typically expected to be less than 50 centimetres. The possible exception to this is within the alluvial formations mentioned above.

A review of the range of flora and fauna that would have been likely to occur within the LWB4-B7 Modification Area prior to non-Aboriginal landscape modification would have included a large range of animals and plants targeted by Aboriginal people for use as food, medicines and to manufacture various implements (refer to Table 2.2 in **Appendix 2**). However, the area has been subject to occupation by non-Aboriginal people since the early 1830s, with the majority of the LWB4-B7 Modification Area located within the Barraba Estate which was granted in 1834 (Umwelt 2008). Since this time, the area has been used for grazing and some limited agriculture purposes. From the early 1900s, mining commenced within the local area, with the establishment of the Pelton, Ellalong, Bellbird and Southland Collieries resulting in increased activity within the local area, noting that grazing and agriculture remained a key land use.

As a result of the land use history described above, a relatively large proportion of the LWB4-B7 Modification Area has been subject to modification as a result of grazing and agricultural land use, including clearance of large portions of native vegetation and the introduction of pasture grasses, with mining related activity also occurring in the local area. The ongoing clearance of the landscape, the introduction of hard hoofed animals and attempts at water conservation (in the form of construction of dams and works such as contour banks) would have had significant impacts on stream morphology and hydrology. Throughout the Hunter Valley, these changes have resulted in incision of tributary streams and extension of gullies, erosion and sedimentation during major floods, and in some places, increases in water salinity (Dean-Jones and Mitchell 1993:4). Other areas of localised impacts visible within the modification area include a former quarry south of Sandy Creek Road and a number of houses and associated outbuildings (as visible in **Figure 1.3**). The extent of these disturbances has implications for the likely Aboriginal cultural values of the landscape, including any archaeological evidence that may remain.

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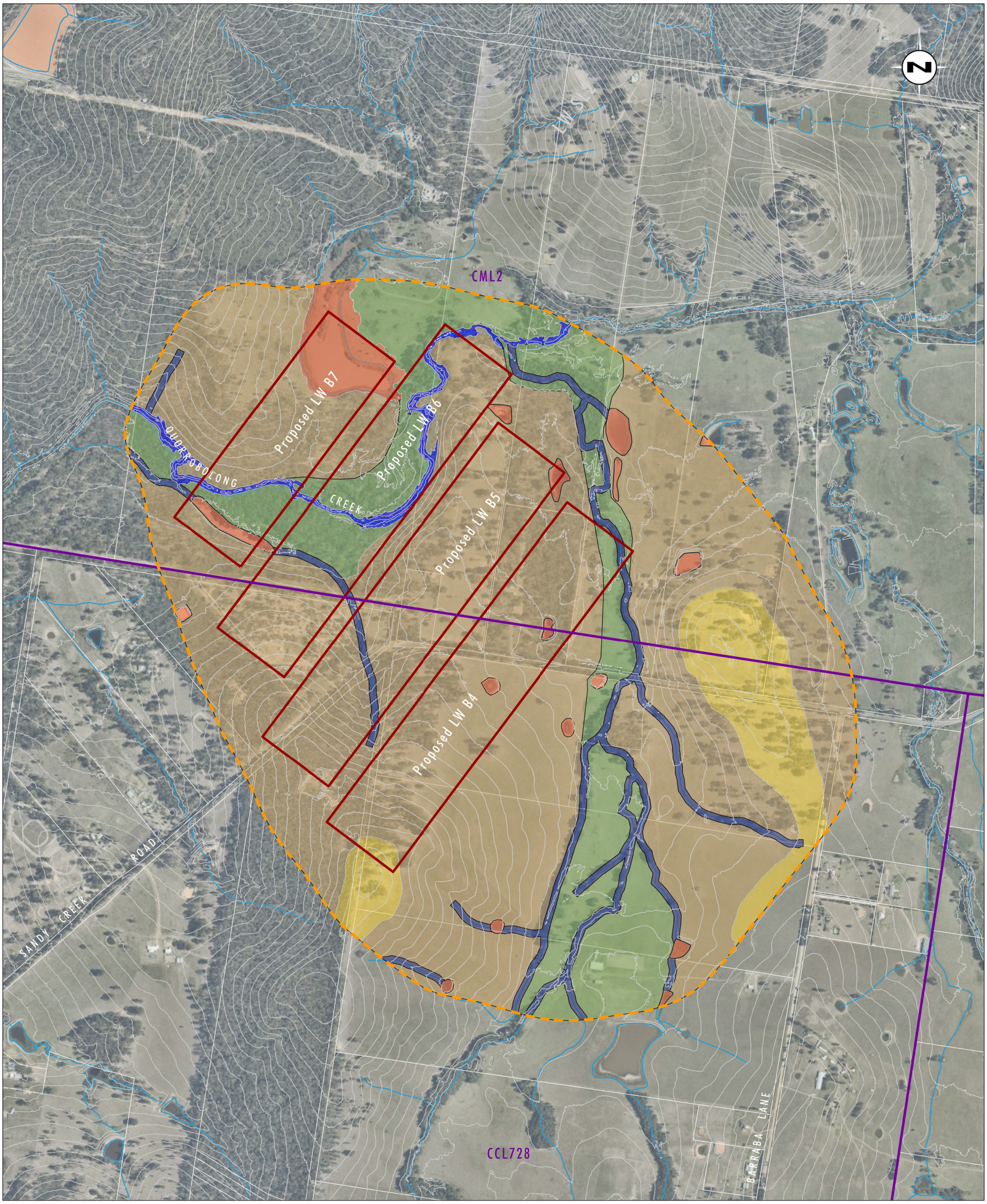

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)
Note: Contour Interval 2m

0 250 500 750m
1:15 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- Mining Lease Boundary
- Modified (Dam)
- Hill Crest
- Stream Channel (Quorrobolong Creek)
- Drainage Depression
- Valley Flat
- Slopes (Unspecified)

FIGURE 4.1

Preliminary Landform Mapping

File Name (A4): R04/3900_082.dgn
20170516 13.05

4.2 Ethnohistoric Information

Historical records, such as official records and personal observations recorded in diaries or publications, can provide information on Aboriginal history of a region since European contact. Although a valuable source of information, the limitations of these documents must be recognised as colonial observers generally tended to record unusual rather than everyday events, religious and social life rather than economic activity, and men's behavior rather than that of women and children. Further, early observations of the Hunter Valley tended to focus on coastal regions rather than inland areas. As such, ethnohistoric records are neither unbiased nor complete, and they cannot provide a complete understanding of Aboriginal beliefs and practices at the time of contact.

Published ethnohistoric sources for the Central Lowlands of the Hunter Valley region are relatively rare, although information can be found in sources such as Breton (1833), Cunningham (1827), Curr (1887), Dawson (1830), Ebsworth (1826), Eyre (1859), Grant (1803), Howe (1819), Ridley (1864) and Sturt (1833). Secondary sources such as Blyton et al (2004), Brayshaw (1966; 1986), Davidson and Lovell-Jones (1993), Miller (1985), Needham (1981) and Wood (1972) form the basis of the following discussion of the Aboriginal history of the Central Lowlands and the Cessnock-Wollombi area, with specific reference to locations and material culture utilised to provide context for this ACHAR.

These sections of the report are adapted from information originally presented by Umwelt (2008b).

4.2.1 Traditional Boundaries

The issue of identifying the boundaries of Aboriginal nations and tribes is complex. The LWB4-B7 Modification Area is located an area broadly indicated by Tindale (1974) as being located in the vicinity of the boundary between the lands of the Wonnarua[1] and Awabakal people, with Wonnarua territory mapped as extending south of Cessnock and north of Sugarloaf Range. However, there is a degree of variability in how Aboriginal tribal boundaries are mapped and, in this regard it was thought more appropriate to choose to use the registered Native Title boundaries as these have been mapped by and for Aboriginal people and not ethnographers or archaeologists.

The LWB4-B7 Modification Area is located within the boundaries of a registered native title claim (NC2013/006 *Scott Franks and Anor on behalf of the Plains Clans of the Wonnarua People*). A second application (NC2013/002), falls just outside the LWB4-B7 Modification Area, but covers other land within the Austar Coal Mine. Representatives from the NC2013/002 registered native title application (*Kerrie Brauer & Ors on behalf of the Awabakal and Guringai People*) have previously registered an interest in the Austar Coal Mine, as parts of the mine are within their registered Native Title application area. The details of these native title claims are not reviewed in detail here as the detailed information may represent sensitive cultural knowledge and it is the prerogative of the relevant claimants to identify how they wish this information to be shared. It is however noted that representatives of both claimant groups are registered Aboriginal parties for this ACHAR and may provide additional cultural information where relevant.

[1] The Wonnarua have variously been called: Wanaruah, Wonaruah, Wanarua and Wonnah-Ruah. Wonnarua is the spelling which will be used in this report except where a direct quote from another source is cited.

4.2.2 Historical accounts of Aboriginal people in the region

Early European observers recorded the lives of Aboriginal people in the Hunter Valley as intensely religious and constrained by strictly enforced laws (Ridley 1864 in Brayshaw 1986). The traditional lives of the Aboriginal people focused on the Hunter Valley and were structured around a schedule of social interactions designed to take advantage of seasonal availability of resources; meaning that people moved often, but not at random. Before the arrival of the Europeans the Wonnarua was a large grouping of individual family units and bands which occasionally came together for religious and ceremonial functions (Davidson and Lovell-Jones, 1993:3). People travelled freely within the broad area of responsibility of their own group. Social responsibilities and obligations meant that people also travelled beyond their own territories to attend ceremonies with neighbours, to trade and to develop social networks that linked people across extensive areas. There were documented links between the Wonnarua and the Awabakal and other tribal groups along the coastline and into western New South Wales (Brayshaw 1986: 38-41).

Ancestral Aboriginal people often lived and travelled in small groups of less than twenty people, but regularly met relations and neighbours for ceremonies where hundreds and sometimes thousands of people gathered for weeks at a time. Events like this were scheduled when and where seasonal resources were plentiful. Successive gatherings were rotated between a number of sites to allow the local environment to fully recover from periods of intensive exploitation. These gatherings were an opportunity to trade a wide range of goods from ceremonial songs and dances to stone axes, spears and native tobacco (Mulvaney 1986). Different groups sometimes specialised in producing high quality trade goods.

Most of the time, Aboriginal people were recorded as living in small groups moving regularly from camp site to camp site, living on local resources. There is little ethnographic evidence about where Aboriginal people camped; however, there is mention of the importance of fresh water, particularly in a non-coastal context. Also of importance when determining the location of camp sites, was the suitability of a site as a vantage ground in the case of enemy attack (Fawcett 1898:152 in Brayshaw 1986:42). While camping at a particular site, people would travel each day through the surrounding country to gather plant foods and to hunt or to visit areas that provided other required resources (for example stone, ochre, bark and resin). The daily foraging area was generally within a day's walk of camp (usually within about five kilometres).

Brayshaw (1986:59) notes that of all raw materials available, bark appears to have been the most widely used and the most adaptable. Use of bark for huts, or 'gunyers' as they are frequently referred to, is well documented, with descriptions by Caswell (1841) and Threlkeld (in Gunson 1974:45). Breton (1833) and Eyre (1859) noted suitable trees were also available to provide bark for wooden implements such as shields.

Early historic reports describe the Hunter Valley as having extensive grasslands and floodplains with few trees (Breton 1833, Cunningham 1827, Howe 1819). These grasslands are thought to be the result of Aboriginal fire stick farming techniques, which involved continually burning the countryside as a hunting strategy (Davidson and Lovell-Jones, 1993:5). Burning also cleared the undergrowth and fresh growth produced green shoots that attracted prey animals. Fawcett (1898) refers to the use of fire by the Wonnarua; and other early accounts (Cunningham 1827) also report the use of fire in the area.

Kangaroos, emus, possums and fish were recorded as plentiful (Breton 1833, Cunningham 1827, Dawson 1830), and mention was made of an abundance of food on the flatter ridges and plains that supported large populations of kangaroos (Cunningham 1827: 157). Early observations refer to hunted animal species, including kangaroos, wallabies and emus (Fawcett 1898:153), echidna (Fitzpatrick 1914:43 from Brayshaw 1986), goanna and native dogs (Dawson 1830:203), bandicoot (Ebsworth 1826:80), snakes (Threlkeld (in Gunson 1974:55), flying foxes (Dawson 1830:309), possums (Dawson 1830:68) and larvae (Grant 1803:162-3). There is very little evidence regarding the place of birds in the Aboriginal diet, although there are references to the mutton bird hunted on Nobbys Island, and ducks, geese, swans and pigeons (Threlkeld in

Gunson 1974:55). Hunting was frequently a group exercise, although animals were sometimes speared by individual hunters.

Weirs, or fish traps, were observed by early colonial observers, such as one observed by Grant (1803:154-155 in Brayshaw 1986:42) along the lower Hunter in 1801. The construction of a weir was also described by Threlkeld (in Gunson 1974:190) as:

> …planting sprigs of bushes in a zig-zag form across the streams, leaving an interval at the point of every angle where the men stand with their nets to catch what others frighten towards them by splashing in the water.

Brayshaw (1986:83) describes initiation ceremonies of the Hunter, which are described as using one or two cleared circles, which were often 350 metres apart. Around the circles, the trees were carved and in some cases, figures of raised earth were created on the ground. Threlkeld (in Gunson 1974:63-66) described that red ochre was used on important ceremonial occasions, as well as for other purposes. Threlkeld further describes that Aborigines got red ochre that was used on important ceremonial locations, being from a volcano 'up the River Hunter'. Reddish earth was sourced from this location, which was transformed into red ochre through a process involving wetting the earth, moulding it into balls and burning them in a strong fire.

Several forms of burial have been recorded in the Hunter Valley. Burial in the earth is the most commonly recorded, although the placement of the body could be varied and could be extended or flexed, face down or on its side or up (Brayshaw 1986:86). The use of bark as a burial shroud was widespread. There is some indication that burial practices varied between coastal and inland areas, with Threlkeld (in Gunson 1974:47,89,100) indicating that coastal burials were deliberately smoothed and scattered with branches to leave little indication of the burial on the surface. This contrasts with descriptions of inland burials (Breton 1833, Howitt 1904:446, Sturt 1833:14), where burials were usually marked with carved trees. A description of the burial of four men and two women of the Kamilaroi tribe by Breton (1833:203-204) involves the individuals being covered with mounds of earth (instead of being placed in a hole) in the centre of a circle approximately thirty feet in diameter cleared of vegetation. Breton further notes that the trees for some distance were carved with figures representing kangaroos, emus, possums and weapons, some of which extended twenty feet above ground.

4.2.3 Impacts of non-Aboriginal occupation

European arrival in the Hunter Valley began with the discovery of coal at Newcastle in 1797. By 1801 the Valley was reserved by the Crown as both a new convict settlement (a penal settlement was established in the Newcastle area in 1804) and for its resources in coal and timber (Davidson and Lovell-Jones, 1993:8). This reservation placed on the region by the Crown effectively restricted free settlement of the area; however, by 1819 the demand for grazing land and land for rural settlement increased beyond the current bounds of the colony's free settlement area and in 1821 Henry Dangar was commissioned to undertake a survey of the Hunter area to assess its suitability for settlement and farming.

Davidson and Lovell-Jones state that within months of Dangar reporting the Hunter Valley as suitable for settlement, claims for purchase and leasehold were being made from selectors in Sydney and by 1825 '…both sides of the Hunter River and associated brooks had been claimed' (Davidson and Lovell-Jones, 1993:8). The rapid settlement in the area disrupted the Aboriginal economy and, in a very short time, the Aboriginal population was substantially affected by a combination of starvation, introduced diseases and massacres.

First contact between the Wonnarua and the settlers may have been cordial (see citations in Davidson and Lovell-Jones, 1993:10) but rapidly turned hostile and violent with the Aboriginal community actively resisting the colonisation and appropriation of their land and resources, and the European landholders and their stockmen implementing 'widespread and indiscriminate' violence against Aboriginal people. This violence escalated significantly after 1826 and was fuelled in particular by the institutionalised violence by the Mounted Police (MacDonald and Davidson, 1998:60).

Documentary evidence suggests that by 1830 (only nineteen years after the first European settlers arrived in the Hunter) 'all armed resistance by local Aborigines' had ceased (Davidson and Lovell-Jones, 1993:17) and the traditional use of the land by Aboriginal people and their social structure and interactions had dramatically been affected – all within one generation. On the other hand, there are also some accounts of cultural ceremonies being conducted decades later, such as a ceremony held at Bulga in 1852, noted by Blyton et al. (2004:9); and a ceremony held at the junction of the Page and Isis Rivers at Gundy reported in the 1870s (McDonald 1878:255-258).

Since European settlement the Hunter Valley landscape has undergone radical changes. European colonisation saw the establishment of pastoral holdings, small towns and villages. Blyton et al. (2004:9) argue that the European pattern of settlement and land use rapidly became the normative occupation pattern 'replacing traditional Aboriginal communities' (Blyton et al., 2004:9). Davidson and Lovell-Jones (1993:17) also argue that shortly after European settlement all that remained were isolated family groups of Aboriginal people in the Hunter Valley existing 'on the fringes of towns and on properties trying as best they could to survive in a European modified environment'.

The material culture of Aboriginal people also changed dramatically following contact, with the rapid influx of new technologies and materials. For example, Threlkeld (in Gunson 1974:54, 67) provides two examples of new technologies being utilised by Aboriginal people within the Lake Macquarie area, noting that bottle glass was replacing stone ('fragments of quartz') in Aboriginal weapons and that iron and glass were being used for fish hooks.

European settlement and encroachment on resources and traditional camping groups restricted Aboriginal occupation and dramatically affected Aboriginal communities, but it did not completely destroy connections to traditional camping grounds. There is a continuation of cultural connection and in some cases occupation of these places that date well into the twentieth century.

4.2.4 Records relating to Cessnock and Wollombi

In addition to the above, there are a number of specific references to the Aboriginal history of the Cessnock and Wollombi areas. Aboriginal camp sites were recorded by early observers, such as Felton Mathew's recording (as late as 1830) of Aborigines camped in a 'romantic spot' on the bank of the Wollombi River near Broke (Brayshaw 1986:42). Another observation from this early period relates to local Aboriginal tribal groups, with Breton (1833:90-92 in Brayshaw 1986:57) stating:

> *Some miles from the inn we fell in with several of the aborigines, and the farther we rode the more we saw, until at length there were not less than sixty with us… These people consisted of the two tribes, one from Illarong, the other belonging to the Wallombi [sic] and were on their way to wage war with another tribe. Some of them were diligently employed in painting their sable bodies in a most fantastic manner, with a substance that resembled pipe clay.*

Needham (1981) discusses the Aboriginal history of the Cessnock and Wollombi region, based on review of primary sources and from discussions with local residents and Percy Haslam (University of Newcastle lecturer), and the Aboriginal meaning of several locations within the Quorrobolong Valley, as listed in **Table 4.1**.

Table 4.1 Aboriginal Place Names in the local area (Needham 1981:8)

Aboriginal Place Name	Meaning	Reference
Quorrobolong	A line of low hills	P. Haslam (*pers. comm.*)
Barraba	Place of Descent	P. Haslam (*pers. comm.*)
Congewai	Valley of the Lily	E. Crawford (*pers. comm.*)
Ellalong	Low swampy ground	*NA*
Coorabare	Derivation of the word: corroboree	P. Haslam (*pers. comm.*)
Watagan	Place of Many Ridges	P. Haslam (*pers. comm.*)
Wollombi	Place where the waters meet	*NA*

Needham identifies a number of Aboriginal sites within the Cessnock and Wollombi region, including one ceremonial ground (1981:35.) and two burial sites (1981:38) at Quorrobolong, based on information from Percy Haslam and local residents. The ceremonial location at Quorrobolong is described as a small ring with an apparent corridor leading away from it, therefore exhibiting bora characteristics (Needham 1981:36 from Haslam *pers. comm.*). The description further states there is no evidence of a larger ring, which is known on several other Hunter Valley bora grounds. A second ceremonial site is also described as being near Payne's Crossing (to the west of Millfield), and this site is described as consisting of a triplet of rings.

The burial sites at Quorrobolong are reported to be two of three known in the Wollombi region (1981:38 from Reynolds *pers. comm.*). All three burial sites are described as being under a tree or trees. As outlined in Needham (1981:35 from Reynolds *pers. comm.*):

> *The positioning and detail at one Quorrobolong site would suggest that the deceased was a person of some importance within the tribe. This rectangular plot measures three metres in length by two metres wide. There is a raised mound at the site…At each corner of the plot there stood an ironbark tree. However, only two of these trees now remain. One was chopped down, and the other was struck by lightning. The site faces north.*

Needham (1981:38) further states the second burial at Quorrobolong was reportedly of a young boy.

A map of the Aboriginal sites along the major creek systems of the Cessnock-Wollombi area is presented in Needham (1981:37), and this map illustrates two burial sites near Quorrobolong Creek. To determine the locations of these two areas more accurately, an attempt to overlay Needham's map on a topographic map for analysis was made; however, this was unsuccessful as the Needham map is unscaled and the creek systems illustrated do not match the actual creek line configuration of the area. Although the map cannot be used to identify any exact burial locations, it does depict both burials in a large southern bend of Quorrobolong Creek.

Mr Reynolds (the informant cited by Needham) was contacted by Umwelt on 12 April 2011 to establish the reliability of this information. He explained the burials he referred to were shown to him by his father and were located in relation to an earthen mound on a ridge (midslope) in a resource rich habitat near Wallis Creek near the Sandy Creek bridge. Mr Reynolds clarified that the bora site was also as being located in low lying land no more than 150 metres from Wallis Creek (Umwelt 2011). These locations are over 5 kilometres south-east of the LWB4-B7 Modification Area. However, the presence of highly significant sites of this type indicates that ceremonial activities were being undertaken within the local area.

Needham (1991) also references the importance of Ellalong Lagoon to local Aboriginal people. This is supported by the information included on a site card held by OEH. The site (AHIMS #37-6-0473) was recorded as a natural/mythological site based on a secondary account received from a Mr E. Cody who identified that the early non-Aboriginal occupants of the area referred to the lagoon as Catch-a-Boy Swamp based on their understanding of an Aboriginal cultural belief that the lagoon was inhabited by an entity who had taken a small boy who had been playing or swimming in the lagoon. This account is somewhat unclear and, in all likelihood, represents a simplification of a complex cultural story that was told at varying levels depending on the cultural knowledge of both the story teller and their audience. However, it does provide evidence of the assignation of cultural beliefs to key landscape features within the local area.

In describing the period of early non-Aboriginal settlement of the local area (including the Congewai Valley to the south-west of the LWB4-LWB7 Modification Area), Needham (1981:67) documented accounts from local non-Aboriginal informants relating to conflict between early non-Aboriginal people and the traditional owners of the area. In one account, poison bread was intentionally provided to Aboriginal people to ensure that they did not remain within the local area.

4.2.5 Material Evidence of Aboriginal land use

A review of previous archaeological investigations undertaken in the local area (refer to Section 3.1.1 of **Appendix 2**) focused on investigations undertaken within the Austar Coal Mine area. It is acknowledged that this does not represent an exhaustive review of Aboriginal archaeological assessments within the Hunter Valley. However, it is considered that the scale of review of available documentation is appropriate to the requirements of the current assessment.

These investigations (refer to Umwelt 2008b, 2011, 2013 and 2015) resulted in the identification of a number of Aboriginal archaeological sites, the majority of which comprise isolated stone artefacts or low density artefact scatters. All sites containing more than ten artefacts were identified in landforms bordering Cony Creek, including adjacent to a former terrace on Cony Creek (a creek that feeds into Quorrobolong Creek) on a creek flat. The landforms bordering Cony Creek and Sandy Creek (both of which flow into Quorrobolong Creek) were considered to have higher archaeological potential based on the likely resource availability within these areas when considered with reference to the pattern of site distribution in the local area, although it was acknowledged that these landforms were likely to have been subject to disturbance.

Other site types included one grinding groove site (AHIMS #37-6-1890) which was identified on a sandstone conglomerate platform within a first order drainage line, one scarred tree (AHIMS #37-6-2756) and four areas of Potential Archaeological Deposit. The areas of Potential Archaeological Deposit were identified in association with potential terrace landforms bordering Cony Creek.

Based on the outcomes of the previous archaeological investigations undertaken within the locality (particularly those undertaken within the Austar Coal Mine), a range of extensive predictions have been made and reassessed based on the outcomes of previous assessments (as undertaken in Umwelt 2008a, 2011, 2013). The key aspects of these predictions, with reference to the environmental context of the LWB4-B7 Modification Area, are provided below.

- Artefact scatters and isolated artefacts are the most likely site type to occur within the LWB4-B7 Modification Area. These sites may occur in any landform within the modification area but are most likely to occur in proximity to watercourses (noting that it must be taken into account that watercourse morphology may have been subject to significant change, as will be discussed below). Elevated areas (such as spur crests or ridge crests) that provide access to water resources may also be associated with higher numbers of sites and densities of sites.

- For sites containing stone artefacts, site numbers and artefact densities will typically be relatively low, with the majority of sites likely to contain less than 10 artefacts. However site and artefact densities may increase in proximity to the main channel of Quorrobolong Creek based on the more reliable nature of this watercourse when compared to others within the general locality (with the exception of Ellalong Lagoon).

- While pre-survey landform mapping did not identify any areas of terracing within the LWB4-B7 Modification Area, previous assessments have identified small areas of potential terracing along Cony Creek and the channel of Quorrobolong Creek (outside the LWB4-B7 Modification Area). In addition, it was identified that there is the potential for colluvial/alluvial interfaces within the areas of valley flats bordering the watercourses, particularly Quorrobolong Creek. Terraces and areas of alluvial-colluvial interface have the potential to contain archaeological deposit at depth, with the subsequent deposition of alluvial and/or colluvial material potentially introducing an element of stratigraphic integrity to any such deposits. Landforms of these types, should they occur within the modification area, may have higher archaeological potential than the surrounding landforms within which deposits have been subject to higher levels of impact and are unlikely to retain stratigraphic integrity.

- Scarred trees may occur in portions of the LWB4-B7 Modification Area where mature native vegetation remains. Based on the land use history of the modification area, the majority of the vegetation may comprise regrowth however consideration should be given to the potential for scarred trees to remain.

- Grinding groove sites (and potentially other sites associated with sandstone such as engraving sites) may occur in the LWB4-B7 Modification Area if suitable sandstone outcrops are exposed within the channel of Quorrobolong Creek and associated watercourses. However, given the relatively sandy nature of much of the soils within the local area, the potential for sandstone outcrops (and therefore sites found on sandstone outcrops) is relatively low.

- Levels of disturbance across the LWB4-B7 Modification Area are likely to have impacted the visibility and integrity of sites that may be present. The extent of these impacts will depend on the nature of the disturbance and the likely depth of any archaeological deposits that may be present.

The survey of the LWB4-B7 Modification Area was undertaken with reference to the predictions outlined above. The outcomes of the survey are summarised in **Section 5.0**, with further details provided in the ATR in **Appendix 2**.

4.2.6 Previous Statements Regarding Aboriginal Cultural Values

As discussed in **Section 3.1**, ongoing consultation has occurred at regular intervals with the registered Aboriginal parties since 2007. Over this period, the outcomes of consultation indicate that there is a strong connection from registered Aboriginal parties to the wider areas subject to prior assessment. Key value statements or comments provided by registered Aboriginal parties are summarised below.

In relation to the assessment of the Stage 3 area (refer to **Figure 1.2**), during the field survey all Aboriginal representatives involved in survey stated that all archaeological sites are of cultural significance, but that the grinding groove site (ACM6) identified in that area was of particular significance due to its rarity.

Registered Aboriginal party representatives also stated that site ACM14, an artefact scatter along Cony Creek, was also of higher cultural significance as the area would have been an area of high occupation and use. In addition, Arthur Fletcher (Kauwal) stated that areas around water courses are culturally significant as they represent a livelihood and a connection to country. On the ACM6 grinding groove, Mr Fletcher indicated that the site is of particular significance as it represents a tangible link to past traditional use of the area. The grooves represent an area where tools could have been repaired, and are evidence of our cultural existence and belonging to the area. Mr Fletcher further indicated that this area is of the highest cultural significance as it serves as a cultural link to his ancestors' lives. On the ACM14 artefact scatter, Mr Fletcher indicated that the site represents an obvious area of high occupation, on which basis the area is highly culturally significant.

During consultation for the LWB1-B3 Modification Area (part of which overlaps with the current Modification Area), the majority of registered Aboriginal parties did not supply additional cultural information. However, Margaret Matthews (Aboriginal Native Title Consultants) indicated that she felt that the area was not likely to have contained a camp site and that it was used more transiently by Aboriginal people moving between Ellalong Lagoon and Wollombi (Umwelt 2015).

On behalf of Tocomwall, Danny Franks raised some concerns with the nature of the archaeological survey and requested that any future assessment give consideration to 'all of the data the study area in question has to offer' and requested that 'in future developments the scientific approach towards the study area needs to take into account the diffusion of values and ideologies that the landscape and archaeological record can provide to future stakeholders.' Mr Franks then went on to reference the importance of documenting stone artefact assemblages as part of the assessment process. These comments (as documented in Umwelt 2015) have been taken into consideration in terms of the information provided in the ATR (**Appendix 2**).

It is acknowledged that the information presented above may be subject to change with reference to the current ACHAR however this information is provided to demonstrate that previous statements made by Aboriginal parties regarding cultural values have been accepted and used to inform the current assessment.

5.0 Outcomes of Survey of Modification Area

The survey of the LWB4-B7 Modification Area was conducted on 9-10 February 2017, with an additional survey undertaken on 21 March 2017. This section documents the survey outcomes.

5.1 Information provided by Aboriginal Party Representatives

In accordance with the approved methodology, Aboriginal party representatives who participated in the survey were requested to provide information on any Aboriginal cultural values that they identified within the LWB4-B7 Modification Area. Key information provided by Aboriginal party representatives is documented in **Section 3.3.1** and is not repeated here.

5.2 Aboriginal Archaeological Sites/Areas of Archaeological Potential

Detailed information on the archaeological sites and areas of archaeological potential is provided in the ATR (**Appendix 2**) and is summarised below. The LWB4-B7 Modification Area was divided into survey units, as shown with reference to key landforms in **Figure 5.1.** These survey units were subject to pedestrian inspection by Aboriginal party representatives and archaeologists. During the survey, it was noted that the modification area has been subject to a range of disturbance factors associated with historical land use however the potential for alluvial soils to exist in areas along Quorrobolong Creek was identified.

A total of 13 new sites were identified, of which one is located outside the LWB4-B7 Modification Area. Site cards for each site have been completed and submitted to OEH in accordance with the requirements of the NPW Act.

Site locations are shown in **Figure 5.2** and information on sites is summarised in **Table 5.1.**

Table 5.1 Contents of newly identified archaeological sites

Site Name	Site Type	# of Artefacts	Artefact classes	Artefact raw materials
ACM37	Artefact scatter	2	Flakes	Mudstone, quartz
ACM38	Artefact scatter	27	Broken flakes, flakes, broken backed flakes, broken grindstone, flaked piece, heat shatter	Mudstone, silcrete, quartz, tuff, sandstone
ACM39	Isolated artefact	1	Flake	Silcrete
ACM40	Artefact scatter	29	Broken flakes, flakes, broken backed flakes, core, flaked piece, retouched flake	Mudstone, silcrete, quartz, chert, quartzite, petrified wood
ACM41	Isolated artefact	1	Flake	Quartz
ACM42	Artefact scatter	4	Broken flakes, flakes, core	Silcrete, quartzite

Site Name	Site Type	# of Artefacts	Artefact classes	Artefact raw materials
ACM43	Artefact scatter	4	Broken flake, grindstone, retouched flake	Silcrete, unknown
ACM44	Artefact scatter	3	Broken flake, flake, retouched flake	Silcrete, quartzite, fine grained siliceous
ACM45	Artefact scatter	3	Broken flake, retouched flake	Mudstone, silcrete
ACM46	Isolated artefact	1	Flake	Mudstone
ACM47	Artefact scatter	3	Broken flakes	Mudstone, silcrete
ACM48	Isolated artefact	1	Flake	Silcrete
ACM49	Isolated artefact	1	Flaked piece	Silcrete

These sites consisted of isolated artefacts and artefact scatters, with only two sites (ACM38 and ACM40) containing more than five artefacts. The distribution and contents of these sites is relatively comparable to the outcomes of previous archaeological investigations within the Austar Coal Mine and surrounds. No grinding grooves or scarred trees were identified within the LWB4-B7 Modification Area and no areas of outcropping sandstone were present within Quorrobolong Creek.

Based on the criteria for the assessment of archaeological potential, the majority of the LWB4-B7 Modification Area was assessed as having low archaeological potential. The exceptions to this are the valley flats bordering Quorrobolong Creek (moderate potential), slopes within 100 metres of the main channel of Quorrobolong Creek and identified overflow channels and the spur crest in Survey Unit 9 (all of which have low to moderate archaeological potential).

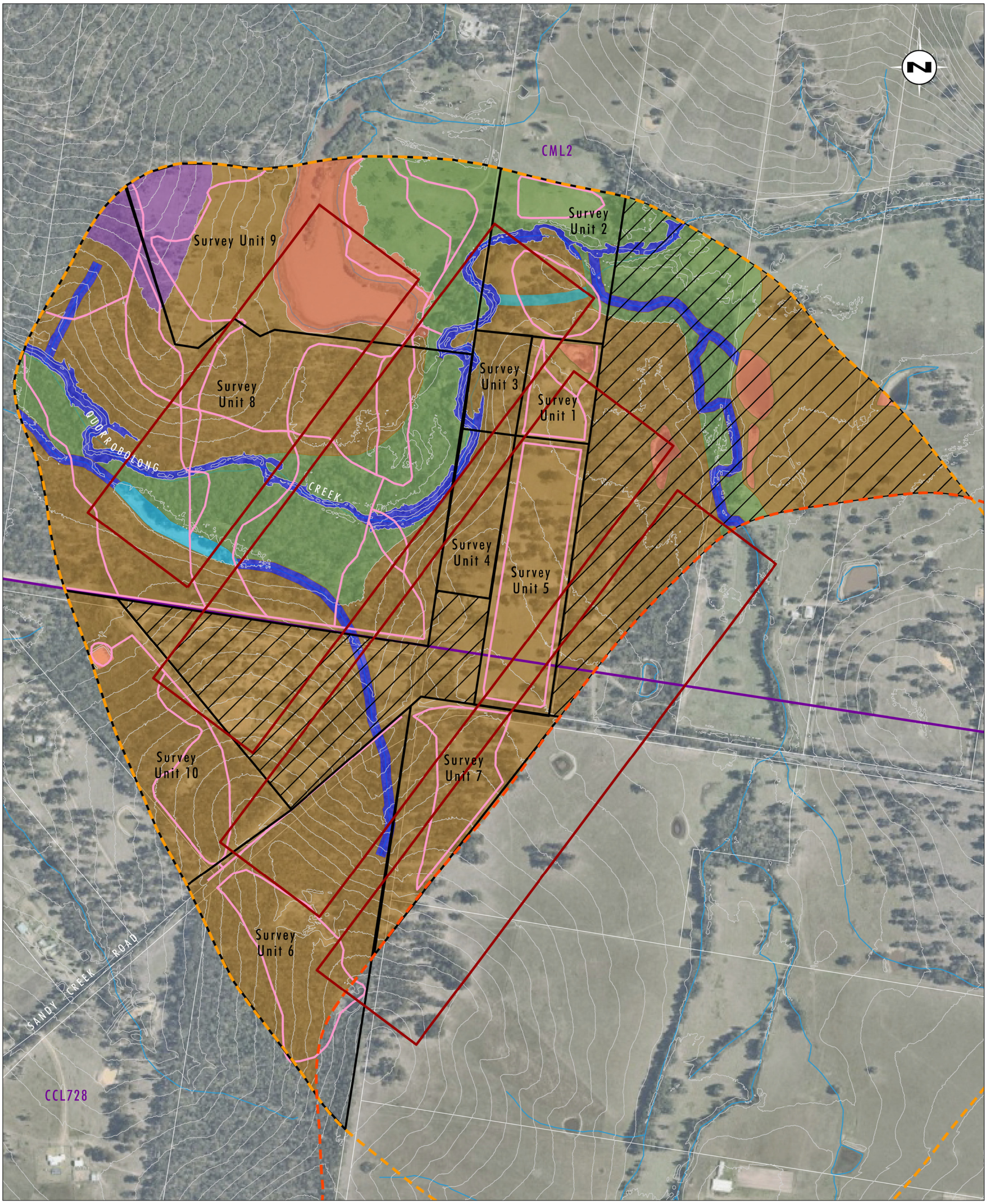

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)
Note: Contour Interval 2m

0 100 250 500m
1:10 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- LWB1-B3 Modification Area
- Mining Lease Boundary
- Modified (Dam)
- Hill Crest
- Overflow Channel
- Stream Channel (Quorrobolong Creek)
- Valley Flat
- Slopes (Gently Inclined)
- Minor Spur Crest
- Survey Transect
- Survey Unit
- Area not accessible for survey

FIGURE 5.1

Survey Units

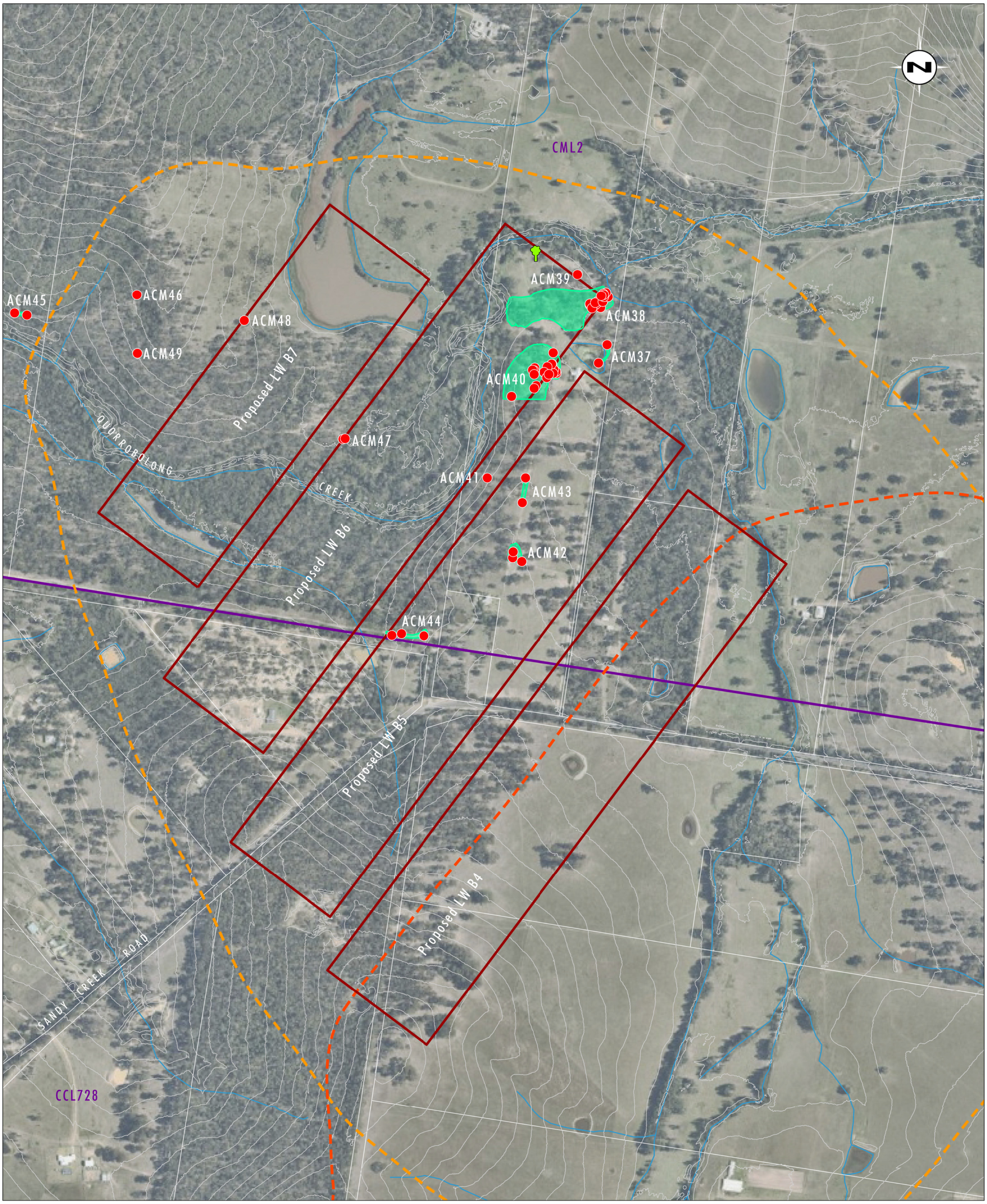

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)
Note: Contour Interval 2m

0 100 250 500m
1:10 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- LWB1-B3 Modification Area
- Mining Lease Boundary
- Archaeological Site Area
- Artefact Location
- Tree with Non-cultural Scarring

FIGURE 5.2

Location of Newly Identified Sites

File Name (A4): R04/3900_081.dgn
20170516 13.02

6.0 Assessment of Cultural Value

6.1 Social or Cultural Value

Cultural heritage value refers to the spiritual, traditional, historical or contemporary associations and attachments a place has for Aboriginal people (OEH 2011:8). There is not always consensus about the cultural value of a place as people experience places and events differently, and in some instances cultural values may be in direct conflict. Cultural significance can only be determined by Aboriginal people, and is identified through Aboriginal community consultation.

A draft of this report was provided to the registered Aboriginal parties with an invitation to provide information regarding the cultural significance of the LWB4-B7 Modification Area, the landscape features, archaeological sites and areas of archaeological potential that it contains. . No objections were raised by registered Aboriginal parties to the following summary of information regarding cultural values within the LWB4-B7 Modification Area and surrounds provided by registered Aboriginal parties to date.

Over the course of previous assessments undertaken in the local area, the registered Aboriginal parties have identified that the landscape including the LWB4-B7 Modification Area is of cultural value due to the natural and cultural features it contains and its place within the broader cultural landscape. Previously identified sites have been assessed as being culturally significant as the artefacts within these sites provide a tangible connection to Aboriginal use of the area. In the past, a grinding groove site located outside the LWB4-B7 Modification Area has been identified as having very high Aboriginal cultural significance due to its comparative rarity within the local area and the nature of this particular site type. Registered Aboriginal party representatives also stated that site ACM14, an artefact scatter along Cony Creek, was also of higher cultural significance as the area would have been an area of high occupation and use.

In relation to the current assessment, registered Aboriginal party representatives who participated in the survey identified that Quorrobolong Creek is a key water resource within the area and has high cultural value for both its natural aspects and its association with archaeological evidence. Maintaining the health of watercourses within the LWB4-B7 Modification Area was seen as very important to ensure protection of natural and cultural values.

The Aboriginal party representatives indicated general agreement with the identification of areas of archaeological potential in association with Quorrobolong Creek and the elevated landform in the north-western portion of the LWB4-B7 Modification Area. The Aboriginal party representatives indicated that the identified archaeological sites have inherent Aboriginal cultural value. Danny Franks (Tocomwall) indicated that he felt that the sites or areas of potential where there is an increased likelihood that deposits will retain integrity are of greater value as the interpretation of these sites/deposits could provide more specific information about the Aboriginal occupation of the area and how this may have changed over time.

In providing comments on the draft report, Tracey Skene (Culturally Aware) identified that the landscape in the vicinity of the LWB4-B7 Modification Area has high cultural significance, with each site (both recorded and unrecorded) having unique spiritual and cultural values and connections. The high significance of Ellalong Lagoon was identified by Ms Skene who also stated that the LWB4-B7 Modification Area ‘has a known creek called Quorrobolong creek, this area may have a low scientific values but holds a high importance and cultural significance to the Aboriginal Community.’

6.2 Historic Value

Historic value encompasses all aspects of history and as such is often underlying other values. A place may have historic value because it has influenced, or been influenced by, an historic event, phase, movement or activity, person or group of people. The historical values associated with the LWB4-B7 Modification Area are assessed in Umwelt (2017a:Section 6.7). This assessment did not identify any items of historical significance at the local or State level within the LWB4-B7 Modification Area.

As a result of this assessment and previous assessments undertaken in the local area, no specific areas or items of historical value with a direct association with Aboriginal people have been identified. No further information regarding historic value was provided by Aboriginal parties in response to the draft report.

6.3 Scientific (archaeological) Value

An assessment of the scientific (archaeological) value of the sites and areas of archaeological potential is conducted in Section 6 of **Appendix 2**. This assessment was conducted in accordance with OEH requirements and with reference to the key criteria identified in *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011). The factors taken into account in assessing scientific significance are described in Section 6 of **Appendix 2**, with a summary of outcomes provided below.

The archaeological significance of the identified sites was assessed as low, with the exception of sites ACM38 and ACM40, which were assessed as having low-moderate archaeological significance, largely based on their research potential. The assessment of significance of areas of archaeological potential remains a provisional assessment of potential significance only and is linked almost entirely to the research potential of the site. That is, areas of moderate archaeological potential have a provisional assessment of moderate archaeological significance, with areas of low-moderate potential having low to moderate significance.

6.4 Aesthetic Value

Aesthetic value refers to the sensory and perceptual experience of a place. It may consider form, scale, texture and material of the fabric or landscape and may also include smell and sounds associated with the place (OEH 2011:9).

No further information regarding aesthetic value was provided by Aboriginal parties in response to the draft report.

7.0 Impacts of Proposed Modification

The purpose of this section is to identify whether the LWB4-B7 Modification will result in impacts to Aboriginal cultural heritage within the LWB4-B7 Modification Area.

7.1 Subsidence Predictions

The maximum predicted subsidence parameters within the LWB4-B7 Modification Area have been determined by MSEC (2017) and are summarised in **Table 7.1**. The values presented in **Table 7.1** represent the maximum cumulative subsidence associated with the extraction of approved LWB1-B3 and proposed LWB4-B7.

Table 7.1 Maximum predicted subsidence parameters for Aboriginal archaeological sites within the LWB4-B7 Modification Area

Longwall	Max. Predicted Total Subsidence (mm)	Max. Predicted Total Tilt (mm/m)	Max. Predicted Total Hogging Curvature (km^{-1})	Max. Predicted Total Sagging Curvature (km^{-1})
After LWB4	125	1.5	0.03	<0.01
After LWB5	400	3.0	0.03	0.01
After LWB6	1025	3.5	0.03	0.04
After LWB7	1225	4.5	0.04	0.04

The subsidence predictions outlined in **Table 7.1** for the LWB4-B7 Modification Area are less than those for the previously approved Stage 2 and Stage 3 mining areas, where there has been no significant or notable subsidence or surface cracking observed and no requirement for remediation of any ground surface cracking.

7.2 Potential Impacts of the Proposed Modification

The LWB4-B7 Modification does not involve any additional surface development and therefore will have no direct impact on the landscape within the LWB4-B7 Modification Area. The potential impacts of the proposed modification on archaeological sites are therefore limited to indirect impacts associated with subsidence, including potential landscape impacts, surface cracking, subsidence remediation works or hydrological changes.

7.2.1 Landscape Impacts

The nature of the modification (i.e. underground longwall mining) and the existing undulating landform means there is very limited potential for detectible changes to the landscape to occur as a result of the modification. Potential visual impacts are limited to minor changes in terrain associated with subsidence within the LWB4-B7 Modification Area. Based on this assessment, it is unlikely that the extent of subsidence and subsequent changes to the overall landscape will be able to be detected by eye.

7.2.2 Subsidence related Surface Cracking and Remediation

Potential changes in the ground surface resulting from subsidence have been assessed by MSEC (2017). MSEC notes that surface cracking in soils as the result of conventional subsidence movements is not commonly observed where the depths of cover are greater than 400 metres, as is the case for the proposed modification. The subsidence assessment findings indicate that due to the depth of mining within the proposed modification area (minimum 400 metres), the massive nature of the Branxton Formation sandstones overlying the coal seam resulting in the small magnitudes of predicted ground curvatures and strains and the absence of steep slopes or cliffs within the modification area, the potential for surface cracking is low.

This conclusion is supported by subsidence monitoring evidence within the Stage 2, Stage 3 and LWB1-B3 mining areas, where there has been no significant or visible surface cracking above previously extracted longwalls A3 to A8 or LWB2.

Any surface cracking that does occur is expected to be minor and isolated and unlikely to directly or adversely impact the LWB4-B7 Modification Area. Based on previous experience within the broader Austar Coal Mine, remediation of surface cracking is unlikely to be required within the LWB4-B7 Modification Area.

7.2.3 Hydrological Changes

Flood modelling has been undertaken by Umwelt (2017d) to assess the potential changes in flooding and surface water flows resulting from predicted subsidence associated with the extraction of LWB4-B7. The flooding and drainage assessment concludes that the proposed modification is unlikely to have a significant impact on runoff regimes, bank stability or channel alignment and will not result in scouring or increased erosion of the landscape. The assessment predicts minor changes to remnant ponding around some existing flow paths and farm dams. These minor changes to the extent of remnant ponding occur within low lying areas that are already subject to periodic inundation during periods of high rainfall. Therefore additional periods of inundation in these locations are highly unlikely to result in any additional impact to Aboriginal cultural values that may be present. It is noted that the proposed extent of subsidence is considered unlikely to result in changes to the course of Quorrobolong Creek or to necessitate any mitigation works along the Quorrobolong Creek or associated watercourses.

7.2.4 Summary

Based on the outcomes of assessments undertaken by MSEC (2017) and Umwelt (2017d), the proposed LWB4-B7 Modification is unlikely to result in direct or indirect impacts that will impact the Aboriginal cultural values associated with the area. On this basis, it is not currently necessary to develop avoidance or mitigation strategies as there is no identified impacts.

8.0 Recommendations

The following recommendations were provided to the registered Aboriginal parties for review and comment prior to the finalisation of this report. The recommendations have been developed to reflect the outcomes of consultation with the registered Aboriginal parties and in light of the archaeological context of the LWB4-B7 Modification Area; the findings of the current survey and the previous survey of the LWB1-B3 Modification Area; the low likelihood of impact of the proposed modification on identified archaeological sites and areas of archaeological potential and current cultural heritage legislation:

- The Austar Coal Mine should continue to implement the management strategies currently in place at the Austar Coal Mine, including those in the Austar Aboriginal Cultural Heritage Management Plan (ACHMP). Consistent with existing management strategies, in the unlikely event that subsidence remediation works are required that will impact on the identified sites or areas of low-moderate or higher archaeological potential, an Aboriginal Heritage Impact Permit (AHIP) will be sought for the portion of the site or area of potential to be impacted prior to the commencement of any remediation works in proximity to the recorded site or area of potential (noting that, in some instances, it may be necessary to undertake test excavation to inform the requirement for an AHIP). Appropriate mitigation measures for the site or area of potential to be impacted by the remediation works will be developed as part of the AHIP application process in consultation with the registered Aboriginal parties and in accordance with OEH requirements. The ACHMP includes provision for pre and post subsidence monitoring of recorded sites to provide comparative data on site condition and to allow for the identification of any unexpected subsidence impacts.

- The Austar ACHMP should be reviewed to incorporate the outcomes of this assessment and to include provisions for the monitoring of identified archaeological sites within the LWB4-B7 Modification Area in accordance with the management strategies currently implemented within the Austar Coal Mine.

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APPENDIX 1

RAP Consultation

From: Nicole Davis
To: Nicola Roche
Subject: RE: Austar Mine Consultation Query
Date: Thursday, 15 December 2016 1:23:32 PM

Dear Nic,

I ran your query past Richard Bath and he had no concerns with the approach you have outlined for continued community consultation for the Austar Mine.

Regards
Nicole

Nicole Y Davis
Archaeologist - Planning
Hunter Central Coast Region
Regional Operations Group
Office of Environment and Heritage
Locked Bag 1002 Dangar NSW 2309
(Level 4/26 Honeysuckle Drive Newcastle)
T: (02) 4927 3156
M: 0409 394 343
E: nicole.davis@environment.nsw.gov.au
Please note that I work part-time Monday to Thursday.

From: Richard Bath
Sent: Thursday, 15 December 2016 12:06 PM
To: Nicole Davis <Nicole.Davis@environment.nsw.gov.au>
Subject: RE: Austar Mine Consultation Query

Sounds reasonable to me.

Regards

Richard Bath
Senior Team Leader Planning
Hunter Central Coast Region
Regional Operations Group
Office of Environment and Heritage
Locked Bag 1002 Dangar NSW 2309
(Level 4/26 Honeysuckle Drive Newcastle)
T: 4927 3152
M: 0408 266 986
W: www.environment.nsw.gov.au

From: Nicole Davis
Sent: Thursday, 15 December 2016 10:22 AM
To: Richard Bath <Richard.Bath@environment.nsw.gov.au>
Subject: Austar Mine Consultation Query

Dear Richard,

Can you please read below and advise if you are a happy for me to give them the go ahead to maintain the current consultation process? Their request sounds reasonable to me.

Cheers Nicole

Nicole Y Davis

Archaeologist - Planning
Hunter Central Coast Region
Regional Operations Group
Office of Environment and Heritage
Locked Bag 1002 Dangar NSW 2309
(Level 4/26 Honeysuckle Drive Newcastle)
T: (02) 4927 3156
M: 0409 394 343
E: nicole.davis@environment.nsw.gov.au
Please note that I work part-time Monday to Thursday.

Hi Nic
Further to our discussion yesterday, Austar Mine will shortly be commencing the Aboriginal cultural heritage assessment process in relation to a proposed modification to their existing approval.

Consultation with registered Aboriginal parties for the existing approvals has been consistent and ongoing. The most recent consultation has been in relation to a revision of the ACHMP, with consultation ongoing up to Oct/Nov of this year.

Given the above, Austar proposes to continue to consult with the existing group of registered Aboriginal parties for the project rather than redoing the public notification and registration process. Can you please confirm whether this approach is acceptable to OEH.

Happy to discuss at any stage.
Nic

Copy of Letter Sent to all Aboriginal Parties Reference Draft Methodology for ACHAR

Our Ref: 3900_RAPs_20170105a_ltr

5 January 2017

<<Company Name>>
<<Contacts>>
<<Address>>

<<Email>>

Dear<< Contacts>>

Re: Proposed Modification to DA 29/95 (MOD 7) – LWB4-B7, Austar Coal Mine Pty Ltd

Austar Coal Mine Pty Limited (Austar), a subsidiary of Yancoal Australia Limited (Yancoal) operates Austar Coal Mine, an underground coal mine located approximately 10 kilometres south of Cessnock (refer to **Figure 1**).

Austar is seeking to modify its development consent DA29/95. The modification will be sought under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The proposed modification is to permit the transfer and processing of coal from four (4) proposed longwall panels (LW) B4 to B7. The location of LWB4 to B7 is shown on **Figure 1** and **Figure 2**. There is no proposed change to any existing approved surface operations or associated infrastructure.

Austar has commissioned Umwelt (Australia) Pty Limited (Umwelt) to prepare an Aboriginal cultural heritage and archaeological assessment (ACHAA) for the proposed modification in consultation with the registered Aboriginal parties, including your organisation. The ACHAA will be undertaken in accordance with the requirements of the *National Parks and Wildlife Act 1974* (NPW Act), the *National Parks and Wildlife Regulation 2009* (NPW Regulation) and the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (the Code of Practice). The ACHAA will form part of an Environmental Assessment for the proposed modification.

As a registered Aboriginal party for Austar Coal Mine we are writing to advise you of the proposed modification and to invite you to participate in the Aboriginal consultation process for the project. In line with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (ACHCRs), this letter provides a draft methodology for the ACHAA of the modification area for your review and comment.

1.0 Description of the Modification Area

The LWB4-B7 modification area is shown on **Figure 2** and extends south of the existing Bellbird South mains to cover the proposed longwall panels and the extent of associated subsidence.

As shown by **Figure 1**, there has been significant longwall mining undertaken within the surrounding region over a long period of time. As a result, Austar has a detailed understanding of the potential subsidence impacts associated with its mining activities. Monitoring of previous longwall mining activities in the surrounding area has shown no

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significant impacts on natural features or surface infrastructure. This is primarily due to the significant depth of mining, the site characteristics and Austar's existing management and mitigation measures. Mining of LWB4-B7 will occur at a similar depth to the adjacent LWB1-B3 and on this basis it is expected that subsidence impacts on natural features will be similarly low. This will be confirmed by a comprehensive assessment of mine subsidence impacts on natural features and surface infrastructure for LWB4-B7.

The LWB4-B7 modification area incorporates a mix of Austar owned land, privately owned rural land, and Crown and Council land including sections of Sandy Creek Road and Quorrobolong Creek. Portions of the modification area are relatively heavily vegetated, in particular along the main drainage line of Quorrobolong Creek and on the Crown landholding. The remainder of the LWB4-B7 modification area has been cleared for agricultural grazing.

2.0 Methodology for the Aboriginal Cultural Heritage and Archaeological Assessment

As discussed in **Section 1.0**, the consultation process will be undertaken in accordance with the DECCW (2010) ACHCRs. The proposed methodology for the ACHAA (pending comments from registered Aboriginal parties) is as follows:

1. Provide information to all registered Aboriginal parties regarding the proposed modification, including a draft methodology for review and comment (this letter)

2. Undertake a survey of the LWB4-B7 modification area in accordance with the draft methodology provided in this assessment (refer to **Section 3.0**)

3. Develop a draft ACHAA report to include:

   - details of the nature of the proposed LWB4–B7 modification
   - a description of the potential impacts from subsidence
   - full details of the registered Aboriginal party consultation process
   - the results of an Office of Environment and Heritage (OEH) Aboriginal Heritage Information Management System (AHIMS) search and Native Title search
   - a review of the cultural context of the LWB4-B7 modification area which will draw heavily on information provided by registered Aboriginal parties and the known archaeological sites in the area
   - a review of background information related to the environmental characteristics of the LWB4-B7 modification area that may have determined how Aboriginal people may have occupied/utilised the area and the likelihood of site survival
   - the preparation of a predictive model drawing on all of the above
   - details of the survey methodology and results
   - details of any sites/objects/potential archaeological deposits located during the survey
   - an assessment of the Aboriginal cultural heritage significance
   - an assessment of the archaeological significance of any sites/objects/potential archaeological deposits located during the survey
   - an assessment of the potential impact by subsidence/subsidence remediation works to any sites/objects/potential archaeological deposits located during the survey
   - a discussion of management options and
   - management recommendations.

Participating registered Aboriginal parties will be encouraged to provide information they feel is appropriate for inclusion in the report. Registered Aboriginal parties will also have the opportunity to provide information that they would like taken into account but not presented in a report that will be made available to the public. Registered Aboriginal parties will be given 28 days to review and provide their response to the draft report.

After completion of the final ACHAA, the current Austar Aboriginal Cultural Heritage Management Plan (Umwelt 2016) will be revised to include the proposed modification upon its approval. The revised Aboriginal Cultural Heritage Management Plan will also be subject to registered Aboriginal party review.

3.0 Survey Methodology

A survey of the LWB4-B7 modification area would be undertaken in accordance with the following methodology.

The LWB4-B7 modification area is approximately 300 hectares in size. It includes areas of cleared agricultural land and heavily vegetated areas. The LWB4-B7 modification area is crossed by the main channel of Quorrobolong Creek and a number of first and second order tributaries.

The proposed survey will target indicative landforms within the LWB4-B7 modification area where Aboriginal archaeology is predicted to occur and in areas where landholder permission has been granted. The survey will be designed to ensure there is adequate coverage of landforms and will be undertaken with reference to levels of visibility and exposure. The areas predicted to be likely to contain discernible Aboriginal archaeology are limited to hill crests, spur crests and in proximity to water resources. In addition to these predicted areas, the registered Aboriginal parties will be provided the opportunity to inspect the remainder of the LWB4-B7 modification area that has not been previously assessed, as required, subject to landholder access. It is noted that portions of the LWB4-B7 modification area adjacent to LWB3 were surveyed by the registered Aboriginal parties in 2015 as part of the previous LWB1-B3 modification.

4.0 Survey Date

The survey will be undertaken in early February 2017 on a date to be determined pending Aboriginal party responses to this correspondence. It is proposed that the survey will be undertaken over the course of one to two days however this will depend on land access and confirmation of the survey methodology. Further details of the survey date and time will be provided to groups that express an interest in participating.

5.0 Schedule of Rates

In order to clarify Austar's payment for the field survey engagement and meetings called by Austar, **Table 1** provides a schedule of rates. GST will be paid in addition on all invoices.

Table 1 Schedule of Rates

Item	Rate per Group (ex GST)	Detail
Full day (8:00am to 4:00pm typically)	$550 / day	Full day rate includes survey works/meetings greater than 4 hours duration.
Half day (less than 4 hours)	$300 / half day	Half day rate for survey works / meetings less than four hours, or non-notified survey cancellations due to wet weather or other reasons.
Travel allowance	$50 / day	For groups travelling each day, and for first day of consecutive survey days for those from further afield that requiring accommodation.
Accommodation and subsistence allowance	$150 / night	Only available to groups from further afield (e.g. Scone, Muswellbrook) where consecutive field survey days are planned. Not applicable where Group travels home each day.
Notified cancellation	Nil	

6.0 Documents Required Prior to Survey

If it has been more than 12 months since the last time you undertook any field survey at Austar Coal Mine, we will require you to provide us with information related to your insurance coverage including certificates of currency.

Please fill out the attached field work application form and return with the appropriate attachments to me by mail or email (gary.mulhearn@yancoal.com.au) **prior to 5.00 pm on 23 January 2017**.

7.0 Summary

This letter provides details of the proposed methodology for an Aboriginal Cultural Heritage and Archaeological Assessment associated with a modification of development consent DA29/95 at Austar Coal Mine for your review and comment. In order to participate in the process, we request that your group provides the following:

- completed field work expression of interest form (attached) and **returned by close of business 23 January 2017**

- in accordance with the requirements of the NPW Regulation, we ask that your group provides comments on the draft methodology by no later than **5.00 pm on 6 February 2017**. Comments regarding the draft methodology can be provided verbally or in writing and contact information is provided below.

Should you require any further information or wish to discuss any aspect of this project, please do not hesitate to contact Nicola Roche of Umwelt on (02) 4950 5322 or Gary Mulhearn of Austar on (02) 4993 7334 or 0403 963 081.

Yours sincerely

Nicola Roche
Manager Cultural Heritage

Enclosures: Archaeological Fieldwork Application Form
Figure 1: Locality Plan
Figure 2: Proposed LWB4-B7 Modification

Archaeological Fieldwork Application Form Austar Coal Mine – Proposed Modification to DA29/95 (MOD 7) - LWB4-B7

To: Austar Coal Mine Pty Ltd (Return by 5:00 pm on 23 January 2017)
Email: Gary.Mulhearn@yancoal.com.au
Phone: 02 4993 7334
Attention: Gary Mulhearn

Item	Response (Circle response and provide detail)
Nominated field work representative and representative contact phone number.	Name:______________________________ Phone:______________________________
The Awabakal and Guringai People have current appropriate insurance, please attach certificate of currency for insurance.	Y / N Y / N Certificate of currency attached
The Awabakal and Guringai People will provide their representative with appropriate Personal Protective Equipment and Clothing (PPE&C) including boots; long trousers and hat, which must be worn by all participants during fieldwork; and water.	Y / N
The The Awabakal and Guringai People representative is physically fit, capable of walking over steep slopes and has no serious medical conditions which are likely to inhibit fitness during fieldwork. (All pre-existing medical conditions or illnesses must be identified).	Y / N Provide details if NO.
The The Awabakal and Guringai People representative will only represent The Awabakal and Guringai People for the purposes of this fieldwork.	Y / N
The The Awabakal and Guringai People representative has demonstrated appropriate experience, ability and reliability.	Y / N
The Awabakal and Guringai People accepts the terms in Austar letter dated 5/1/17.	Y / N

Name:_________________________________ Signature:_________________________________

Date:_________________________________

The Awabakal and Guringai People

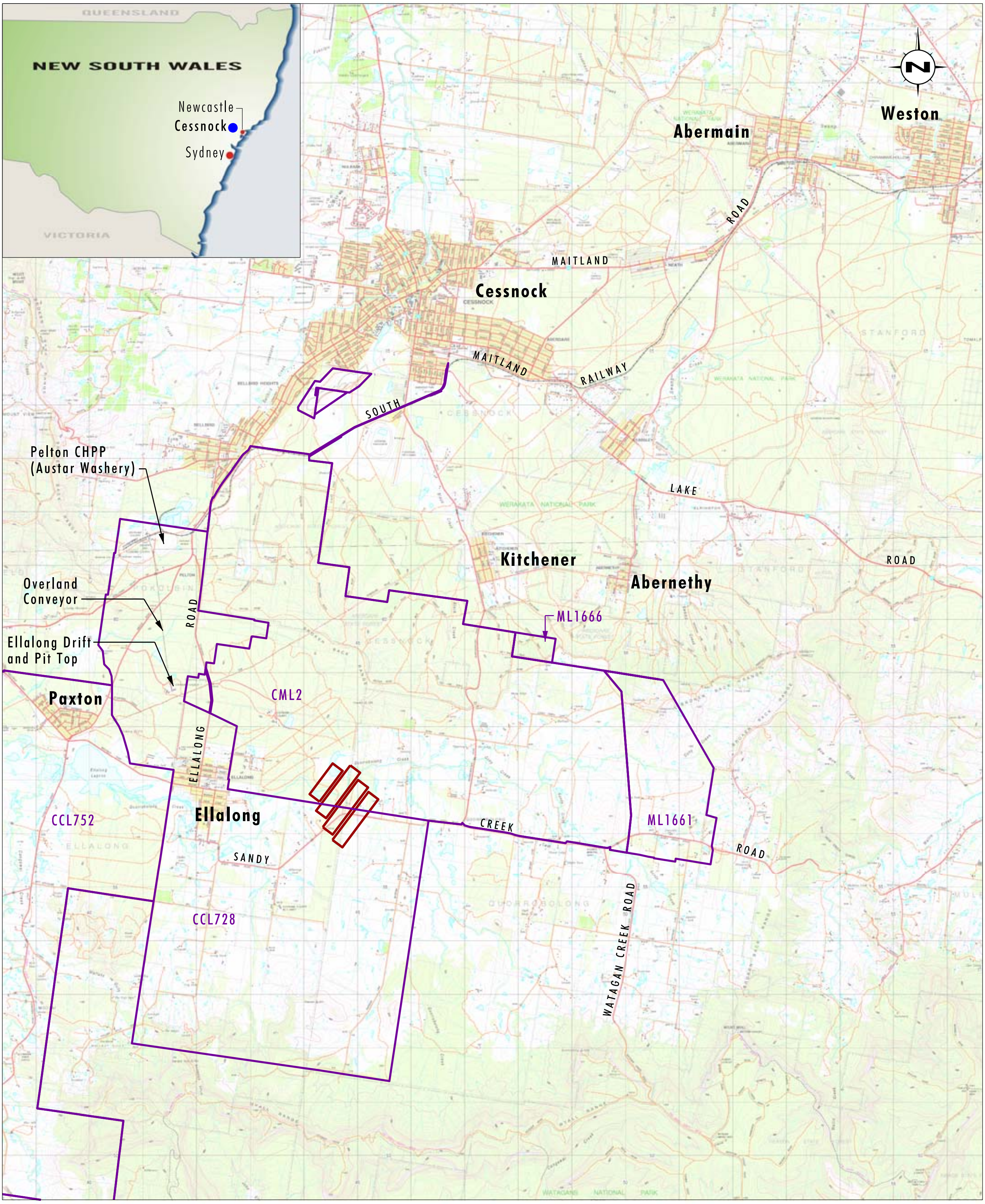

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

0 1.0 2.5 5.0km
1:100 000

Legend

Proposed LW B4-B7 Longwall Panels
Mining Lease Boundary

FIGURE 1

Locality Plan

umwelt

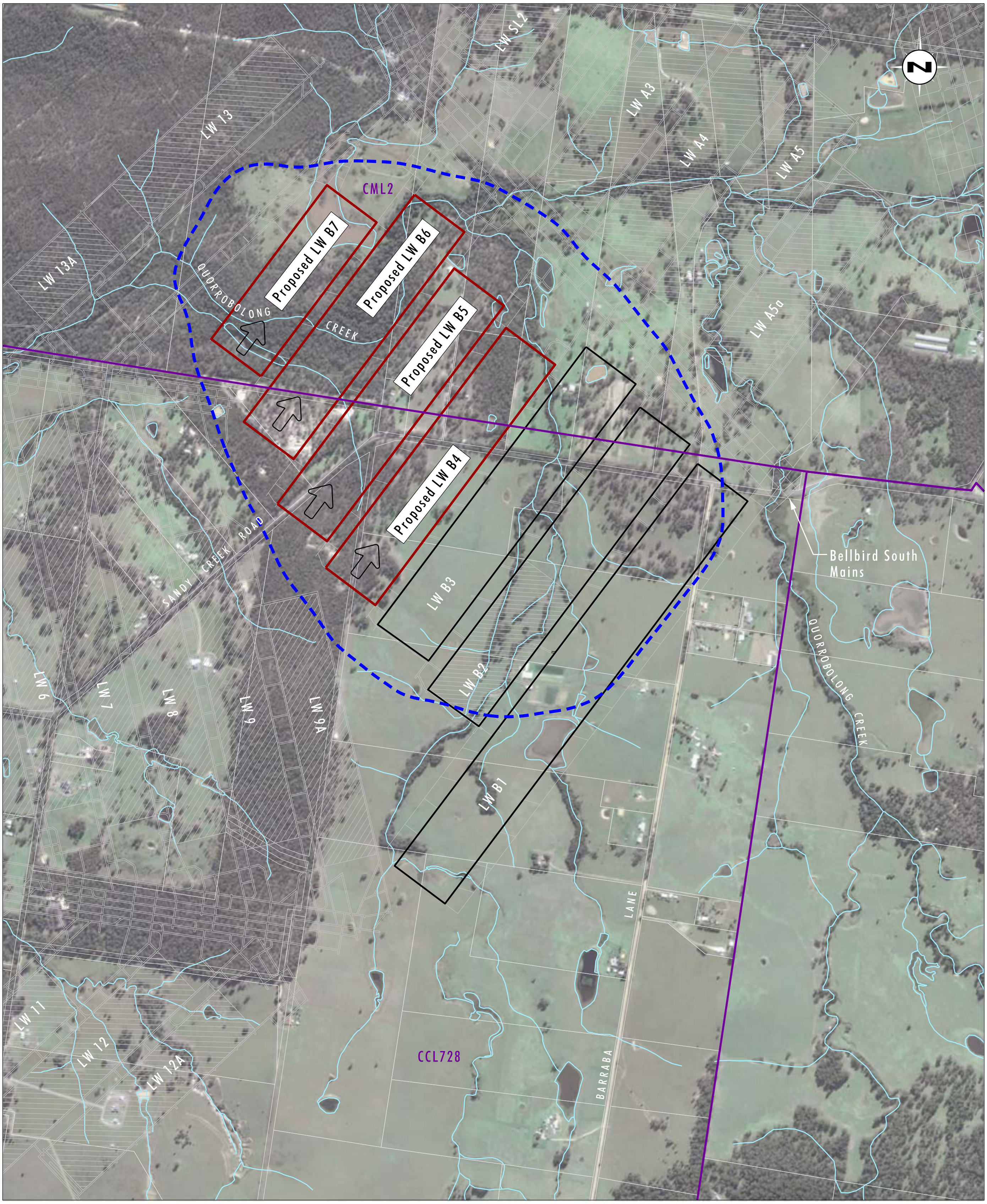

Image Source: Google Earth (2014)
Data Source: Austar Coal Mine (2016)

0 0.25 0.5 1.0km
1:20 000

Legend

- LW B1-B3 Longwall Panels (DA29/95)
- Proposed LW B4-B7 Longwall Panels
- LW B4-B7 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Direction of Mining
- Drainage Line

FIGURE 2

Proposed LW B4-B7 Modification Area

File Name (A4): 3900_007.dgn
20170104 12.43

From:	Gary Mulhearn
To:	Nicola Roche; Alison Lamond; Gabrielle Allan
Subject:	FW: Message from "RNP00267383D840" - Awabakal comment on methodology and EOI
Date:	Tuesday, 17 January 2017 2:59:48 PM
Attachments:	image001.png image002.jpg 20170117133821397.pdf Workers Comp.pdf Public liability.pdf

---

Hi Ladies,

See attached and below from Awabakal.

Regards,

Gary Mulhearn | ENVIRONMENT & COMMUNITY MANAGER

Austar Coal Mine Pty Ltd

SITE: Middle Road, Paxton NSW 2325
POSTAL: Locked Bag 806, Cessnock NSW 2325 Australia
PHONE: +61249937334
FAX: +61249937326
MOBILE: +61403963081
EMAIL: Gary.Mulhearn@yancoal.com.au
WEBSITE: www.austarcoalmine.com.au

From: Awabakal [mailto:culture@awabakallalc.com.au]
Sent: Tuesday, 17 January 2017 3:27 PM
To: Gary Mulhearn
Cc: Terry Lawler
Subject: FW: Message from "RNP00267383D840"

Hi Gary,

Please see attached Awabakal LALC's current insurances (certificates of currency) & field work expression of interest.

Further to that, I am satisfied with the proposed methodology.

If you have any queries, please do not hesitate to contact me.

Regards

Pete Townsend
Culture & Heritage Officer

cid:image002.png@01CF6391.FD38CE80

Awabakal Local Aboriginal Land Council
Address: 127 Maitland Road Islington NSW 2296
Postal address: PO Box 101 Islington NSW 2296
Ph: 49654532
Fax: 49654531
Mob: 0401128987
E-mail: culture@awabakallalc.com.au

Yaama; I am a Wiradjuri & Weilwan man of Western NSW. I pay my respects to the Traditional owners elders, past, present & future. I also extend my acknowledgement to the Traditional Lands, Waterways, Flora & Fauna of this country I work and live on.

-----Original Message-----
From: ricohscanner@awabakallalc.com.au [mailto:ricohscanner@awabakallalc.com.au]
Sent: Tuesday, 17 January 2017 2:38 PM
To: Awabakal <culture@awabakallalc.com.au>
Subject: Message from "RNP00267383D840"

This E-mail was sent from "RNP00267383D840" (MP C3003).

Scan Date: 01.17.2017 13:38:21 (+1000)
Queries to: ricohscanner@awabakallalc.com.au

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From:	Tracey Skene
To:	Nicola Roche; gary.mulhearn
Cc:	Alison Lamond
Subject:	Austar Methodology and signed papaer work
Date:	Monday, 16 January 2017 8:03:03 AM
Attachments:	austar.pdf

Good Morning all,

Alison I have included you into email so you can forward onto Nic as sometimes Nics email bounces back to me .

Please see attached signed paper work and a list of representatives I have working for me at Culturally Aware.

I have viewed and read the proposed Methodology for upcoming field work on the Modification to DA 29/95(MOD7)-LW84-87,Austar Coal Mine Pty Ltd.

Culturally Aware at this stage has no issues or concerns in this proposed Methodology.

Thanks
Tracey Skene (Culturally Aware)

Kind Regards,
Tracey Skene

Marrung-ta Indigenous Training & Employment
7 Crawford Place, Millfield NSW 2325
Mobile: 0474106537

From:	Gary Mulhearn
To:	Nicola Roche; Alison Lamond
Cc:	Gabrielle Allan
Subject:	FW: Austar Coal Mine - Wonn1 comment on methodology
Date:	Friday, 20 January 2017 3:58:54 PM

Gary Mulhearn | ENVIRONMENT & COMMUNITY MANAGER

Austar Coal Mine Pty Ltd

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FAX: +61249937326
MOBILE: +61403963081
EMAIL: Gary.Mulhearn@yancoal.com.au
WEBSITE: www.austarcoalmine.com.au

-----Original Message-----
From: Lynne Fletcher [mailto:kauwul@gmail.com]
Sent: Friday, 20 January 2017 3:53 PM
To: Gary Mulhearn
Subject: Austar Coal Mine

Good afternoon Gary

At this time we have don’t have any problems with the proposed methodology.

Have a good weekend

Kind Regards

Lynne and Arthur Fletcher

Kauwul Pty Ltd T/A Wonn1

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For more information please visit http://www.symanteccloud.com

From:	Jakub Czastka
To:	Nicola Roche; Gary.Mulhearn@yancoal.com.au
Cc:	Scott Franks; Danny Franks
Subject:	Re: Registration of Interest/Submission of Archaeological Fieldwork Application Form (AFAF) for Proposed Modification to DA29/95 (MOD 7) - LWB4-B7
Date:	Wednesday, 18 January 2017 11:06:38 AM
Attachments:	8AC97A74-9858-49E4-8975-60A5C1A16263[22].png Supply nation logo[22].png 05012017131402-0001.pdf Tocomwall AFAForm 18JAN17.pdf Austar Coal Mine MOD6 Consolidated Consent.pdf Tocomwall Workers compensation EXP 30SEP17.pdf

Good morning Nicola and Gary,

Tocomwall are responding to your letter dated 5 January 2017 re: the proposed modification to DA29/95 (MOD 7) - LWB4-B7 as a RAP. Please note that we are currently preparing a response to your draft methodology and ancillary documentation which we will email to you by COB on Monday 6 February 2017, as per your letter.

Please note that your original letter (attached) did not have any figures attached to it: Figures 1 and 2 are mentioned in the text but not supplied with the documentation. We would appreciate you forwarding these to us as soon as possible. Please also note that the letter is not signed by Miss Roche and that the Section numbers do not match up with references in the text: could we please receive an updated letter with these mistakes rectified. Thank you.

I have also attached a copy of your completed AFAF and copies of the insurances requested from Tocomwall.

Please feel free to call me if you have any questions or require additional information.

Regards,

Jakub Czastka (Chaz)
Senior Archaeologist

Tocomwall Pty Ltd
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PARRAMATTA NSW 2150
m: 0418 738 521
p: 02 8843 1326
f: 02 9524 4146
e: Jakub@tocomwall.com.au

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Tel: 02 9542 7714 Fax: 02 9524 4146
Email: info@tocomwall.com.au www.tocomwall.com.au
ABN: 13 137 694 618

Nicole Roche
Manager Cultural Heritage
Umwelt Pty Ltd
Via Email: nroache@umwelt.com.au
Cc: Gary.Mulhaern@yancoal.com.au

6 February 2017

Dear Nicole,

Re: Draft Methodology for ACHAA for Austar Coal Mine – Proposed Modification to DA29/95 (MOD 7) – LWB4-B7

Tocomwall has reviewed the draft methodology ACHAA dated the 5 January 2017.

Tocomwall would like to reiterate the words of the Plains Clan of the Wonnarua People (the PCWP), the Registered Native Title Claimants for the Hunter Valley, with the statement that: "*We the PCWP have never ceded our sovereign rights to be ruled by another race of people, nor, ceded our sovereign rights to our natural resources within our lands, nor have we ceded our sovereign right to our lands. This is the history of our people, and our lands, one day someone will have to pay the rent plus*."

Introduction

As Tocomwall understand the draft methodology, this is a proposed modification of an existing development consent (which has been modified 6 times already). The modification is occurring under section 75W of the EPAA (part of the old Part 3A provisions that continue to apply to this development because it was approved under that provision). The Director-General (now Secretary) of the Department of Planning would have set out requirements for the environmental assessment. We would like to ask Umwelt whether there are environmental assessment requirements, and if there are, could we have a copy of them?

Tocomwall have reviewed the proposed methodology and have the following comments, suggestions and recommendations to make. Importantly, Tocomwall consider the proposed research design and methodology to be scientifically and culturally inappropriate because of the reasons discussed below and will not sign off on it until considerable changes have been made.

What little there is in terms of actual methodology (see below for more detail), the most obvious comment to make about the document is that it is very heavy on archaeology and very light on any other kind of cultural values which may be affected or impacted upon.

Consultation Process

Section 2 on page 3 of the draft methodology states – in relation to consultation – that (pp3):

> *'Participating registered Aboriginal parties will be encouraged to provide information they feel is appropriate for inclusion in the report. Registered Aboriginal parties will also have the opportunity to provide information that they would like taken into account but not represented in a report that will be made available to the public. Registered Aboriginal parties will be given 28 days to review and provide their response to the draft report.'*

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Email: info@tocomwall.com.au www.tocomwall.com.au
ABN: 13 137 694 618

Tocomwall would like to raise several points in regards to this statement.

Firstly, consultation in relation to the proposed methodology for information gathering and significance assessment is a separate matter from substantive consultation with cultural knowledge holders using a mutually acceptable process to identify:

1. The Aboriginal objects or Aboriginal places within the assessment area; and
2. The significance of those objects or places, including in light of any identified intangible heritage values (for the reasons explained in Ashton (No.3) at [82]: 'these intangible aspects of Aboriginal culture are of equal or often of more significance than objects themselves and they can add an extra and different layer of significance to these objects').

Secondly, there is no consultation identified with the persons who are required to be consulted under the DECCW (2010; now OEH) *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (the 'Guidelines'). The intent of the OEH Guidelines in terms of who should be consulted and the objective of consultation is clear. The requirements are set out in Part 3.3, under the heading '*Information required for decision-making.*' The decision-maker has, through the guidelines, identified the class of persons who it believes are qualified to provide the information required and it is the proponent's responsibility to ascertain who they are. These primarily are:

- Aboriginal owners;
- Native title holders; and
- Registered native title claimants.

The only registered native title claimants for the study area are Scott Franks and Robert Lester. At this stage there are no Aboriginal owners or determined native title holders. Identifying *'Traditional owners or custodians with appropriate cultural heritage knowledge to inform decision making'* is at the core of the consultation process the proponent is required to follow. It is what the Court recognised in *Ashton (No.3)* when it identified what a proper cultural assessment required and why it said there was a need for balanced cultural assessments for Statutory decision-making. Beyond the people described in Part 3.3 of the guidelines, other cultural knowledge holders should be identified based on standard anthropological techniques (such as genealogical, ethnographic and oral history recording). The statement quoted above from Umwelt does not identify any particular persons or groups of persons as holding traditional or historical knowledge of the cultural heritage significance for the assessment area.

This methodology is not explicit in the methods it will employ to collate cultural information, but a very generic statement. It would seem that the consultation process being proposed relies upon a document- or submission-based process, without any face-to-face consultation or on-site consultation. This way of eliciting cultural heritage information from knowledge holders is not something that in our experience a professional anthropologist would use. This approach:

1. Is removed from the environmental and social context in which cultural knowledge is typically disclosed;
2. Does not proceed from, or indeed appear to place any value in, building a relationship of trust or confidence with informants which characterises a respectful research process;
3. May in fact limit the information provided (both for reasons of cultural sensitivity and because of reasons of literacy and writing proficiency); and

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4. Is apt to produce unreliable or incomplete responses, rather than to systematically address the matters required. For example, are respondents obliged to draw maps to accompany their responses? Or commission their own reports?

Finally, the methodology does not consider the need for a cultural survey to precede the archaeological survey in order to both inform and contextualise the archaeological aspect in regards to cultural knowledge and significance, particularly from the perspective of a cultural landscape. This should be rectified in order for the subsequent *archaeological* fieldwork to be culturally guided and/or appropriate.

Archaeology

On page 3 of the draft methodology a short three-paragraph description is presented purporting to be a *'Survey Methodology.'* The 'methodology' falls far short of a methodical approach to an archaeological survey. Again, as for the consultation process discussed above, it is so generic as to be uninformative, subject to manipulation by the consultant should issues arise later and inadequate at explaining and exploring a scientific approach to a systematic archaeological investigation of the assessment area. In the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010:2), under Section 1.2 headed *Objective of Archaeological Investigation* it clearly states that one of the objectives should be to:

> *'Present a feasible and appropriate methodology for the archaeological survey and other investigations to ensure that work can be clearly linked to these aims.'*

Of the three paragraphs that make up this methodology, the first two paragraphs are merely introductory and describe the study area. The third paragraph states (page 3):

'The proposed survey will target indicative landforms within the LWB4-B7 modification area where Aboriginal archaeology is predicted to occur (which are?) *and in areas where landholder permission has been granted* (what does this mean? How much area can be accessed? Are their landforms that are only represented on inaccessible lands? Can we have a map illustrating all the landforms and accessible verses inaccessible areas as well as a table breaking down landforms and accessible verses inaccessible areas as percentages? In order to test a predictive model there also needs to be a component of pedestrian survey in areas where archaeology is not predicted to occur, otherwise the 'model' becomes little more than a self-fulfilling prophecy!?)*. The survey will be designed to ensure there is adequate coverage of landforms and will be undertaken with reference to levels of visibility and exposure. The areas predicted to be likely to contain discernible Aboriginal archaeology are limited to hill crests, spurs and in proximity to water sources* (this does not consider the fact that the best, most intact and significant <u>archaeological deposits</u> will be retained in areas of soil and sediment aggradation such as foot slope – floodplain boundaries and terrace systems within floodplains; it further fails to consider proximity to <u>former</u> water courses/palaeochannels/oxbow lakes [billabongs]: as such the survey will fail to adequately address the extant potential archaeological resource but simply concentrate on the eroding archaeological resource which are in contextual and geomorphic terms essentially secondary context lag gravels and reflects therefore only a small, undetermined percentage of the archaeological resource). *In addition to these predicted areas, the registered Aboriginal parties will be provided the opportunity to inspect the remainder of the LWB4-B7 modification area that has not been previously assessed, as required, subject to landholder access. It is noted that portions of the LBB4-B7 modification area adjacent to LWB3 were surveyed by the registered Aboriginal parties in 2015 as part of the previous LWB1-B3 modification* (where are these areas? Maps please?).' (My additions in brackets and no italics)

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As per the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010) and specifically Requirement 5a - Survey sampling strategy - Tocomwall would like to see a more thorough representation and details of this methodology, namely (*ibid: 12*):

> *'The archaeological survey must not begin until a sampling strategy has been developed. Sampling must:*
>
> *· include all landforms that will potentially be impacted. Where there is more than one instance of similar or the same landforms that have the potential to be impacted each individual landform must be sampled.*
>
> *· place a proportional emphasis on those landforms deemed to have archaeological potential, clearly describing and justifying the reasons for their selection (see Requirement 4).*
>
> *The sampling strategy must:*
>
> *· describe how sampling relates to the footprint that is proposed to be impacted by the development*
>
> *· clearly state when a full coverage survey will be undertaken and justify when it is not. The sampling strategy must be documented in the Archaeological Report as set out in Requirement 11.'*

Conclusions

Tocomwall would like to see the issues they have raised in this review addressed by Umwelt as soon as possible and certainly before we sign off on the proposed methodology.

Please feel free to call me if you have any questions.

Regards,

Jakub Czastka (Chaz)
Senior Archaeologist
Tocomwall Pty Ltd
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Our Ref: 3900/NR/Tocomwall/07022017

7 February 2017

Jakub Czastka
Senior Archaeologist
Tocomwall Pty Ltd
PO Box 76
CARRINGBAH NSW 1495

BY EMAIL: jakub@tocomwall.com.au

Dear Chaz

Re: Response to Draft Methodology for Austar Coal Mine – Proposed Modification to DA29/95 (MOD 7) – LWB4-B7

Thank you very much for your comprehensive response to the draft methodology for the Aboriginal cultural heritage and archaeological assessment for the above project. We appreciate the time and effort that went into drafting your response and your commitment to consulting with us regarding this matter. We acknowledge the reiteration of the statement made by the Plains Clan of the Wonnarua People (PCWP) as registered native title claimants for the area that includes the current project area.

This letter provides responses to queries and issues raised in your letter of 6 February 2017.

1.0 Approvals Context

As noted in our previous correspondence, Austar Coal Mine Pty Ltd (Austar) is seeking to modify DA29/95 under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The original approval was issued under Part 4 of the EP&A Act and approval of the modification will be sought under Section 75W of the EP&A Act.

Given the nature of the proposed modification, the Secretary of the Department of Planning & Environment has not issued environmental assessment requirements for this project, but has accepted a proposed environmental assessment approach and consultation plan provided to the Department by Austar. The accepted environmental assessment approach includes the completion of an Aboriginal cultural heritage and archaeological assessment in accordance with relevant legislation and guidelines, including the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (the Code of Practice – DECCW 2010a) and the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011).

Inspired People.
Dedicated Team.
Quality Outcomes.

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ABN: 18 059 519 041

2.0 Consultation Process

Umwelt acknowledges and understands that cultural values, by definition, relate to values outside those associated with specific archaeological sites/objects. As stated in our initial correspondence, we invite comment from Aboriginal parties regarding any cultural values associated with the project area and will ensure that any information provided regarding cultural values (be they associated with a specific site or provided with reference to a landscape feature or within a broader context) are documented and recorded in accordance with the wishes of the relevant Aboriginal party for inclusion in the assessment report. We note that the inclusion of any such information is dependent on its provision by the Aboriginal parties.

In terms of the identification of persons who are required to be consulted in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010b) (the consultation requirements), Austar has been undertaking consultation with Aboriginal parties (including Tocomwall) in this region over many years and the current consultation represents a continuation of this process. We note that Section 3.2 specifies that the objective of consultation is to ensure 'that Aboriginal people have the opportunity to improve assessment outcomes'. Factors specified as assisting in meeting this objective include providing Aboriginal parties with the opportunity to provide information on cultural values (as invited in our letter of notification and in the draft methodology), influence methods regarding assessment of significance for Aboriginal objects/places (which can be undertaken in response to the draft methodology, during fieldwork and in commenting on the draft assessment report) and commenting on the draft assessment report. Our approach is designed to ensure compliance with this objective.

As you rightly point out, Section 3.3.1 provides guidance on who can provide this information. We acknowledge and recognise that the project area is located within the broader area that is the subject of a registered native title claim held by the PCWP. Based on the currently accepted Native Title process, it is our understanding that members of the PCWP have presented sufficient genealogical documentation, ethnohistoric information and oral history to satisfy the requirements of the National Native Title Tribunal for registration of a claim. We therefore do not propose to replicate this process but will consult with PCWP. It is possible that over the course of consultation regarding the project, additional Aboriginal parties may identify particular or cultural knowledge relevant to the project area. If this occurs, we will liaise with appropriate stakeholders to resolve a methodology to appropriately verify such information.

Your correspondence raises issues with the lack of explicit provision of methods for the collation of cultural information. This reflects our very strong belief that consultation is most effective when Aboriginal parties engage on their own terms and with consideration of their own unique requirements. Based on our extensive and lengthy experience in undertaking consultation in this region, some Aboriginal parties wish to operate independently, others wish to be involved in group or family-based decision making process, others wish to work collaboratively with our archaeologists to ensure their comments and feedback are appropriately documented. Our assessment methodology was provided in draft format, with the invitation to provide information as Aboriginal parties feel appropriate. We believe it is inappropriate for us to specify how this must be done and therefore welcome input from Aboriginal parties (both collectively and individually) as to how they wish to be consulted.

Your statement that the proposed consultation approach is 'removed from the environmental and social context in which cultural knowledge is typically disclosed' fails to recognise that the opportunity is provided for in-field consultation during the completion of the survey of the project area. Umwelt archaeologists are trained to seek and document cultural feedback provided by Aboriginal party representatives during fieldwork. This is not limited to cultural values associated with archaeological sites but may encompass any values identified by Aboriginal people (refer to

Section 3.2.2 for more detail). Based on the scope of the project, the results of previous assessments (including those undertaken in consultation with Tocomwall) and the nature of the proposed project impacts, it is not proposed to undertake a separate 'cultural survey' of the project area but to document both cultural values and archaeological values during the survey process.

We note that the Umwelt cultural heritage team has been undertaking consultation with Aboriginal parties in this region for several decades, with Nicola Roche (who is directing the project) having being involved in Aboriginal cultural heritage assessments in the Hunter Valley for over 12 years. During this time we believe we have built a stable and professional relationship with Aboriginal parties and that we have an understanding of the context within which we undertake consultation.

Off the back of this ongoing relationship, we fully understand that some Aboriginal parties may not have access to the range of professional staff and extensive resources available to organisations like Tocomwall. On this basis, we will always assist Aboriginal parties who may request assistance with matters of literacy, documenting feedback or reviewing documentation. However, we respectfully allow Aboriginal parties to identify when they do or do not require such assistance and consider this to be a matter for discussion between the relevant Aboriginal party and Umwelt.

3.0 Archaeology

The draft survey methodology is designed to ensure compliance with requirements for archaeological survey as established in the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (the Code of Practice). The requirements of the Code of Practice were not duplicated *verbatim* in our original correspondence or below but rather we reiterate our commitment is to ensure compliance.

However, we appreciate your request for further information and include below a more detailed account of the rationale and specifications of our survey methodology. We note that this is information that we would typically include in a draft assessment report but are happy to bring forward its provision to address your concerns.

As is appropriate and expected from an archaeological perspective, the survey methodology has also been developed with reference to the predicted impacts associated with the project, as will be discussed below.

3.1 Predicted impacts associated with the project

The project does not involve any additional surface activities and therefore will have no direct impact on archaeological sites as a result of land clearing. The potential impacts of the proposed modification on archaeological sites are therefore limited to indirect impacts associated with subsidence, including potential surface cracking, subsidence remediation works and hydrological changes. Specialist input on subsidence impacts is being prepared (MSEC in prep), with additional modelling of changes to hydrology also being undertaken.

Due to the similarities in geology, topography, depth of mining and strata between the current project area and the adjoining approved LWB1-B3 area, it is predicted that subsidence and subsidence related impacts within the current project area will be similar to that documented within the LWB1-B3 area. Subsidence monitoring following mining of LWB2 has identified that the levels of subsidence are very low such that there is no significant or visible surface cracking or surface impacts. No subsidence remediation works have been required for the previously extracted LWB2. This is supported by similar findings following the extraction of LWA1 to A8 in the Stage 1, Stage 2 and Stage 3 mining areas. Based on previous this experience within the Austar Coal Mine, the nature of the proposed mining and site characteristics, it is expected that the project area will be subject to similarly minimal surface impact.

On this basis, there is limited rationale for undertaking extensive or invasive investigation of the potential for sub-surface deposits (such as test excavation), as the impacts of any such investigation on Aboriginal cultural heritage will be more damaging than the impacts of the project itself. In accordance with best practice, the draft methodology does not include provision for any such investigations.

3.2 Archaeological Survey

The aim of the archaeological survey is to identify and appropriately document any material evidence of Aboriginal land use within the project area. It is also noted that Aboriginal party involvement in the survey provides an opportunity to document information Aboriginal party representatives may provide regarding cultural values. Given our current understanding of the potential for limited visibility within the project area, the archaeological survey will also assess the potential that additional material evidence may be present but not detectible within the project area, including evidence that may be present in a sub-surface context (noting the qualificatory statement provided above).

3.2.1 Sampling Strategy

In accordance with the Code of Practice, a survey sampling strategy was developed for the project area. This strategy is developed with reference to the environmental and archaeological context of the project area.

The survey will be undertaken to ensure that a representative sample of all landforms within the project area is surveyed, as required to ensure compliance with Code of Practice. A map showing the distribution of landforms (mapped using landform elements as defined in Speight 2009) within the project area is provided as **Figure 1**. This landform mapping is provisional only and has been developed with reference to available contour data. We expect that we will modify this landform mapping based on the outcomes of the survey, particularly with reference to more specific categorisation of slope landforms.

In response to the specific landforms raised in your correspondence, we note that the project area does not contain any areas of identifiable terracing, paleochannels or oxbow lakes. The project area is within the Quorrobolong soil landscape which is broadly described as typically containing soil profiles not exceeding 50cm in depth (Kovac and Lawrie 1991) and with no consideration of the formation of deep alluvial soils. It is recognised that soil landscape mapping is undertaken on a broad basis and requires further consideration with reference to localised conditions. However, based on the topography, extent of the catchment areas associated with the project area, and the outcomes of previous archaeological investigations, it is not expected that the landforms referenced above will occur with the project area. In the unlikely circumstance that any such landforms are identified during the survey, the sampling strategy can be adjusted to expend appropriate survey effort within any such landform.

There is potential for the colluvial/alluvial interfaces within the mapped valley flats (flat to gently inclined landforms bordering watercourses), which were broadly referenced in our previous correspondence as 'low elevation slopes in proximity to Quorrobolong Creek and its tributaries'. As identified in our previous correspondence, based on the archaeological pattern in the region, this landform (along with crests) are predicted to have higher archaeological potential and a proportional emphasis will be placed on survey of these landforms. We note that this does not exclude the survey of other portions of the project area and reiterate the intent to obtain a representative sample of all landforms.

Other considerations in developing the survey strategy include:

- Part of the project area has been subject to previous archaeological survey and assessment (completed in August and September 2015) conducted in accordance with the Code of Practice and in consultation with the registered Aboriginal parties (including Tocomwall). As noted in our previous correspondence, the survey strategy does not include provision for re-survey of this area (shown in **Figure 2**).

- Parts of the project area are located on privately owned land for which the landholder has refused access (areas shown in **Figure 2**). These areas therefore cannot be subject to survey.

- As shown in **Figure 2**, the project area is relatively densely vegetated with open forest in some areas, with other areas appearing to also be relatively heavily vegetated with pasture grass and other introduced species. Based on our understanding of the area and the outcomes of previous archaeological investigations, it is likely that visibility across much of the project area will be relatively low. On this basis, it is proposed to target areas of visibility and exposure during the survey in order to obtain maximum benefit from survey effort. Consideration of the potential for additional deposits to be present but not visible will be a key component of the archaeological assessment report, as will be discussed further in this document.

When all of these factors are taken into consideration, it is apparent that the area subject to survey is relatively small. The location of specific transects will therefore be discussed in the field with Aboriginal party representatives and will be decided collectively but with reference to the identified requirements of the Code of Practice. This allows us to also ensure that requirements for survey of areas in relation to cultural values (as opposed to archaeological values) can be taken into account.

3.2.2 Recording of information during survey

Survey units will be defined and named with reference to Requirement 5c of the Code of Practice, including recording start and finish points and/or boundaries for all survey units using a hand-held GPS receiver (set to allow recording of data with datum MGA94) and topographic mapping (where relevant), with track logs to be recorded for all pedestrian transects. Start and finish points/boundaries for survey units will be defined based on landforms, project area boundaries, access area boundaries or other arbitrary terminations (as specified in the Code of Practice). The spacing between individuals will also be recorded for each survey unit.

Photographs will be undertaken for landforms/survey units (where informative). Information recorded for each survey unit will include

- Landform (in units based on those established by McDonald *et al* 2009)

- Gradient (where relevant)

- Vegetation

- Geology and soils (where suitable areas of exposure/visibility are present)

- Identified Aboriginal resources (food and medicine plants, prey animals, stone and water)

- Levels of average ground surface visibility within the survey unit (in accordance with the Requirement 9 of the Code of Practice)

- Extent and type of exposures within the survey unit (with reference to the factors leading to the exposure such as erosion, earth-moving activities, track establishment etc.)

- Any information provided by the registered Aboriginal parties in relation to cultural values, noting that such information will be recorded in accordance with the wishes of the party providing the information.

- Any site, area of Potential Archaeological Deposit (PAD) or landscape feature of Aboriginal cultural value present within the survey unit (see below for further information on site/PAD recording).

Any Aboriginal archaeological sites identified during the survey will be assessed with reference to the site boundaries. Factors that will be taken into consideration in defining and mapping site boundaries may include the distribution of surface artefacts, landforms or physical boundaries and cultural information.

Sufficient information will be recorded for all sites to meet Requirement 7 of the Code of Practice. The archaeological and Aboriginal and cultural significance of any site will be discussed with the registered Aboriginal parties participating in the survey.

As noted in **Section 2.1**, it is likely that levels of visibility and exposure will be limited across much of the project area. It will therefore be necessary to assess the archaeological potential of landforms/specific areas within the project area. This assessment will be undertaken with reference to factors including the archaeological context of the local area, the evaluation of the soil profile (based on soil landscape mapping, exposed soil profiles identified during the survey and geomorphic understandings of the area) and the identification of landforms that may have greater archaeological sensitivity (such as alluvial fans, terraces, colluvial/alluvial interfaces etc.). The extent of any area of identified archaeological potential will be defined and documented for inclusion in subsequent reporting. The archaeological and Aboriginal and cultural significance of any area of identified archaeological potential will be discussed with the registered Aboriginal parties participating in the survey.

4.0 General Comments

We note that in your letter you raise a concern with the focus on archaeology in our initial correspondence. As expressed throughout this letter, we believe that it is culturally inappropriate for us as non-Aboriginal people to comment on Aboriginal cultural values unless utilising information expressly provided by Aboriginal people with interests in the area being discussed. Our previous letter included the provision of opportunity to registered Aboriginal parties to provide any cultural information they feel is appropriate regarding the project area. This opportunity extends throughout the assessment process, with input from Aboriginal parties welcomed, particularly (but not exclusively) in response to the draft methodology, during survey and following review of the draft assessment report. We thank you again for your commitment to taking up this opportunity and look forward to ongoing consultation with you and other Tocomwall representatives throughout this project.

Should you wish to discuss any aspect of this letter, we ask that you contact either myself or Gary Mulhearn by close of business Wednesday 8 February 2017.

Yours sincerely

Nicola Roche
Manager Cultural Heritage

5.0 References

Department of Environment, Climate Change and Water (DECCW) 2010a. Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW. Department of Environment, Climate Change and Water: Sydney.

Department of Environment, Climate Change and Water (DECCW) 2010b. Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010. Department of Environment, Climate Change and Water: Sydney.

Kovac and Lawrie. 1991. Soil Landscapes of the Singleton 1:250,000 Sheet. Soil Conservation Service of NSW: Sydney.

Office of Environment and Heritage, Department of Premier and Cabinet (OEH) 2011 Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW. Office of Environment and Heritage, Department of Premier and Cabinet: Sydney.

Speight, J.G. 2009. Landforms. In The National Committee on Soil and Terrain (eds). Australian Soil and Land Survey Field Handbook. CSIRO: Collingwood.

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Nicola Roche
Manager Cultural Heritage
Umwelt Pty Ltd
Via Email: nroache@umwelt.com.au
Cc: Gary.Mulhaern@yancoal.com.au

9 February 2017

Dear Nicole,

Re: Response to Draft Methodology for Austar Coal Mine – Proposed Modification to DA29/95 (MOD 7) – LWB4-B7

The following comments relate specifically to your letter dated 7 February 2017. A more general discussion follows these comments. Overall, the response by Umwelt whilst being lengthy, does not actually answer the questions or concerns of Tocomwall's letter dated 6 February 2017 in regards to assessing cultural significance. From a review of your letter, it is very heavy on justifications for your previous procedures and current approach, rather than genuinely reflecting on a more appropriate method(s) for investigating cultural significance.

Response to Section 2: Consultation Process

On page two of your letter, you state that:

> *'As stated in our initial correspondence, we invite comment from Aboriginal parties regarding any cultural values associated with the project area and will ensure that any information provided regarding cultural values (be they associated with a specific site or provided with reference to a landscape feature or within a broader context) are documented and recorded in accordance with the wishes of the relevant Aboriginal party for inclusion in the assessment report. We note that the inclusion of any such information is dependent on its provision by the Aboriginal parties.'*

This statement follows on from what Umwelt had previously identified (page 3: paragraph 1: letter dated 5 January 2017) and does not provide any form of structure or method to your enquiry into cultural significance, i.e. how you will specifically go about collating this information. Furthermore you go on to state on page 2, in the second paragraph (7 February 2017):

> *'We note that Section 3.2 specifies that the objective of consultation is to ensure 'that Aboriginal people have the opportunity to improve assessment outcomes'. Factors specified as assisting in meeting this objective include providing Aboriginal parties with the opportunity to provide information on cultural values (as invited*

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> *in our letter of notification and in the draft methodology), influence methods regarding assessment of significance for Aboriginal objects/places (which can be undertaken in response to the draft methodology, during fieldwork and in commenting on the draft assessment report) and commenting on the draft assessment report. Our approach is designed to ensure compliance with this objective* (my emphasis).'

Whilst you rely on RAPs to 'lead' you on how and what they want to say, you inexplicably shy away from undertaking culturally appropriate and specific studies that are, essentially, ethnography. Furthermore, you continue to believe that cultural significance can be collated during the course of archaeological fieldwork, limited as it is in time, resources, with large areas to be covered for the purpose of archaeological investigations (see also discussion below). I am, as an archaeologist, familiar with the challenges of understanding anthropological and archaeological consultation. The fact is - if one is genuine, honest and ethical with oneself - it is clear that anthropological consultation requires a different skill-set and a stand-alone, rather than 'bolted on,' investigation.

In Tocomwall's letter of the 6 February 2017, we stated:

> *'This methodology is not explicit in the methods it will employ to collate cultural information, but a very generic statement. It would seem that the consultation process being proposed relies upon a document- or submission- based process, without any face-to-face consultation or on-site consultation. This way of eliciting cultural heritage information from knowledge holders is not something that in our experience a professional anthropologist would use* (pp2).'

Furthermore, we added that:

> *'Finally, the methodology does not consider the need for a cultural survey to precede the archaeological survey in order to both inform and contextualise the archaeological aspect in regards to cultural knowledge and significance, particularly from the perspective of a cultural landscape. This should be rectified in order for the subsequent archaeological fieldwork to be culturally guided and/or appropriate* (pp3).'

I believe that Tocomwall needs to be more specific and explicit in how we '*influence methods regarding assessment of significance* (Umwelt 7 February 2017: 2)', as Umwelt have asked in their letter. Tocomwall is stating, categorically, that based on the organisation's experience with the Native Title process – its expectations legally and relying on professional anthropological approaches – Umwelt should engage a professional anthropologist to design and implement an anthropological research design and methodology to investigate the cultural significance of the

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region and how the particular study area of Umwelt's proponent fits into that larger cultural landscape. This study should precede, support and inform any subsequent archaeological investigations.

In regards to Umwelt's position on identifying appropriate knowledge holders, we acknowledge your position on the PCWP's position as a registered Native Title Claimant. However, it is still unclear how Umwelt identifies the other RAPs that can or should be consulted on matters of '*Traditional owners or custodians with appropriate cultural heritage knowledge to inform decision making* (Tocomwall 6 February: 2)?' This is largely a question related to your statement (Umwelt 7 February 2017: 2):

> *'It is possible that over the course of consultation regarding the project, additional Aboriginal parties may identify particular or cultural knowledge relevant to the project area. If this occurs, we will liaise with appropriate stakeholders to resolve a methodology to appropriately verify such information.'*

Umwelt goes on to state that (*ibid*):

> *'Your correspondence raises issues with the lack of explicit provision of methods for the collation of cultural information. This reflects our very strong belief that consultation is most effective when Aboriginal parties engage on their own terms and with consideration of their own unique requirements. Based on our extensive and lengthy experience in undertaking consultation in this region, some Aboriginal parties wish to operate independently, others wish to be involved in group or family-based decision making process, others wish to work collaboratively with our archaeologists to ensure their comments and feedback are appropriately documented. Our assessment methodology was provided in draft format, with the invitation to provide information as Aboriginal parties feel appropriate. We believe it is inappropriate for us to specify how this must be done and therefore welcome input from Aboriginal parties (both collectively and individually) as to how they wish to be consulted.'*

And:

> '*Based on the scope of the project, the results of previous assessments (including those undertaken in consultation with Tocomwall) and the nature of the proposed project impacts, it is not proposed to undertake a separate 'cultural survey' of the project area but to document both cultural values and archaeological values during the survey process* (*ibid*: 3).'

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To Tocomwall this is another way of stating that not only do you not have an explicit and appropriate research design and methodology for investigating cultural significance, but that your reasoning for this is that the RAP should be leading the way with this! It is Umwelt's contractual (and ethical) obligation to present a research design and methodology for both the archaeological and cultural components for the proposed works. Tocomwall's perspective on this work is presented in our reviews: it is not our job to write or re-write your research designs and methodologies. Tocomwall has pointed out that for the cultural significance assessment, there is no method in your approach and an over reliance on archaeologists -rather than trained anthropologists - to undertake this work during archaeological, rather than ethnographically-specific, orientated work.

Your subsequent comment therefore that:

> *'Your statement that the proposed consultation approach is 'removed from the environmental and social context in which cultural knowledge is typically disclosed' fails to recognise that the opportunity is provided for in-field consultation during the completion of the survey of the project area. Umwelt archaeologists are trained to seek and document cultural feedback provided by Aboriginal party representatives during fieldwork* (*ibid*)…'

continues to compound the fact that Umwelt does not or is not willing to grasp the fact an ethnographic approach is needed here. Furthermore, we welcome your statement that '*Umwelt archaeologists are trained to seek and document cultural feedback provided by Aboriginal party representatives during fieldwork* (*ibid*),' but Tocomwall would like to see evidence of either the professional anthropological qualifications of your staff or, failing that, a series of excerpts from previous Umwelt cultural significance assessments on the Hunter Valley that demonstrate that you have the relevant knowledge or experience. You go on to state that:

> '*We note that the Umwelt cultural heritage team has been undertaking consultation with Aboriginal parties in this region for several decades, with Nicola Roche (who is directing the project) having being involved in Aboriginal cultural heritage assessments in the Hunter Valley for over 12 years. During this time we believe we have built a stable and professional relationship with Aboriginal parties and that we have an understanding of the context within which we undertake consultation* (*ibid: 3*).'

To avoid misunderstanding therefore, Tocomwall would like to see evidence of:

- Professional anthropological qualifications of Umwelt staff involved in this project;

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- A specific set of excerpts from previous cultural significance assessments by Umwelt that demonstrate that experience and qualifications; and
- Letters of reference from other RAP in the Hunter Valley that explicitly support your approaches to the assessment of cultural significance.

Discussion on Consultation Process and the Investigation of Cultural Significance

In regards to the consultation process, with all due respect, most archaeologists in NSW who undertake this work are exactly that: archaeologists. They – in common with the vast majority of Australian based archaeologists – are not trained in ethnographic or indeed ethnoarchaeological techniques. For example, if the terms 'etic' or 'emic' were to be used in relation to ethnography, how many archaeologists without training in ethnographic techniques, would honestly know what these terms meant or how they applied to social anthropology?

In undertaking cultural assessments, the process of assessing cultural significance is moving away from ethnoarchaeological approaches and moving firmly into the context of ethnographic observations. This is because we are not investigating material culture, but entering the realm of social/cultural anthropology. Whilst we can and indeed do use this knowledge to help us – as archaeologists – understand the material archaeological record, this should not be our primary goal in undertaking cultural assessments. Rather, we should be trying to participate and understand cultural knowledge through an 'emic' lens, instead of the usual approach by archaeologists to understand culture through the often inappropriate archaeological (material) 'etic' perspective. Obviously, this requires a considerable shift in our paradigm and at the same time trying to learn Indigenous culture "..*through the following processes of observations, asking questions, interpretation, and participant observation, the primary methods used in Basic Classical ethnographic field methods* (Whitehead 2005)." The judicial system – at least in NSW – has made several landmark decisions (*cf*. Ashton Coal; Calga Quarry) in relation to woefully inadequate assessments of cultural significance by archaeologists.

It is not appropriate to undertake archaeological fieldwork with the expectation that cultural knowledge will somehow 'naturally' flow on from the Indigenous participants as this work is conducted. Archaeological fieldwork is confined by study area boundaries defined by proponents and although we use predictive modelling from adjacent areas to fine-tune our survey methods, our findings are usually confined to a distinct spatial area. Anthropological fieldwork – and by extension, our investigations of traditional cultural knowledge – is not confined by historic, modern or 'study area' boundaries. Cultural landscapes and the associated cultural knowledge flow across landscapes that have boundaries that are not 'beholden' to a proponents study area or to any modern boundary for

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that matter. Therefore, it is not only unreasonable but also shows a distinct lack of understanding or empathy for ethnography (cultural knowledge), to have the expectation that an archaeologist can wander across their confined study area and that somehow, that will also allow them to soak up the cultural significance of the area in doing so. Ethnographic fieldwork, as one of its precepts, relies on the fact that the people being observed should direct *where* and *how* the access to cultural knowledge should take place in order to see the world through Aboriginal eyes. In other words, we are saying that the collation of cultural significance should not only precede archaeological fieldwork, but should follow ethnographic procedures and be led by the Aboriginal participants, who inevitably will be looking at a wider landscape context than the archaeologist's study area.

If as archaeologists we continue to look down from an 'etic' perspective on our inappropriate or misinformed attempts to collate cultural significance, we will continue to not only fail in the task that we are supposed to be undertaking, but also find ourselves in a position that increasingly leaves us open to legal challenges.

Response to Section 3: Archaeology

Thank you for a more detailed response to Tocomwall's request for further information on the archaeological survey methodology. The additional information on sampling strategies and how information will be recorded in the field is appreciated in order for us to be able to fully understand and comment on the methodology.

The purpose of a research design and methodology is not to reiterate the Code of Practice '*verbatim*', but rather to present an approach to the archaeological fieldwork that considers the experience and knowledge of the consultants – as well as sound archaeological practice – in formulating a framework of enquiry. In other words, a research design and methodology should be specific to a study area *and* explicit in terms of what, how and why is being investigated, with a view to making the results comparable to previous work *and* building upon that earlier work. Tocomwall notes that Umwelt have responded and answered the questions posed in our earlier letter dated 6 February 2017.

There are two comments that Tocomwall would like to raise. Firstly, as thorough as the methodology is, it does not explicitly explore the questions that a research design should be formulating to direct the fieldwork. However, as long as the draft report provides these questions and answers them adequately, Tocomwall is willing to wait for this information. We would respectfully ask that in future, questions that drive the research design and methodology are provided in the initial documentation. Secondly, the question of whether anthropological and archaeological fieldwork has already been covered in the previous section to this letter. Tocomwall would like to pose some

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questions: if Umwelt intend to discuss cultural significance during archaeological fieldwork '*with the registered Aboriginal parties participating in the survey* (Umwelt 7 February: 6)':

- On what basis does Umwelt justify the inclusion of other RAPs in fieldwork when the PCWP are the only recognised group with Traditional Connections to the study area? And
- If your fieldwork goes ahead tomorrow (Thursday 9 February 2017) as planned, how will Tocomwall be afforded the opportunity to participate in the *archaeological* fieldwork?

Conclusions

In conclusion, Tocomwall would like to thank Umwelt in responding promptly to our letter dated 6 February 2017. As is reflected in our response, Tocomwall would like to see a more deliberated approach to evaluating the assessment of cultural significance.

We note based on a phone call with Nicola Roche (*pers.comm. 8 February 2017*) and confirmed today ((*pers.comm. Nicola Roche. 8 February* 2017) that the archaeological fieldwork for this project is planned to start today. Tocomwall has grave concerns with this because it would seem that consideration of our views is being superseded by commercial decisions by both the proponent and Umwelt. This seems to negate the consultation process that we have been engaging in to date and certainly provides - from Tocomwall's perspective – a view that our concerns are not being adequately addressed or considered in a timely manner that allows us to '*influence methods regarding assessment of significance* (Umwelt 7 February 2017: 2).'

Tocomwall would like to see the concerns raised in this review addressed by Umwelt as soon as possible and certainly before any subsequent fieldwork is proposed.

Please feel free to call me if you have any questions.

Recommendations

1. Tocomwall have a long-standing relationship with a professional anthropologist – Dr. Neale Draper – who has been working on the PCWP's connection to country, as our preferred anthropologist, particularly if it would help Umwelt design an appropriate ethnographic approach to the assessment of cultural significance.

2. At the very least, Umwelt should prepare a specific and appropriate (ethnographic) research design and methodology to investigate cultural significance before undertaking any archaeological or anthropological fieldwork.

References

Whitehead, T.L. 2005. Basic Classical Ethnographic Research Methods. In *Ethnographically Informed Community and Cultural Assessment Research Systems (EICCARS) Working Paper Series.*

Regards,

Jakub Czastka (Chaz)
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Our Ref: 3900/NR/Tocomwall/080317

8 March 2017

Jakub Czastka
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BY EMAIL: jakub@tocomwall.com.au

Dear Chaz

Re: Response to Draft Methodology for Austar Coal Mine – Proposed Modification to DA29/95 (MOD 7) – LWB4-B7 – 9 February 2017

We refer to your correspondence dated 9 February concerning the methodology for consulting with Aboriginal parties to assess the Aboriginal cultural significance of the proposed Austar modification.

1.0 Consultation as a self-determined process

As previously communicated, Umwelt acknowledges that Aboriginal parties may differ significantly in how they wish to be consulted and how they wish to undertake the assessment of cultural significance. We therefore typically invite Aboriginal parties to identify any aspects/methods of consultation that they feel will assist them in the assessment process. This approach is adopted with reference to the consultation guiding principles established in Section 1.3 of the *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010) and the objectives of consultation provided in Section 3.2, which includes '*ensuring Aboriginal people have the opportunity to improve assessment outcomes by...influencing the design of the method to assess cultural and scientific significance of Aboriginal object(s) and places*.'

Our role is to assist Aboriginal parties by facilitating the provision of information and site access to inform the assessment of cultural values, but we do not undertake this assessment on their behalf. Rather, we assist in documenting this assessment of cultural values as requested by the Aboriginal parties.

Given your advice that that Tocomwall is currently working with an anthropologist to document aspects of connection to country, should Tocomwall wish to provide ethnographic information to which it has access then this will be documented and addressed in the Aboriginal Cultural Heritage Assessment report on the project.

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2.0 Relevant experience to undertake consultation with Aboriginal parties and document feedback from Aboriginal parties

Umwelt has a proven and demonstrated ability to consult on and conduct Aboriginal cultural heritage assessments in accordance with relevant guidelines and requirements and to the satisfaction of OEH and other relevant regulatory authorities. Further, Umwelt has extensive experience in conducting Aboriginal cultural heritage assessments to the satisfaction of the OEH. This includes numerous assessments where Tocomwall has been consulted as a registered Aboriginal party and has participated in the assessment and has been provided with copies of the relevant assessments.

At no time has OEH questioned or raised any issues concerning the appropriateness of Umwelt's qualifications or level of experience in consulting on or conducting Aboriginal cultural heritage assessments.

In addition, we note that Section 3 of *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010b) provides a list of skills and competencies required to deliver effective consultation, none of which specify the requirement for the completion of formal anthropological training. Nevertheless, we note that our team is managed by Nicola Roche, who has a Bachelor of Arts (Honours) with a double major in Anthropology.

3.0 Detailed assessment requirements

As is our standard practice, the Aboriginal cultural heritage assessment report will be completed in accordance with the requirements of the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011). As specified in this document, the Aboriginal cultural heritage assessment report will include a review of available ethnohistoric (or ethnographic) literature pertinent to the project area and its surrounds.

Austar has previously committed to Tocomwall participating in a survey of the area. Austar has advised that this offer remains open to Tocomwall to participate in a field survey at any time prior to **22 March 2017.** Regardless of whether Tocomwall takes up the opportunity for further participation, a copy of the Draft Aboriginal Cultural Heritage Assessment will be provided to Tocomwall as part of the consultation process with Registered Aboriginal Parties.

We trust this clarifies our position on the consultation requirements for an Aboriginal cultural heritage assessment of the proposed Austar modification. Please contact Nicola Roche or Gary Mulhearn if you wish to take up the opportunity to participate in a survey process.

Yours sincerely

Nicola Roche
Manager Cultural Heritage

Copy of Letter Sent to all Aboriginal Parties Reference Draft ACHAR

Our Ref: 3900/R04/GA/NR/27042017

27 April 2017

«Company_Name»
«Contacts»
«Address»

«Email»

Dear «Contacts»

Re: Draft LWB4-B7 Modification Aboriginal Cultural Heritage Assessment Report, Austar Coal Mine

Please find attached the draft LWB4-B7 Modification Aboriginal Cultural Heritage Assessment Report, Austar Coal Mine. This report is provided for your review and comment in accordance with the requirements of Part 8A, Clause 80C of the *National Parks and Wildlife Regulation 2009* and Stage 4 of the *Aboriginal cultural heritage consultation requirements for proponents* (DECCW 2010).

The Aboriginal Cultural Heritage Assessment Report has been prepared in accordance with the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011).

An Archaeological Technical Report is provided as Appendix 2 to the Aboriginal Cultural Heritage Assessment Report. Appendix 2 has been written to address the requirements of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010) and contains all relevant archaeological information.

Please note that this report is provided in draft format only and has been developed to incorporate feedback and comments provided by registered Aboriginal parties. As acknowledged throughout the report, there are some sections of the report that are to be completed based on the information provided by registered Aboriginal parties. We ask that you please review the report and respond carefully. All comments received will be addressed in the finalised report (noting that registered Aboriginal parties may identify that they wish their comments/feedback to be confidential and not publically available)

In accordance with Office of Environment and Heritage consultation requirements, please provide feedback within 28 days, that is, by no later than close of business on **Thursday 25 May 2017**. Comment can be provided (preferably in writing) to Nicola Roche (Manager Cultural Heritage) via email (nroche@umwelt.com.au), telephone (02 4950 5322) or post (75 York St, Teralba, NSW 2284).

Should you wish to discuss any aspect of the draft report or the LWB4-B7 Modification, please do not hesitate to contact me.

Yours sincerely

Nicola Roche
Manager Cultural Heritage

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From: Tracey Skene [mailto:tracey@marrung-pa.com.au]
Sent: Friday, 26 May 2017 10:29 PM
To: Nicola Roche
Subject: LWB4-B7 Draft Report

Good Evening Nicola,

Sorry for the delay in getting my comment to you in regards to the Austar LWB4-B7 Modification Aboriginal Cultural Heritage Assessment Report-Austar Coal, I have viewed and read the report and made myself aware of the Aboriginal Communities comments and concerns.

I have lived in the surround area of Austar mine for many years and I have been involved since the first stages of Aboriginal Community consultation of this mine site.

As shown on figure 3.2 the Aboriginal Land Council Boundary areas associated with this location, and like it noted that these boundaries are completely different to the Aboriginal Tribal Boundaries of this area.

The Cultural landscape of this location is regarded to have a high cultural significance, each site that have been recorded and unrecorded over the years in this area (as there is several Sites in the surrounding landscape that have not been recorded due to being on private properties and of local knowledge) and that they all poses its own unique spiritual and cultural values and connections.

The Catch a boy swamp-Ella long lagoon has been recorded and known as a mythological story of the area and has been spoken about by locals for many years, and was recorded by non-aboriginal person, this swamp would have been a highly significant area for our ancestors for resources and food and also would have been utilized along their travels to many of the surrounding ceremony and significant sites and have connection and association to the sites within this same landscape some being recorded and unrecorded that shows the cultural connectivity to the sites of the area and it stories.

The Assessment area has a known creek called Quorrobolong creek, this area may have a low scientific values but holds a high importance and cultural significance to the Aboriginal Community.

Aboriginal community establishes the significance of the site from an Aboriginal community perspective rather than a scientific perspective.

As stated on page 37- 7.2.4 Summary that the LWB4-B7 is unlikely to result in direct or indirect impact that will impact the Aboriginal cultural values associated within this area that no mitigation strategies will be implemented due to having no impact in this area, I feel that it being monitored along with any other recorded sites on Austar Coal mine site is adequate and should have community out on site once the modifications of this area have taken place with the Long wall being constructed and that Its importance that by Keeping the natural surrounds as they are (e.g. water flows, creek lines) that are within this area and kept monitored for any damage by the mine and any natural impacts that may lose or impact any recorded sites.

Tracey skene

Culturally Aware

Kind Regards,
Tracey Skene

Marrung-ta Indigenous Training & Employment
7 Crawford Place, Millfield NSW 2325
Mobile: 0474106537

MARRUNG-TA
INDIGENOUS TRAINING

Nicola Roche

From: Frances Davies
Sent: Monday, 22 May 2017 4:10 PM
To: Nicola Roche
Cc: Gabrielle Allan
Subject: FW: 3542 - Draft Austar Aboriginal Cultural Heritage Management Plan

Forwarded for your attention - I received this email today in response to the draft Austar ACHMP.

Regards

Frances Davies
Directors Assistant

Umwelt (Australia) Pty Limited
75 York Street
Teralba, NSW 2284

Phone: (02) 4950 5322

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Newcastle ph. 02 4950 5322 | **Perth** ph. 08 6260 0700 | **Canberra** ph. 02 6262 9484 | **Sydney** ph. 1300 793 267 | **Brisbane** ph. 1300 793 267

From: Awabakal [mailto:culture@awabakallalc.com.au]
Sent: Monday, 22 May 2017 2:31 PM
To: Frances Davies
Cc: CEO
Subject: RE: 3542 - Draft Austar Aboriginal Cultural Heritage Management Plan

Hi Frances,
On behalf of Awabakal LALC and its members, I am comfortable with the content in the Draft Austar Cultural Heritage Management Plan and do not wish to add anything further.

Regards

Pete Townsend
Culture & Heritage Officer

MINDARIBBA
LOCAL ABORIGINAL LAND COUNCIL

1A Chelmsford Drive, Metford NSW 2323 | PO Box 401, East Maitland NSW 2323
P: 02 4015 7000 | F: 02 4934 8544 | E: admin@mindaribbalalc.org

24th May 2017

Ms Nicola Roche
Manager Cultural Heritage,
Umwelt (Australia) Pty Limited
75 York Street
Teralba NSW 2284

Dear Ms Nicola Roche

RE: Austar Coal Mine: Aboriginal Cultural Heritage Assessment Report for LWB4-B7 Modification to DA 29/95 under Section 75W

Mindaribba Local Aboriginal Land Council: Review of the DRAFT Aboriginal Cultural Heritage Assessment Report, April 2017

Mindaribba Local Aboriginal Land Council, (MLALC), would like to firstly identify its dismay at the lack of face to face engagement and consultation in regards to the content of the DRAFT Aboriginal Cultural Heritage Assessment Report (DRAFT report) with the Registered Aboriginal Parties (RAPs). Within paragraph two of the draft reports' acknowledgement section; it seeks to acknowledge "the post-contact experiences of Aboriginal people who have an attachment to the Quorrobolong Valley". However, it fails to acknowledge the possible insufficiency of literacy and writing competences of these same peoples, by undertaking this final part of the consultation process with a requirement to review a lengthy and highly technical document.

In the time available to us, MLALC has conducted a brief review of the DRAFT report and make the following comments.

Social or Cultural Values

MLALC has reviewed the social or cultural values section of the report which describes values identified by the Aboriginal stakeholder representatives who have participated within the surveys and has no further information to be included at this point in time.

Historical Values

MLALC has reviewed the historic values section of the DRAFT report and has no further information to be included at this point in time.

Impacts to Farm Dam

Figure 5.2 of the DRAFT report shows the dam located at the end of LWB7. There is no discussion in relation to the potential impacts of the Modification on this dam structure. MLALC request that this be addressed within the final report.

Management Strategies

Section 6.3 of the DRAFT report identifies two sites assessed to comprise low to moderate archaeological significance and the research potential of these areas. This section suggests a provisional assessment to be undertaken on these areas. However, no detail is provided on what this provisional assessment will entail. MLALC requests that the details of this provisional assessment be included within the final Aboriginal Cultural Heritage Assessment Report.

Whilst Section 8 of the DRAFT report identifies that the management strategies as described within the existing Austar Aboriginal Cultural Heritage Management Plan (ACHMP) should be implemented to manage the impacts resulting from the Modification, the DRAFT report does not currently identify the management strategies from the ACHMP relevant to the Modification which will need to be implemented.

MLALC requests that these details be included within the final report.

Concluding Recommendations

The report states that the potential for impacts on archaeological sites are limited due to those impacts considered to be *"indirect impacts associated with subsidence, including potential landscape impacts, surface cracking, subsidence remediation works or hydrological changes"*. In the case of these potential impacts, MLALC request that (consistent with contemporary conditions for mining approvals) regular meetings be arranged with all RAPs to provide an update of the operations, including performance against the predicted impacts from the mining activities at Austar.

Due to the vegetation cover over the areas surveyed for the Modification, there is the potential for further unrecorded items of Aboriginal heritage sites to be exposed following subsidence or during the completion of any remediation works that will required during mining operations. MLALC requests that in these instances, further inspections of these areas should be undertaken by an archaeologist and RAPs.

For further information in relation to this response, please contact myself on the phone number above.

Kind Regards,

Tara Dever
Chief Executive Officer
Mindaribba Local Aboriginal Land Council

From: Arthur Fletcher [mailto:arthur.c.fletcher@gmail.com]
Sent: Thursday, 25 May 2017 4:13 PM
To: Kirwan Williams
Subject: Draft LWB4/B7 Modification Austar

Hi Kirwan, Thanks for the opportunity to respond to this. I first apologise for the late response, As you may not be aware of my health of late. Anyway at this stage with my limited understanding of it I will be supporting this one. Ps All the best to everyone.
Regards Kauwul-Arthur
Sent from my iPad

Lower Wonnarua Tribal Consultancy
156 The Inlet Road
Bulga NSW 2330

25/05/2017

To

Umwelt
75 York Street
Teralba NSW
2284

Re: Draft LWB4-B7 Modification Aboriginal Cultural Heritage Assessment Report
Austar Coal Mine

Dear Nicola
I have read the draft report dated April 2017. There are few mistakes in section 3.3 Aboriginal party participation in survey. Table 3.2 has my name under the Lower Wonnarua Tribal Council dated 9/02/17 and 10/02/17 could you please amend this.

As to the report itself
1.2 Proposed Modification to DA29/95.
I agree with the proposed method of using the existing infrastructure by Austar Coal Mine.

I agree with the **Recommendations 8.0** and the two dote points that Austar Coal Mine Have put forward to work within the Aboriginal Cultural Heritage Management Plan (ACHMP), for the LWB4-B7 long wall extension.

Yours sincerely
Barry Anderson
Lower Wonnarua Tribal Consultancy

umwelt

Our Ref: 3900/NR/BC/20170526

26 May 2017

Tara Dever
Chief Executive Officer
Mindaribba Local Aboriginal Land Council
PO Box 401
EAST MAITLAND NSW 2323

Dear Tara

Re: Response to submission re Austar Coal Mine LWB4-B7 Modification Draft Aboriginal Cultural Heritage Assessment Report

Thank you for your correspondence in relation to the above draft report. This letter provides a response to matters raised in your letter dated 25 May 2017.

Your response raises concerns regarding the extent of face to face engagement and consultation with registered Aboriginal parties in regards to the content of the draft Aboriginal cultural heritage assessment report. We appreciate that review of the draft Aboriginal cultural heritage assessment report requires literacy competency. However, we note that in all our interactions with Aboriginal parties (including the letter provided to you accompanying the draft report) we emphasise our availability at any stage to discuss the contents of draft report and documents. In future, should you have any concerns of this nature, please let me know and we will make a time to meet with you or your nominated representative to go through the draft report.

You have asked that the report provide further information regarding impacts to the farm dam at the northern end of LWB7. Section 7 of the draft report describes and assesses the potential impacts associated with the proposed modification, including potential impacts on the farm dam. As described in Section 7.2 of the draft report, the potential for surface cracking is low and subsidence remediation works are unlikely to be required. Potential hydrological changes have also been assessed, with Section 7.2.3 including the following statement:

> *The assessment predicts minor changes to remnant ponding around some existing flow paths and farm dams. These minor changes to the extent of remnant ponding occur within low lying areas that are already subject to periodic inundation during periods of high rainfall. Therefore additional periods of inundation in these locations are highly unlikely to result in any additional impact to Aboriginal cultural values that may be present.*

To summarise, the farm dam at the northern end of LWB7 is unlikely to experience cracking or require subsidence remediation works. Minor change in the extent of ponding may occur in low lying areas around the dam within areas that are already subject to periodic inundation. .

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Umwelt (Australia) Pty Limited
ABN: 18 059 519 041

Your response requests details of significance assessment for two sites assessed in Section 6.3 as having low to moderate significance. To clarify, sites ACM38 and ACM40 are assessed as having low to moderate significance, as stated in Section 6.3. Section 6.3 provides a provisional assessment of significance for areas of low-moderate archaeological potential (that is, areas where Aboriginal objects weren't visible but where we predict there is low-moderate likelihood that sub-surface artefacts will be present in detectible quantities). Given that we don't know what these sub-surface deposits might comprise, we can only assess provisional significance. The level of significance would only be able to be refined if impacts were required in these landforms and sub-surface investigations were undertaken to provide us with more information on the nature and extent of deposits.

You have requested further information about the management measures included in the Austar ACHMP. For clarity, Section 8 will be amended to include specific reference to existing managements measures outlined in the ACHMP, as follows:

> *The Austar Coal Mine should continue to implement the management strategies currently in place at the Austar Coal Mine, including those in the Austar Aboriginal Cultural Heritage Management Plan (ACHMP). Consistent with existing management strategies, in the unlikely event that subsidence remediation works are required that will impact on the identified sites or areas of low-moderate or higher archaeological potential, an Aboriginal Heritage Impact Permit (AHIP) will be sought for the portion of the site or area of potential to be impacted prior to the commencement of any remediation works in proximity to the recorded site or area of potential (noting that, in some instances, it may be necessary to undertake test excavation to inform the requirement for an AHIP). Appropriate mitigation measures for the site or area of potential to be impacted by the remediation works will be developed as part of the AHIP application process in consultation with the registered Aboriginal parties and in accordance with OEH requirements. <u>The ACHMP includes provision for pre and post subsidence monitoring of recorded sites to provide comparative data on site condition and to allow for the identification of any unexpected subsidence impacts.</u>*

Site monitoring will be undertaken in consultation with registered Aboriginal parties. We hope that this also addresses your request for regular consultation with Aboriginal parties to review subsidence impacts.

We recognise that visibility with the survey area was low. We note that this is common within the context of the Hunter Valley and that this is why we give consideration to archaeological potential (including the potential for artefacts to be present but not visible). This assessment of potential has been undertaken in accordance with OEH requirements and is addressed in the report. At this stage, we will not be recommending any further archaeological inspections of the area, other than the pre and post subsidence inspections discussed above.

Again, thank you for your time in compiling the response and we hope that this letter has addressed your concerns. Should you wish to discuss any aspect of the above, please do not hesitate to contact me.

Yours sincerely

Nicola Roche
Manager Cultural Heritage

APPENDIX 2

Archaeological Technical Report

LWB4-B7 MODIFICATION ARCHAEOLOGICAL TECHNICAL REPORT

Austar Coal Mine

FINAL

May 2017

LWB4-B7 MODIFICATION ARCHAEOLOGICAL TECHNICAL REPORT

Austar Coal Mine

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Austar Coal Mine

Project Director:	Barbara Crossley
Project Manager:	Gabrielle Allan
Report No.	3900/R04/Appendix 2
Date:	May 2017

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

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Quality ISO 9001

This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

Executive Summary

Austar Coal Mine Pty Ltd (Austar), a subsidiary of Yancoal Australia Limited (Yancoal) operates the Austar Coal Mine, an underground coal mine located approximately 10 kilometres south of Cessnock in the Lower Hunter Valley in NSW. The Austar Coal Mine incorporates the former Pelton, Ellalong, Cessnock No. 1 (Kalingo) and Bellbird South Collieries and includes coal extraction, handling, processing and rail and road transport facilities.

Austar is proposing to modify development consent DA29/95 (the Bellbird South Consent) under section 75W of the Environmental Planning and Assessment Act 1979 (EP&A Act). The modification is required to permit the transfer and processing of coal from four (4) additional longwall panels (LW) B4 to B7 via the existing Bellbird Mains and to extend the development consent area to encompass the four proposed longwall panels**.**

Austar engaged Umwelt (Australia) Pty Ltd (Umwelt) to work with the registered Aboriginal parties to complete an Aboriginal Cultural Heritage Assessment for the proposed modification. This report is provided as a technical report that forms an appendix to the Aboriginal Cultural Heritage Assessment Report (ACHAR) for the proposed modification and is prepared in accordance with *The Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010) (the Code of Practice). The ACHAR will inform the Environmental Assessment (EA) for the proposed modification to development consent DA 29/95.

Mining within the Bellbird South areas (Southland, Stage 1 and Stage 2) was approved by the Minister for Urban Affairs and Planning in 1996 under DA 29/95, while mining of Stage 3 was approved by the Minister for Planning in 2009 under Project Approval 08_0111. Mining is currently being undertaken in the LWB1-B3 mining area in accordance with DA 29/95. It is noted that the impacts of mining LWB1-B3 on Aboriginal cultural heritage was assessed in 2015 (Umwelt 2015) as part of a previous modification of DA29/95.

The potential impacts of the proposed LWB4-B7 Modification on Aboriginal archaeology and cultural heritage have been assessed within the 20 millimetre subsidence contour for LWB4-B7. This area is referred to as the 'LWB4-B7 Modification Area'. The LWB4-B7 Modification Area incorporates portions of the previously assessed LWB1-B3 Modification Area (Umwelt 2015), therefore the archaeological survey and cultural heritage assessment findings from the LWB1-B3 Modification have been considered in this assessment where appropriate.

A review of available environmental contextual information for the LWB4-B7 Modification Area and surrounds demonstrates that the modification area provided access to Quorrobolong Creek, which, although ephemeral, may have held water for extended periods in pools or ponds. In addition, the review of landforms and soils associated with the modification area identified the potential for alluvial landforms along Quorrobolong Creek that intersect with slope landforms, therefore establishing the potential for colluvial-alluvial interfaces, with the associated potential implications for archaeological site preservation. The LWB4-B7 Modification Area is also relatively well resourced with reference to the plant and animal resources that would have been present in the area prior to non-Aboriginal settlement and landscape modification. However, the modification area and surrounds have been settled for a relatively lengthy period of time and have been subject to a range of impacts. These impacts are likely to be in the form of changes to erosion regimes (following vegetation clearance) and subsequent alterations in the nature and morphology of watercourses.

A review of available archaeological information pertaining to the LWB4-B7 Modification Area and surrounds was undertaken to inform the understanding of archaeological site patterning, site survival and the potential for detection of extant archaeological sites. This review identified that the LWB4-B7 Modification Area contains one previously recorded archaeological site (AHIMS #37-6-3398 – ACM35). This site is located within the area previously assessed as part of the previous LWB1-B3 Modification and is managed in accordance with the provisions of the Austar Coal Aboriginal Cultural Heritage Management Plan (Austar 2017).

Based on the review of archaeological and environmental information, a predictive model was developed for the LWB4-B7 Modification Area. This model identified that sites containing stone artefacts are the most likely site type, with the site numbers and density likely to be greatest in association with water resources, particularly Quorrobolong Creek. In addition, it was identified that there is the potential for colluvial/alluvial interfaces within the areas of valley flats bordering the watercourses, particularly Quorrobolong Creek and that sites in these contexts may retain stratigraphic integrity. Scarred trees may occur where mature native vegetation remains whilst grinding groove sites (and potentially other sites associated with sandstone such as engraving sites) may occur if suitable sandstone outcrops are exposed within the channel of Quorrobolong Creek and associated watercourses.

The methodology for the assessment was developed with reference to the predictive model and was subject to consultation with registered Aboriginal parties. The survey of the LWB4-B7 Modification Area comprised pedestrian survey in accordance with the sampling strategy and undertaken with representatives of the registered Aboriginal parties. A total of 13 new sites were identified, of which one is located outside the LWB4-B7 Modification Area. These sites consisted of isolated artefacts and artefact scatters, with only two sites (ACM38 and ACM40) containing more than five artefacts. The distribution and contents of these sites is relatively comparable to the outcomes of previous archaeological investigations within the Austar Coal Mine and surrounds. No grinding grooves or scarred trees were identified within the LWB4-B7 Modification Area and no areas of outcropping sandstone were present within Quorrobolong Creek.

Based on the criteria for the assessment of archaeological potential, the majority of the LWB4-B7 Modification Area has low archaeological potential. The exceptions to this are the valley flats bordering Quorrobolong Creek (moderate potential), slopes within 100 metres of the main channel of Quorrobolong Creek and identified overflow channels and the spur crest in Survey Unit 9 (all of which have low to moderate archaeological potential).

The archaeological significance of the identified sites was assessed as low, with the exception of sites ACM38 and ACM40, which were assessed as having low-moderate archaeological significance, largely based on their research potential.

The proposed modification does not involve any additional surface development and therefore will have no direct impact on Aboriginal archaeological sites as a result of land clearing. The potential impact of the proposed modification on archaeological sites is therefore limited to indirect impacts associated with subsidence, including the potential for surface cracking and changes to hydrology (including ponding or alterations to creekline morphology). Based on the outcomes of assessments undertaken by MSEC (2017) and Umwelt (2017c), the proposed LWB4-B7 Modification is unlikely to result in direct or indirect impacts to the identified archaeological sites or on the identified areas of low-moderate or higher archaeological potential.

The following recommendations have been developed in light of the archaeological context of the LWB4-B7 Modification Area; the findings of the current survey and the previous survey of the LWB1-B3 Modification Area; the low likelihood of impact of the proposed modification on identified archaeological sites and areas of archaeological potential and current cultural heritage legislation:

- Austar Coal Mine should continue to implement the management strategies currently in place at the Austar Coal Mine, including those in the Austar Aboriginal Cultural Heritage Management Plan (ACHMP). Consistent with existing management strategies, in the unlikely event that subsidence remediation works are required that will impact on the identified sites or areas of low-moderate or higher archaeological potential, an Aboriginal Heritage Impact Permit (AHIP) will be sought for the portion of the site or area of potential to be impacted prior to the commencement of any remediation works in proximity to the recorded site or area of potential (noting that, in some instances, it may be necessary to undertake test excavation to inform the requirement for an AHIP). Appropriate mitigation measures for the site or area of potential to be impacted by the remediation works will be developed as part of the AHIP application process in consultation with the registered Aboriginal parties and in accordance with OEH requirements. The ACHMP includes provision for pre and post subsidence monitoring of recorded sites to provide comparative data on site condition and to allow for the identification of any unexpected subsidence impacts.

- The Austar ACHMP should be reviewed to incorporate the outcomes of this assessment and to include provisions for the monitoring of identified archaeological sites within the LWB4-B7 Modification Area in accordance with the management strategies currently implemented within the Austar Coal Mine.

Table of Contents

Figures

Tables

Appendices

1.0 Introduction

Austar Coal Mine Pty Ltd (Austar), a subsidiary of Yancoal Australia Limited (Yancoal) operates the Austar Coal Mine, an underground coal mine located approximately 10 kilometres south of Cessnock in the Lower Hunter Valley in NSW (refer to **Figure 1.1**). The Austar Coal Mine incorporates the former Pelton, Ellalong, Cessnock No. 1 (Kalingo) and Bellbird South Collieries and includes coal extraction, handling, processing and rail and road transport facilities.

Austar is proposing to modify development consent DA29/95 (the Bellbird South Consent) under section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The modification is required to permit the transfer and processing of coal from four (4) additional longwall panels (LW) B4 to B7 via the existing Bellbird Mains and to extend the development consent area to encompass the four proposed longwall panels (refer to **Figure 1.2** and **Figure 1.3**). There will be no change to surface facilities, approved rates of mining, coal processing and handling or product transport rates as a result of the modification.

Austar engaged Umwelt (Australia) Pty Ltd (Umwelt) to work with the registered Aboriginal parties to complete an Aboriginal Cultural Heritage Assessment for the proposed modification. This report is provided as a technical report that forms an appendix to the Aboriginal Cultural Heritage Assessment Report (ACHAR) for the proposed modification and is prepared in accordance with *The Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010) (the Code of Practice). The ACHAR will inform the Environmental Assessment (EA) for the proposed modification to development consent DA 29/95.

1.1 Austar Coal Mine Background

Extensive mining has been undertaken within the Austar Coal Mine since 1916. Historical mining was predominantly via bord and pillar mining and more recently via conventional longwall mining and Longwall Top Coal Caving (LTCC) methods. Mining within the Bellbird South areas (Southland, Stage 1 and Stage 2 refer to **Figure 1.2**) was approved by the Minister for Urban Affairs and Planning in 1996 under DA 29/95, while mining of Stage 3 was approved by the Minister for Planning in 2009 under Project Approval 08_0111. Longwall mining commenced in the Ellalong Colliery area in 1983 and has subsequently progressed into the Bellbird South and the Stage 3 areas.

Mining is currently being undertaken in the LWB1-B3 mining area in accordance with DA 29/95. A review of accessible coal resources within the Bellbird South/Ellalong Colliery areas has identified the potential for four additional longwall panels (LWB4-B7) adjacent to LWB3 (refer to **Figure 1.3**). It is noted that the impacts of mining LWB1-B3 on Aboriginal cultural heritage was assessed in 2015 (Umwelt 2015) as part of a previous modification of DA29/95.

The potential impacts of the proposed LWB4-B7 Modification on Aboriginal archaeology and cultural heritage have been assessed within the 20 millimetre subsidence contour for LWB4-B7. This area is referred to as the 'LWB4-B7 Modification Area' and is shown on **Figure 1.3.** The 20 millimetre subsidence contour is considered the vertical limit of subsidence. The LWB4-B7 Modification Area incorporates portions of the previously assessed LWB1-B3 Modification Area (Umwelt 2015), therefore the archaeological survey and cultural heritage assessment findings from the LWB1-B3 Modification have been used to supplement this assessment where appropriate. The detailed survey data from the assessment of the LWB1-B3 Modification is not repeated within this report but the outcomes of the previous assessment are used to inform the current assessment (including the location of site #37-6-3398).

The LWB4-B7 Modification Area is located entirely within the Austar mining authorities CCL728 and CML 2 and no change to Austar's existing mining authorities would be required to accommodate the LWB4-B7 Modification.

1.2 Proposed Modification to DA29/95

Austar proposes to modify the Bellbird South consent to:

- permit the transfer and processing of coal from LWB4-B7 via the existing Bellbird mains
- extend the development consent area to encompass the four proposed longwall panels (refer to **Figure** 1.3).

Coal will be extracted from LWB4-B7 using conventional longwall mining techniques. The existing Austar Coal Mine infrastructure is sufficient to support the mining of the four proposed longwalls and there will be no change to surface facilities, approved rates of mining, coal processing and handling or product transport rates as a result of the modification.

The proposed modification does not involve any additional surface development and therefore will have no direct impact on Aboriginal archaeological sites as a result of land clearing. The potential impact of the proposed modification on archaeological sites is therefore limited to indirect impacts associated with subsidence, including the potential for surface cracking and changes to hydrology (including ponding or alterations to creekline morphology). The potential impacts of subsidence with reference to Aboriginal archaeological sites and areas of archaeological potential are discussed in detail in **Section 7.0**. However, it is noted that the predicted levels of subsidence within the LWB4-B7 Modification Area are lower than those that have occurred in the previously approved Stage 2 and Stage 3 mining areas (refer to **Figure 1.2**), where there has been no significant or visible surface cracking observed and no requirement for remediation of any ground surface cracking (MSEC 2017).

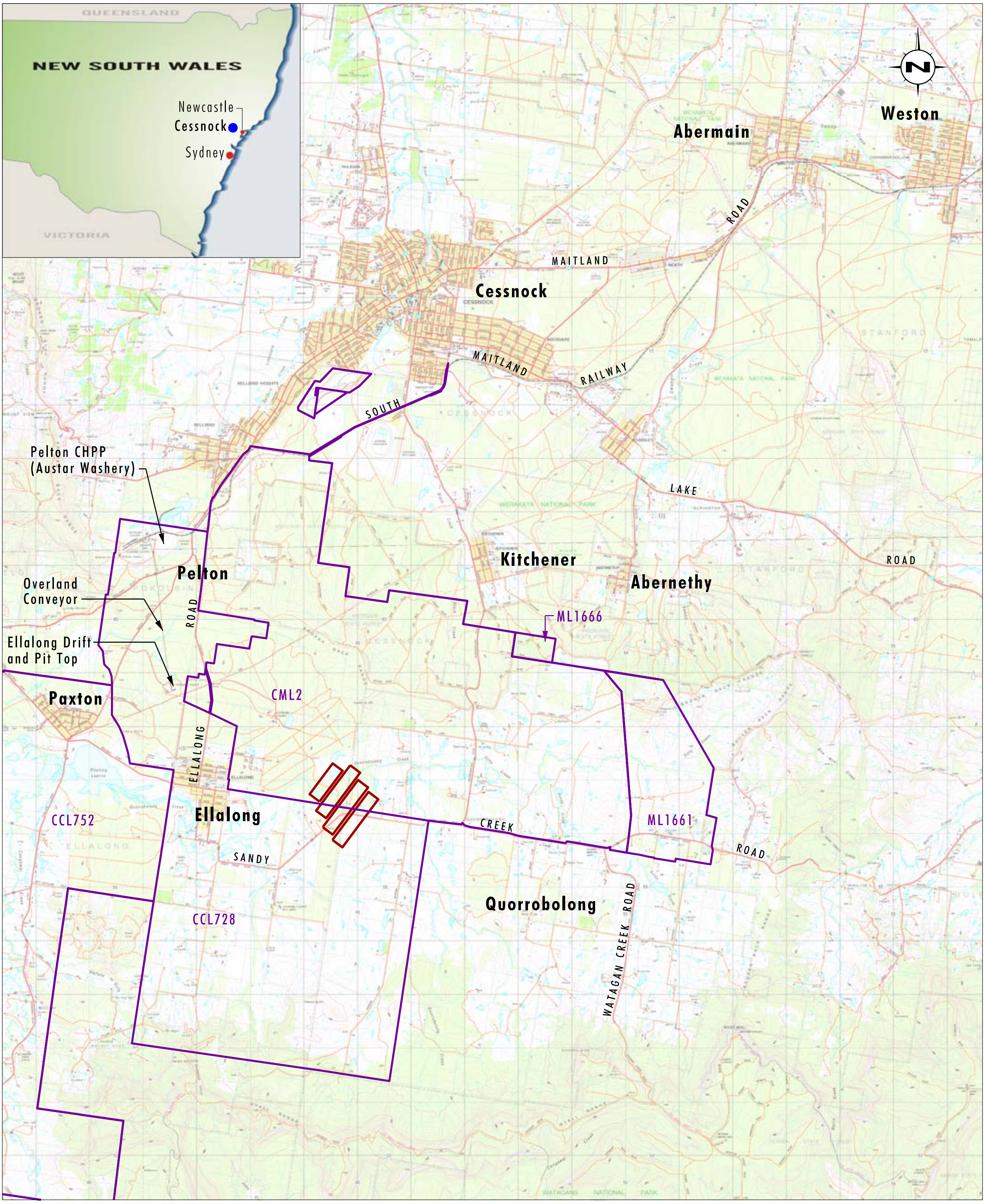

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

0 1.0 2.5 5.0km
1:100 000

Legend

- Proposed LWB4-B7 Longwall Panels
- Mining Lease Boundary

FIGURE 1.1

Locality Plan

umwelt

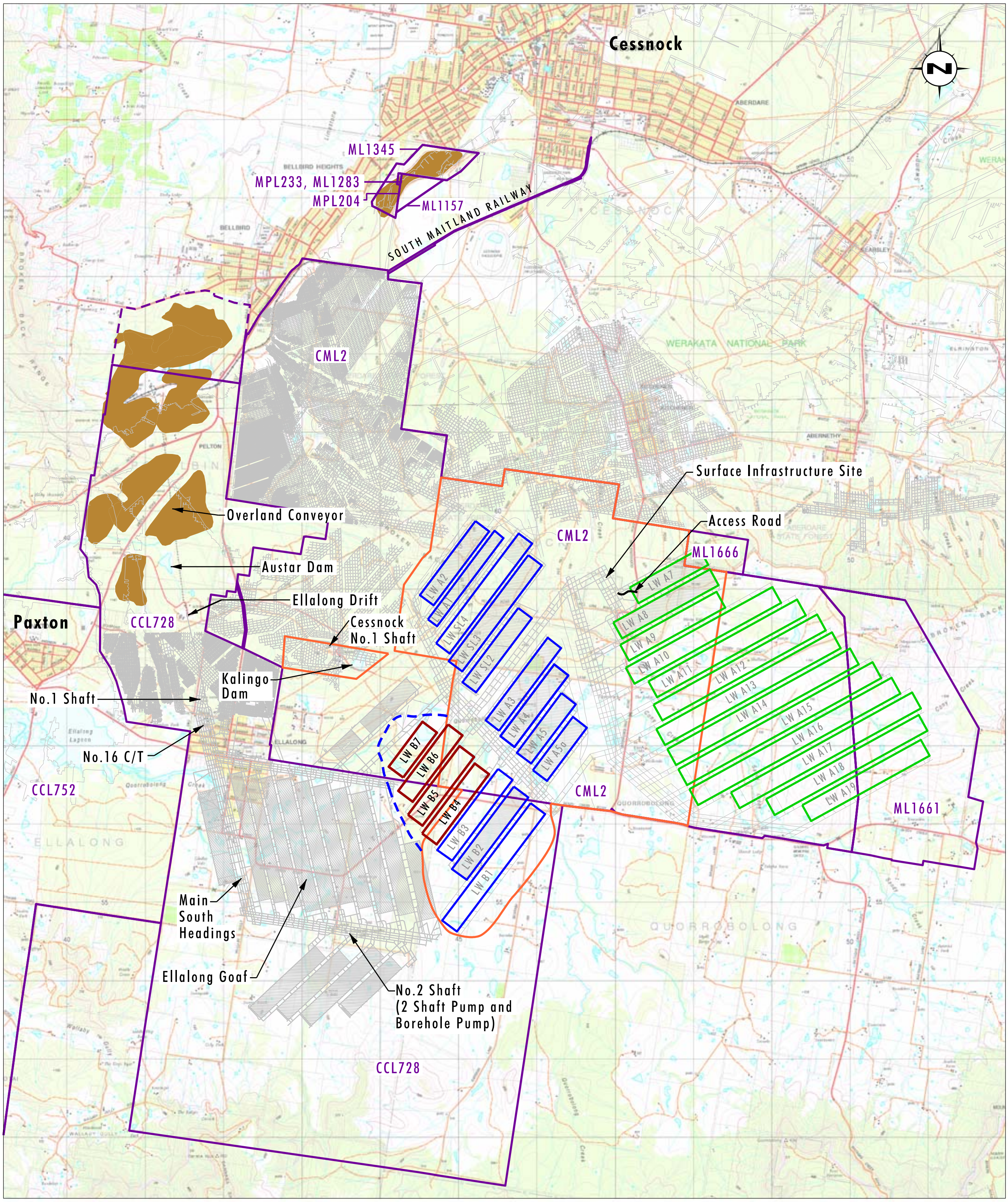

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016)

0 1 2 3km
1:70 000

Legend

- Bellbird South Stage 1, Stage 2, Southland and LWB1-B3 Longwall Panels (DA 29/95)
- Proposed LWB4-B7 Longwall Panels (DA 29/95)
- Stage 3 Longwall Panels (PA08_0111)
- DA 29/95 Bellbird South Consent Area (Subsurface) - As Approved
- DA 29/95 Bellbird South Consent Area (Subsurface) - Proposed Extension
- Approved Reject Emplacement Areas
- Completed Underground Workings
- Mining Lease Boundary
- Austar owned CHPP Land

FIGURE 1.2

Austar Coal Mine and Proposed LWB4-B7

File Name (A4): R04/Appendix2/3900_069.dgn
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umwelt

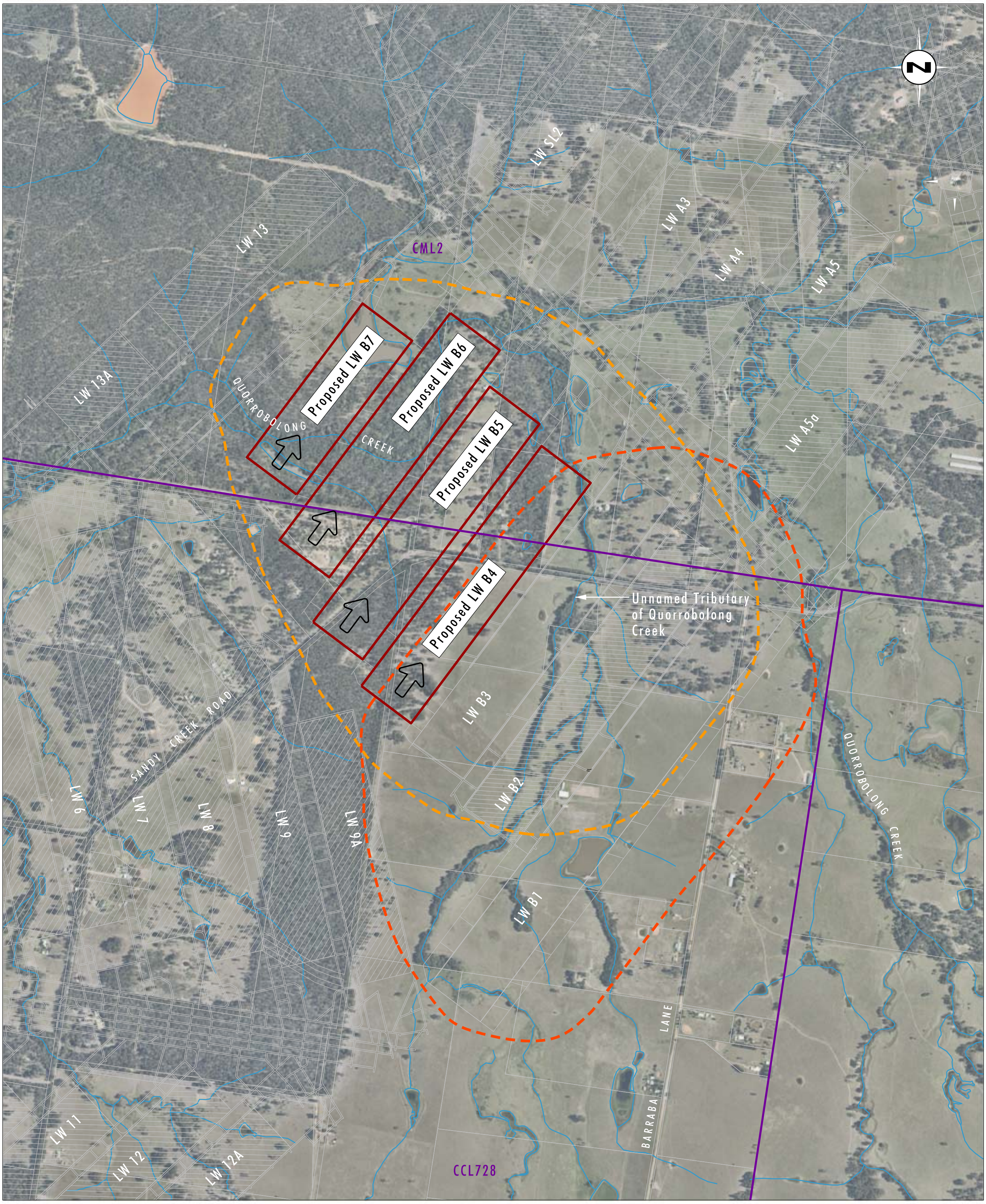

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)

0 0.25 0.5 1.0km
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Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- LWB1-B3 Modification Area
- Mining Lease Boundary
- Completed Underground Workings
- Direction of Mining
- Drainage Line

FIGURE 1.3

Proposed LWB4-B7 Modification

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1.3 Purpose of Assessment

This report has been prepared in conjunction with, and is appended to, the ACHAR as part of the EA to support an application to modify the Bellbird South Consent. The purpose of this report is to provide evidence of the previously recorded and identified material traces of past Aboriginal occupation and land use. This report is provided as a standalone document but is appended to the corresponding ACHAR and provides an assessment of the Aboriginal archaeology to assist in informing the broader assessment of Aboriginal cultural heritage.

This report provides the following information in support of the ACHAR and in accordance with the Code of Practice (DECCW 2010):

- provide an assessment of the environmental and archaeological background of the modification area and wider region (Requirements 1a-b, 2 and 3 of the Code of Practice, refer to **Sections 2** and **3**)
- develop an archaeological predictive model for the modification area (Requirement 4, refer to **Section 3**)
- provide a detailed archaeological assessment methodology (Requirements 5a-c, refer to **Section 4**)
- report on the results of the archaeological survey of the modification area (Requirements 5a-c, 6-10, refer to **Section 5**)
- assess the impact of the proposed modification on Aboriginal archaeological sites and/or areas of Aboriginal archaeological potential (Requirement 11, refer to **Section 7**)
- develop appropriate management and mitigation measures (Requirement 11, refer to **Section 8**)
- provide recommendations as to all further archaeological and consultation requirements (Requirement 11, refer to **Section 8**).

1.4 Aboriginal Party Consultation

Consultation with Aboriginal parties forms a key component of any archaeological assessment. The ACHAR documents consultation in accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (DECCW 2010).

1.5 Report Structure

Table 1.1 below outlines the structure of this report.

Table 1.1. Report Structure

Report Section	Section outcomes
Executive Summary	Provides a plain English summary of the report.
Section 1	Provides information on the modification and the contents of this report.
Section 2	Summarises the environmental background of the modification area.
Section 3	Summarises the Aboriginal archaeological of the modification area, including an archaeological predictive model.
Section 4	Outlines assessment methodology.
Section 5	Provides the results of the survey of the modification area
Section 6	Provides an assessment of the archaeological significance of the modification area.
Section 7	Assesses the potential impact of the modification to the identified Aboriginal archaeological sites and areas of potential.
Section 8	Provides recommendations as part of the management of the archaeological resource.
Section 9	Is a list of references used within this report.
Attachment 1	AHIMS search results (basic)
Attachment 2	Plates

1.6 Legislation

Key legislation relating to the management of Aboriginal cultural heritage for the proposal is reviewed in Section 1.2 of the ACHAR.

1.7 Project Team

This Aboriginal Cultural Heritage and Archaeological Assessment was completed by Nicola Roche (Manager Cultural Heritage, BA Hons.) with support from Joshua Madden (Senior Archaeologist, BA Hons.). Both Nicola and Joshua meet the minimum qualifications to undertake assessments of this kind, as referenced in Section 1.6 of the Code of Practice (DECCW 2010).

Input from Aboriginal parties is as acknowledged in the relevant sections of this report. Field surveys were undertaken by Nicola Roche, Joshua Madden and Aboriginal party representatives as discussed in **Section 5.0**.

2.0 Environmental Context

The decisions that people make regarding such things as where they live, the range of resources they use and other aspects of daily life may be influenced by the environment in which they live. The preservation and visibility of sites is also affected by environmental factors such as vegetation cover, past land-use and disturbance. A review of the environmental context of the LWB4-B7 Modification Area is therefore integral to considerations of site visibility, preservation and occurrence within the modification area.

This section provides a summary of available literature for the LWB4-B7 Modification Area, within a local and regional context. This section also discusses the implications for the archaeological evaluation of the LWB4-B7 Modification Area.

2.1 Geology and Soils

The LWB4-B7 Modification Area is located within the Quorrobolong Valley, between the Broken Back Range and the Myall Range; approximately 1.5 kilometres east of the town of Ellalong and 4 kilometres south of the town of Kitchener (as shown in **Figure 1.1**). This area lies within the Central Lowlands of the Hunter Valley, one of the nine sub-regions of the Hunter Valley defined by the CSIRO (Story 1963) and is part of the larger Sydney Basin Bioregion defined by NPWS (2007).

The Austar Coal Mine is located in the South Maitland Coalfield of the Maitland Group. Throughout the Maitland Group, marine sandstones and siltstones occur, extending from the coal measures to the ground surface (HLA 1995). The LWB4-B7 Modification Area is situated along the southern extent of the Permian Branxton geological formation, with parent material consisting primarily of siltstone, sandstone, mudstone and conglomerate (Kovac and Lawrie 1991). Based on the geological description of mudstones within this formation, it is unlikely that they were of a quality suitable for the manufacture of stone artefacts (with the mudstone typically referenced in archaeological sites better technically described as an indurated rhyolitic tuff). It is possible that raw materials suitable for artefact manufacture may have been present as pebbles/cobbles within conglomerates. In addition, should sandstone outcrop within the LWB4-B7 Modification Area, it may be possible that site types such as grinding grooves or engravings may occur.

The LWB4-B7 Modification Area is underlain by the Quorrobolong Soil Landscape. Typical soil profiles vary with landform, as described in Table 2.1**Table 2.1**Table 2.1 Quorrobolong Soil Landscape Summary (from Kovac and Lawrie 1991)

(refer to Kovac and Lawrie 1991). Based on the information provided in this table, it is clear that soils within the modification area are typically relatively shallow. These soils are typically moderately erodible (Kovac and Lawrie 1991). Topsoil pH ranges between 5.5 and 6.5, and acid topsoil problems are encountered throughout the area (Kovac and Lawrie 1991:109).

Table 2.1 Quorrobolong Soil Landscape Summary (from Kovac and Lawrie 1991)

Landform	A1 soil horizon	A2 soil horizon	B soil horizon	Typical topsoil depth
Lower slopes	Dark brown to black sandy loam, clay loam or silty clay loam		Greyish brown, brown or dark brown sandy clay, yellowish brown at depth	Up to 40cm
	Brown to dark reddish brown light sandy clay loam	Brown loam with orange mottling	Orange or grey mottled medium clay	Up to 40cm
	Dark brown clay loam	Dull yellow orange sandy clay loam	Yellowish brown sandy clay	Up to 25cm
Higher slopes	Dull yellow brown/brown sandy loam	Dull yellow orange bleached sandy loam	Yellowish brown or brown medium to heavy clay	Up to 50cm
Crests	Dark brown loam	Bleached dull brown sandy loam	Brown medium clay with yellow mottling	Up to 20cm

2.2 Landforms

The majority of the LWB4-B7 Modification Area can be broadly classified as low relief rolling hills bordering Quorrobolong Creek, which is the main watercourse in the modification area. Based on the available topographic information, provisional landform mapping was undertaken within the LWB4-B7 Modification Area, as shown in **Figure 2.1**.

Within the LWB4-B7 Modification Area, Quorrobolong Creek is a 5^{th}-6^{th} order drainage line. Quorrobolong Creek is an ephemeral watercourse with flows only occurring as a result of prolonged or high rainfall periods. Areas of ponding do however occur along its alignment within the modification area. A 4^{th} order unnamed tributary of Quorrobolong Creek flows in a northerly direction through the LWB4-B7 Modification Area above LWB1 to LWB4, converging with Quorrobolong Creek upstream of LWB5. Of these watercourses, Quorrobolong Creek comprises the most reliable source of water and is bordered by relatively broad valley flats formed through alluvial deposition. These flats adjoin slopes of varying inclination and there is the potential that the interface between slope and valley flat landforms could incorporate areas of overlapping colluvial and alluvial deposition, as will be discussed in relation to archaeological implications in **Section 3.2**. Quorrobolong Creek flows into Ellalong Lagoon approximately 3.5 kilometres west of the LWB4-B7 Modification Area, with Ellalong Lagoon comprising the most reliable source of water in the local area.

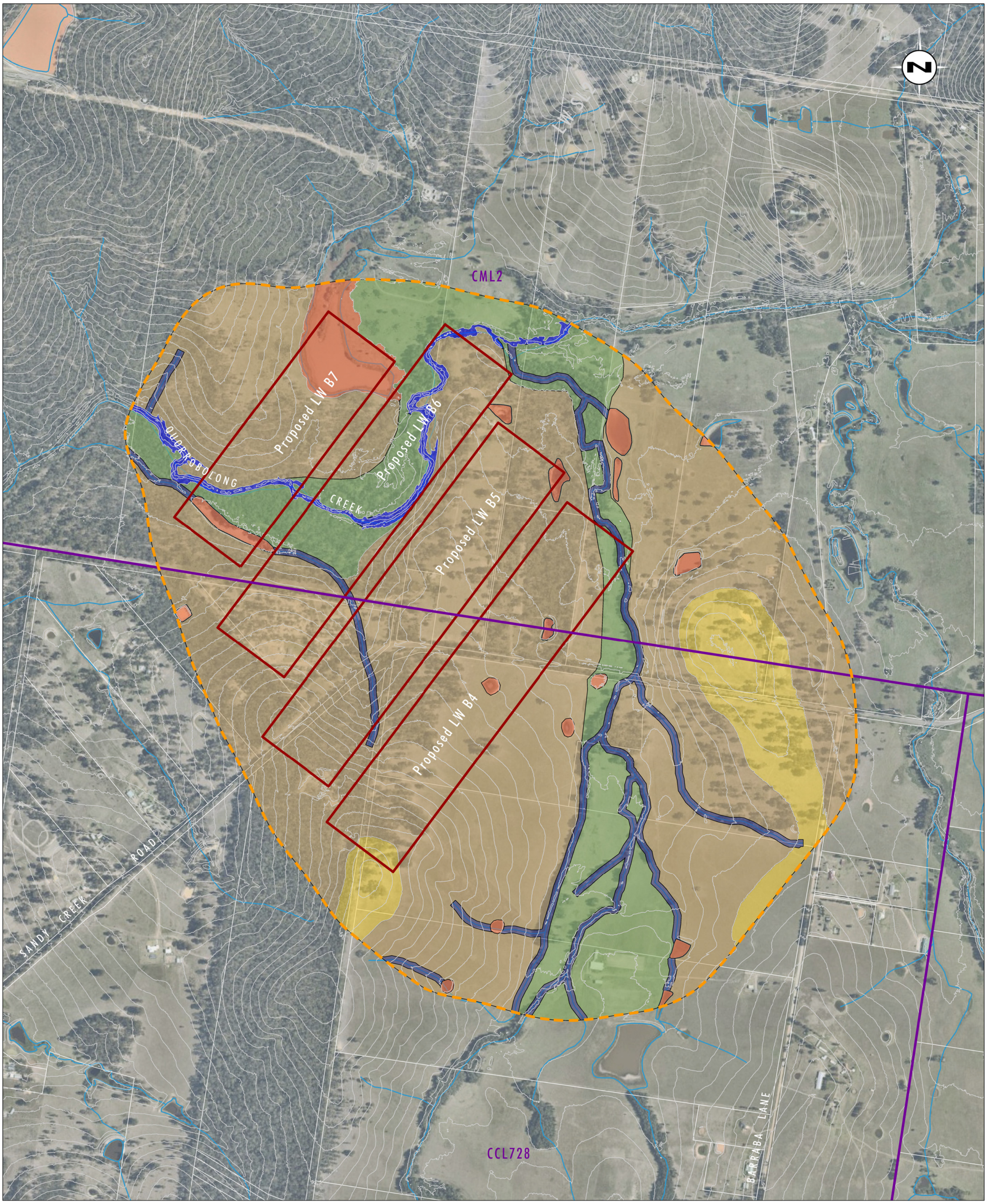

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)
Note: Contour Interval 2m

0 250 500 750m
1:15 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- Mining Lease Boundary
- Modified (Dam)
- Hill Crest
- Stream Channel (Quorrobolong Creek)
- Drainage Depression
- Valley Flat
- Slopes (Unspecified)

FIGURE 2.1

Preliminary Landform Mapping

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2.3 Flora and Fauna

Ecological studies undertaken within the LWB4-B7 Modification Area (Umwelt 2017a:40) identified that the native vegetation communities (excluding cultivated farm land) consist primarily of River Flat Eucalypt Forest (predominantly in the northern portion of the modification area) and Lower Hunter Spotted Gum-Ironbark Forest (predominantly in the southern portion of the modification area), with a small area of potential Quorrobolong Scribbly Gum Woodland in the central portion of the modification area. A range of fauna species have also been identified within and in proximity to the modification area including possums, kangaroos, wallabies, bats, flying foxes, gliders and eagles (Umwelt 2017a:40).

It is however noted that the LWB4-B7 Modification Area has been significantly modified as result of historical land use. These vegetation communities and the range of native fauna currently present within the modification area therefore represent a modified version of the more extensive range of resources that would have been available to Aboriginal people. A list of the plant resources likely to have been available to Aboriginal people (based on current species present in the local area as referenced in Umwelt 2008a) is provided in **Table 2.2**. In addition, it is likely that the modification area would have provided habitat for a broad range of animals including (but by no means limited to) kangaroos, wallabies, wombats, snakes, lizards and birds (including waterbirds targeting the resources along Quorrobolong Creek.

Table 2.2 Flora Species and Known Aboriginal Use

Scientific Name	Name	Known Aboriginal Use	Reference
Acacia sp.	Wattle	Food and economic plant	Australian National Botanic Gardens Education Services 2000
Acacia deanei subsp. *deanei*	Green wattle, Deane's wattle	Food, economic and medicine plant	Gott 1995
Acianthus pusillus	Gnat orchid	Food plant	Flood 1980:94
Allocasuarina sp.	Sheoak	Food and economic plant	Australian National Botanic Gardens 2007
Amyema sp.	Mistletoe	Food and medicinal plant	Flood 1980:94, Zola and Gott 1992:54
Astroloma humifusum	Native cranberry	Food plant	Flood 1980:96
Banksia sp.	Various banksias	Food and economic plant	Australian National Botanic Gardens 2007
Billardiera scandens var. *scandens*	Apple berry	Food plant	Flood 1980:95
Brachychiton populneus subsp. *populneus*	Kurrajong	Food and economic plant	Low 1989: 27; MacDonald and Davidson 1998; Zola & Gott 1992:36

Scientific Name	Name	Known Aboriginal Use	Reference
Bulbine bulbosa	Bulbine lily	Food plant	Flood 1980:94. Zola and Gott 1992:43
Bursaria spinosa var. *spinosa*	Blackthorn	Food and economic plant	Flood 1980:95, Gott 1995
Caladenia sp.	Orchid	Food plant	Zola and Gott 1992:44
Callistemon linearis	Narrow-leaved bottlebrush	Food plant	Australian National Botanic Gardens Education Services 2000
Clematis glycinoides	Headache vine	Food, economic and medicine plant	Zola and Gott 1992:47, Gott 1995, Fraser & McJannett, 1993
Dianella caerulea	Blue flax-lily	Food and Economic Plant	Low 1989: 8
Dianella sp.	Flax lily	Food plant	Australian National Botanic Gardens 2007
Dioscorea sp.	Giant yams	Food plant	Brayshaw 1986:74-75
Dioscorea transversa	Native yam	Food plant	Botanic Gardens Trust 2007
Einadia hastata	Berry saltbush	Food plant	Low 1989: 129
Elaeocarpus obovatus	Hard quandong	Economic plant	Australian National Botanic Gardens Education Services 2000
Eremophila debilis	Amulla	Food plant	MacDonald and Davidson 1998
E. fibrosa spp. *Nubile*	Blue-leafed ironbarks	Economic Plant	MacDonald and Davidson 1998
Eucalypt sp.	Eucalypts	Economic plant	MacDonald and Davidson 1998
		Medicine plant	Australian National Botanic Gardens Education Services 2000
Eucalyptus crebra	Narrow-leaved ironbark	Economic plant	pers. comm. various Aboriginal people from the Dubbo Region (2000) and from AHIMS site card review
Eustrephus latifolius	Wombat berry	Food plant	MacDonald and Davidson 1998
Eucalyptus moluccana	Grey box	Economic plant	MacDonald and Davidson 1998

Scientific Name	Name	Known Aboriginal Use	Reference
Eucalyptus resinifera	Red mahogany	Economic plant	
Exocarpos cupressiformis	Native cherry	Food and economic plant	Brayshaw 1986:74-75. Zola and Gott 1992:48
		Medicinal plant	Watson 2007
Filicopsida sp.	Fern roots	Food plant	Brayshaw 1986:74-75
Gahnia aspera	Rough saw-sedge	Food and economic plant	Low 1989:105; Zola & Gott 1992:60
Geranium solanderi var. *solanderi*	Native geranium	Food and medicinal plant	Flood 1980:95. Zola & Gott 1992:47, 56
Glossodia major	Waxlip orchid	Food plant	Gott 1995
Glossodia minor	Small waxlip orchid	Food plant	Gott 1995
Grevillea montana	Mountain grevillea	Food plant	Low 1989: 171
Hardenbergia violacea	False sarsaparilla	Food plant	Cribb & Cribb 1986:207
Hovea sp.	Hovea	Food plant	Flood 1980:95
Indigofera australis	Australian indigo	Economic plant	Australian National Botanic Gardens 2007
Juncus & Cyperus sp.	Rushes and sedges	Food and/or economic plants	Low 1989:105; Zola & Gott 1992:60
Lomandra sp.	Mat-rush	Food and economic plant	Low 1989: 131, 174; MacDonald and Davidson 1998 Zola & Gott 1992:59
Macrozamia sp.	Macrozamia nuts/seeds	Food plant	Brayshaw 1986:74-75
Macrozamia communis	Burrawang	Food plant	MacDonald and Davidson 1998
Marsilea mutica	Nardoo	Food plant	Flood 1980. Cribb & Cribb 1986 83

Scientific Name	Name	Known Aboriginal Use	Reference
Melaleuca sp.	Melaleuca	Food, economic and medicine plant	ERM 2004:34. Royal Botanic Gardens 2007. Australian National Botanic Gardens Education Services 2000
Ottelia ovalifolia	Swamp lily	Medicinal plant	NSW Department of Education and Training 2007
Pandorea pandorana subsp. *pandorana*	Wonga wonga vine	Economic Plant	Cunningham et al. 1992: 602
Panicum sp.	Grass	Food plant	MacDonald and Davidson 1998
Persoonia linearis	Narrow-leaved geebung	Food plant	Low 1989: 43-44
Pimelea linifolia	Riceflower	Economic plant	Australian National Botanic Gardens 2007
Pterostylis nutans	Nodding greenhood	Food plant	Gott 1995
Rubus parvifolius	Native raspberry	Food plant	Flood 1980:95
Rumex brownii	Swamp dock	Food plant	Low 1989: 28, 30, 153-154
Styphelia triflora	Pink five-corners	Food plant	Low 1989: 43
Themeda australis	Kangaroo grass	Food and medicinal plant	Greenway 1910:16 MacDonald and Davidson 1998 Zola & Gott 1992:58
Triglochin procerum	Water ribbons	Bullet-shaped tubers roasted and eaten	Zola & Gott 1992: 12
Typha sp.	Cumbungi/ bullrush	Economic plant	Australian National Botanic Gardens 2007
Typha orientalis	Broad-leaved cumbungi	Food plant	Gott 2007
Wahlenbergia sp.	Bluebell	Food plant	Fraser and McJannett 1993:65
Xanthorrhoea sp.	Grass tree	Food and economic plant	MacDonald and Davidson 1998

2.4 Past Land Use and Disturbances

As documented in Umwelt (2017b:Section 6.7), the non-Aboriginal history of the Hunter Valley saw major settlement occurring in the Hunter Valley following the completion of Henry Dangar's survey of the region in 1826. Within the region, settlement was initially focused at Wollombi due to the proximity of this town to the key transport route from Sydney to the Hunter Valley. The Cessnock region (including the LWB4-B7 Modification Area) was settled more slowly and was primarily used for pastoral and agricultural purposes (refer to Umwelt 2008b).

The majority of the LWB4-B7 Modification Area was originally within the Barraba Estate, granted in 1834 (refer to Umwelt 2008b). From this time up until the development of the mining industry in the early 1900s, the primary use of the modification area would have been for grazing and potentially for the establishment of crops although given the relatively undulating nature of much of the modification area, it is likely that any areas of cropping would have been discrete and confined to lower slopes bordering watercourses. This land use would have been associated with significant vegetation clearance, the establishment of fencing and other 'general improvements', as required to justify retention of the grant. From the early 1900s, mining commenced within the local area, with the establishment of the Pelton, Ellalong, Bellbird and Southland Collieries resulting in increased activity within the local area, noting that grazing and agriculture remained a key land use.

As a result of the land use history described above, a relatively large proportion of the LWB4-B7 Modification Area has been subject to modification as a result of grazing and agricultural land use, including clearance of large portions of native vegetation and the introduction of pasture grasses, with mining related activity also occurring in the local area. The ongoing clearance of the landscape, the introduction of hard hoofed animals and attempts at water conservation (in the form of construction of dams and works such as contour banks) would have had significant impacts on stream morphology and hydrology. Throughout the Hunter Valley, these changes have resulted in incision of tributary streams and extension of gullies, erosion and sedimentation during major floods, and in some places, increases in water salinity (Dean-Jones and Mitchell 1993:4). Other areas of localised impacts visible within the modification area include a former quarry south of Sandy Creek Road and a number of houses and associated outbuildings (as visible in **Figure 1.3**).

2.5 Summary

A review of available environmental contextual information for the LWB4-B7 Modification Area and surrounds demonstrates that the modification area provided access to Quorrobolong Creek, which, although ephemeral, may have held water for extended periods in pools or ponds. In addition, the review of landforms and soils associated with the modification area identified the potential for alluvial landforms along Quorrobolong Creek that intersect with slope landforms, therefore establishing the potential for colluvial-alluvial interfaces, with the associated potential implications for archaeological site preservation. The LWB4-B7 Modification Area is also relatively well resourced with reference to the plant and animal resources that would have been present in the area prior to non-Aboriginal settlement and landscape modification. However, the modification area and surrounds have been settled for a relatively lengthy period of time and have been subject to a range of impacts. These impacts are likely to be in the form of changes to erosion regimes (following vegetation clearance) and subsequent alterations in the nature and morphology of watercourses. The extent and location of such disturbances has implications for the likely preservation and visibility of archaeological sites, as will be discussed further in **Section 3.0**.

3.0 Aboriginal Archaeological Context

A review of available archaeological information is crucial to the archaeological assessment process, as it informs our understanding of archaeological site patterning, site survival and the potential for detection of extant archaeological sites. This information is discussed with reference to the outcomes of a search of the Aboriginal Heritage Information Management System (AHIMS) database (which documents the location and nature of sites for which site cards have been lodged with OEH) and a summary of the outcomes of previous archaeological investigations in the local area. This information is then considered with reference to key environmental characteristics discussed above to establish a predictive archaeological model for the LWB4-B7 Modification Area.

3.1 Aboriginal Heritage Information Management System

A search of the OEH administered AHIMS database was undertaken on 7 February 2017 (Client Service ID: 265382) for an area of approximately 14 kilometres (east-west) by 11 kilometres (north-south), as bounded by MGA E3384000 – 352341, N6349919 - 6361183. In accordance with requirements, the result of the basic AHIMS search is provided in **Attachment 1**. The results of the extensive AHIMS search are reviewed below and site locations are shown in **Figure 3.1** but individual site coordinates are not provided.

The extensive search identified 84 previously recorded Aboriginal cultural heritage sites and/or objects, of which one is located within the LWB4-B7 Modification Area. **Table 3.1** provides a summary of the sites identified on the AHIMS register. Of these sites, seven are identified as having been destroyed in accordance with an applicable Aboriginal Heritage Impact Permit (AHIP).

Table 3.1 Result of AHIMS searches

Site Type	Site Frequency (#)
Isolated artefact/artefact scatter	52
Art (Pigment or Engraved)	16
Potential Archaeological Deposit (PAD)	7
Scarred tree	2
Art (Pigment or Engraved) with grinding groove and artefacts	1
Art (Pigment or Engraved) with artefacts	1
Isolated artefact/artefact scatter and grinding groove	1
Isolated artefact/artefact scatter and PAD	1
Open Camp Site and midden	1
Grinding Groove	1
Aboriginal Ceremony and Dreaming	1

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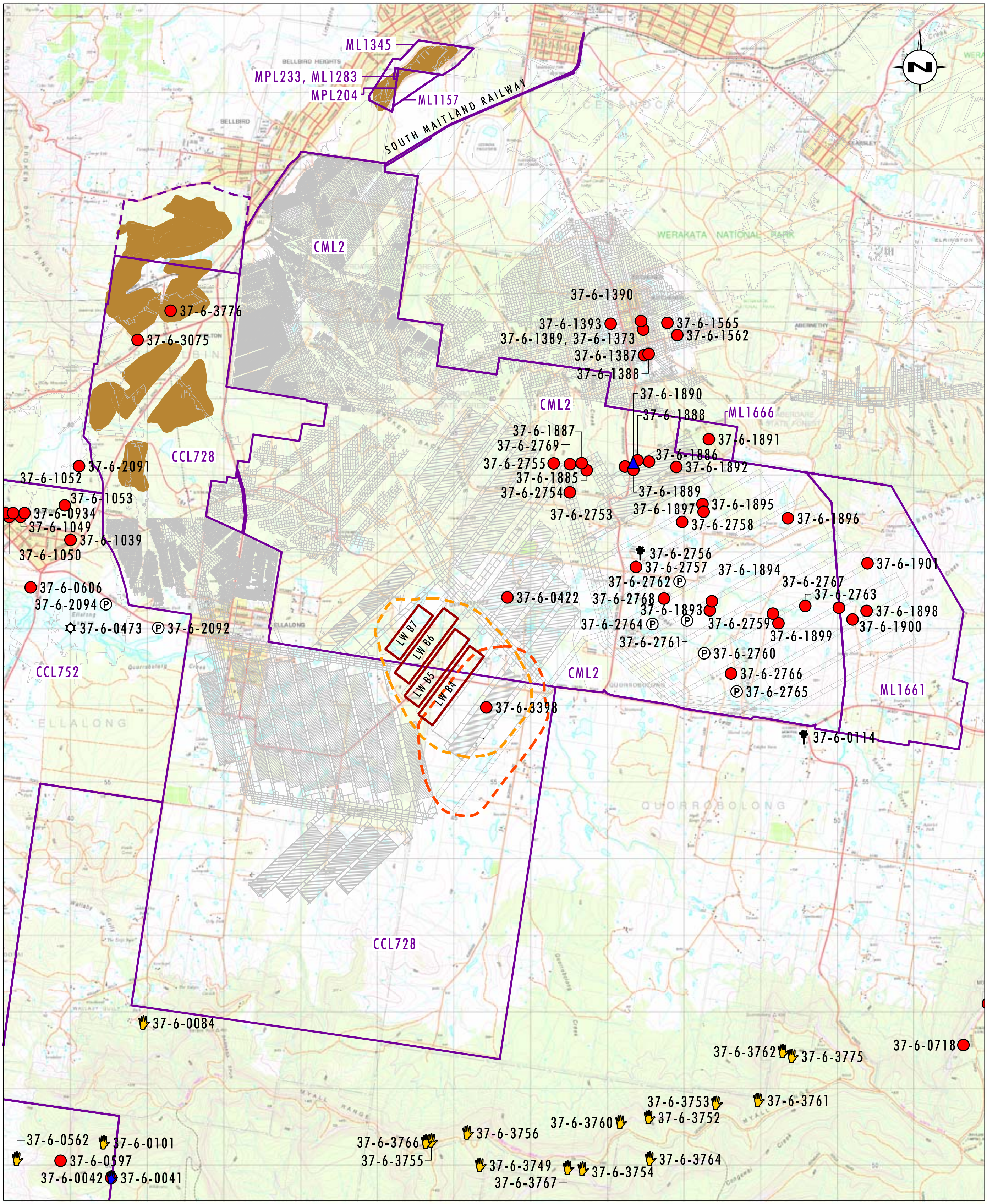

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016), AHIMS (2017)

0 1 2 3km
1:70 000

Legend

- Proposed LWB4-B7 Longwall Panels (DA 29/95)
- LWB4-B7 Modification Area (Proposed)
- LWB1-B3 Modification Area
- Approved Reject Emplacement Areas
- Completed Underground Workings
- Mining Lease Boundary
- Austar owned CHPP Land
- Artefact
- PAD
- Artefact/Grinding Groove
- Art
- Aboriginal Ceremony and Dreaming
- Art/Grinding Groove/Artefact
- Modified Tree

FIGURE 3.1

Location of AHIMS Registered Sites

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As shown in **Figure 3.1**, there is one site recorded within the LWB4-B7 Modification Area. This site (AHIMS #37-6-3398) is located within the area previously assessed as part of the previous LWB1-B3 Modification, as will be discussed further below.

It is also recognised that the number of sites exhibiting art (typically rockshelters containing art) is relatively high within the context of the Hunter Valley. The majority of these sites are located over 4 kilometres to the south of the LWB4-B7 Modification Area and are concentrated in the elevated sandstone outcrops of the Watagans National Park. The terrain in this area (located to the south) is very different to that within the LWB4-B7 Modification Area.

3.1.1 Previous Archaeological Investigations in the Local Area

Umwelt has undertaken a number of archaeological investigations and due diligence assessments in proximity to the LWB4-B7 Modification Area (refer to Umwelt 2008a; 2008b; 2013; 2015). As part of these previous assessments (primarily Umwelt 2008a), an extensive overview of prior archaeological investigations in the local area including the outcomes of prior studies conducted in the vicinity of the LWB4-B7 Modification Area has been undertaken. The results of this review are summarised in **Table 3.2**.

Table 3.2 Summary of Previous Archaeological Assessments in the vicinity of the modification area (adapted from Umwelt 2008a)

Author	Date	Assessment Type	Assessment Area	Results
Appleton, J.	1993	Survey	Paxton to Bellbird via Ellalong	Survey of 8 km cable route. One site recorded: an isolated find.
McCardle, Cultural Heritage	2005	Desktop	Ellalong to Millfield	Evaluation of pipeline alignment. Footslopes and valley floors with duplex soils may be archaeologically important – interaction between colluvial and alluvial soils can result in the formation of sealed deposits. Site density predicted to be greatest in undisturbed areas with access to concentrated water resources.
Brayshaw	1987	Survey	Southland Colliery (within Austar Mine Complex)	Survey of <100 ha. Two sites recorded: a small artefact scatter (7 artefacts) and one isolated find.
HLA-Envirosciences	1995	Survey	Ellalong Colliery (Austar Stage 1)	Survey of 16 ha area, within 95 ha surface infrastructure areas. One site recorded: an isolated find.

More recently, Aboriginal cultural heritage and archaeological assessments have been conducted in relation to the Austar Coal Mine, including the Stage 3 area (PA08_0111 – refer to Umwelt 2008a, 2011 and 2013) and the LWB1-B3 area (DA 29/95 – refer Umwelt 2015). The location of these assessment areas is shown in **Figure 1.2**, with the LWB1-B3 mining area immediately adjoining and in part overlapping the LWB4-B7 Modification Area. The results of these investigations are discussed below.

3.1.1.1 Stage 3 Area – PA08_0111 (Umwelt 2008a, 2011 and 2013)

Previous investigations in the Stage 3 area (PA08_0111) involved the survey of 1028 hectares (84%) of the approved Stage 3 area and were undertaken in accordance with the relevant legislative standard required at the time of survey. These surveys also took into account the outcomes of consultation with Aboriginal parties and were designed with reference to detailed predictive models, as provided by Umwelt (2008a, 2011, 2013).

The previous surveys were conducted on foot by a field team consisting of up to two archaeologists and representatives from the registered Aboriginal parties. Inspections of key known sites were conducted by all field team members, and survey coverage was determined by the inherent conditions of individual survey transects. In accordance with the requests from the registered Aboriginal parties, the surveys attempted to cover 100 per cent of accessible properties. Survey methodologies, survey coverage details, participation registers, general survey results and any cultural information provided by representatives of the registered Aboriginal parties are detailed in the relevant reports.

These assessments resulted in the identification of 17 sites, comprising isolated artefacts (9), artefact scatters (7) and one site (ACM6) containing a single grinding groove associated with an artefact. Of the artefact scatters, only three sites (ACM14, ACM24, ACM28) contained more than ten artefacts. Artefacts recorded consisted predominantly of flakes and broken flakes, with comparatively smaller numbers of cores and retouched artefacts identified. Silcrete and mudstone were the dominant raw materials, with smaller quantities of quartzite, chert and quartz also present.

ACM6 is located approximately three kilometres north of the modification area and consisted of a single grinding groove on a sandstone conglomerate platform within a first order stream, with a single artefact (mudstone broken flake) located 10 metres north of the groove and within the stream bed. Evidence of historical quarrying works was noted within the rock platform.

In summarising the key outcomes of these assessments, it is noted that all sites containing more than ten artefacts were identified in landforms bordering Cony Creek, including adjacent to a former terrace on Cony Creek (a creek that feeds into Quorrobolong Creek) on a creek flat.

The landforms bordering Cony Creek and Sandy Creek (both of which flow into Quorrobolong Creek) were considered to have higher archaeological potential based on the likely resource availability within these areas when considered with reference to the pattern of site distribution in the local area, although it was acknowledged that these landforms were likely to have been subject to disturbance. Based on the location of sites ACM9, ACM10, ACM14 and ACM16 within these landforms, these sites were assessed as having moderate archaeological potential. In addition, four areas of Potential Archaeological Deposit (PAD) were identified in association with potential terrace landforms bordering Cony Creek. These locations (ACM25, ACM26, ACM29 and ACM30) were assessed as having low to moderate archaeological potential on the basis of their location in a sensitive landforms but recognising that they had been subject to disturbance.

Based on the outcomes of these assessments, it was suggested that the Austar area is archaeologically typified by low site and artefact densities, representing relatively low intensity use of the assessed areas by Aboriginal people (Umwelt 2008a, 2011, 2013).

3.1.1.2 LWB1-B3 Area – DA29/95 (Umwelt 2015)

This assessment was undertaken as part of an application to modify the Bellbird South Consent (DA29/95) to allow the transfer and processing of coal from LWB1-B3. As discussed, this assessment incorporated the southern portion of the LWB4-B7 Modification Area, as shown on **Figure 1.3.** The survey of LWB1-B3 Modification Area was conducted in accordance with a methodology subject to review by Aboriginal parties. The survey resulted in the identification of one Aboriginal site - an artefact scatter (#37-6-3398, ACM35) located on the eastern bank of the unnamed tributary of Quorrobolong Creek above LWB2. It contained two artefacts located adjacent to a vehicle access track in an area subject to periodic inundation. Based on the impact of ongoing erosion within the area, it was assessed as having low archaeological potential.

Umwelt (2015), with reference to information provided by MSEC (2015), identified that due to the depth of mining and the small magnitude of predicted subsidence, the extraction of LWB1-B3 was unlikely to result in surface impacts and recommended that site #37-6-3398 be subject to ongoing monitoring, in accordance with the monitoring provisions in place for other sites within the Austar Coal Mine and defined by the Austar Coal Mine Aboriginal Cultural Heritage Management Plan. The Aboriginal Cultural Heritage Management Plan was updated to incorporate the findings of the LWB1-B3 Modification Aboriginal Cultural Heritage Assessment (refer to Austar 2017).

This assessment was completed in accordance with current assessment standards, was completed in consultation with the registered Aboriginal parties and relates to an activity that is now approved under DA29/95. Consequently, the portion of the modification area included within the current DA29/95 approval area is not subject to re-survey as part of this assessment and the recommendations provided by Umwelt (2015) and included in the current Aboriginal Cultural Heritage Management Plan (Austar 2017) will continue to apply for this assessment.

3.2 Predictive model

Based on the outcomes of the previous archaeological investigations undertaken within the locality (particularly those undertaken within the Austar Coal Mine), a range of extensive predictions have been made and reassessed based on the outcomes of previous assessments (as undertaken in Umwelt 2008a, 2011, 2013). The key aspects of these predictions, with reference to the environmental context of the LWB4-B7 Modification Area, are provided below.

- Artefact scatters and isolated artefacts are the most likely site type to occur within the LWB4-B7 Modification Area. These sites may occur in any landform within the modification area but are most likely to occur in proximity to watercourses (noting that it must be taken into account that watercourse morphology may have been subject to significant change, as will be discussed below). Elevated areas (such as spur crests or ridge crests) that provide access to water resources may also be associated with higher numbers of sites and densities of sites.

- For sites containing stone artefacts, site numbers and artefact densities will typically be relatively low, with the majority of sites likely to contain less than 10 artefacts. However site and artefact densities may increase in proximity to the main channel of Quorrobolong Creek based on the more reliable nature of this watercourse when compared to others within the general locality (with the exception of Ellalong Lagoon).

- While pre-survey landform mapping did not identify any areas of terracing within the LWB4-B7 Modification Area, previous assessments have identified small areas of potential terracing along Cony Creek and the channel of Quorrobolong Creek (outside the LWB4-B7 Modification Area). In addition, it was identified that there is the potential for colluvial/alluvial interfaces within the areas of valley flats bordering the watercourses, particularly Quorrobolong Creek. Terraces and areas of alluvial-colluvial interface have the potential to contain archaeological deposit at depth, with the subsequent deposition of alluvial and/or colluvial material potentially introducing an element of stratigraphic integrity to any such deposits. Landforms of these types, should they occur within the modification area, may have higher archaeological potential than the surrounding landforms within which deposits have been subject to higher levels of impact and are unlikely to retain stratigraphic integrity.

- Scarred trees may occur in portions of the LWB4-B7 Modification Area where mature native vegetation remains. Based on the land use history of the modification area, the majority of the vegetation may comprise regrowth however consideration should be given to the potential for scarred trees to remain.

- Grinding groove sites (and potentially other sites associated with sandstone such as engraving sites) may occur in the LWB4-B7 Modification Area if suitable sandstone outcrops are exposed within the channel of Quorrobolong Creek and associated watercourses. However, given the relatively sandy nature of much of the soils within the local area, the potential for sandstone outcrops (and therefore sites found on sandstone outcrops) is relatively low.

- Levels of disturbance across the LWB4-B7 Modification Area are likely to have impacted the visibility and integrity of sites that may be present. The extent of these impacts will depend on the nature of the disturbance and the likely depth of any archaeological deposits that may be present.

4.0 Methodology

This section documents the key methodologies underlying the completion of the archaeological component of survey works, including the methodologies used to calculate survey coverage and the criteria applied in consideration of archaeological potential within the LWB4-B7 Modification Area.

4.1 Sampling Strategy

In accordance with the Code of Practice, a survey sampling strategy was developed for the LWB4-B7 Modification Area. This strategy was developed with reference to the environmental and archaeological context of the modification area and the archaeological predictions discussed in **Section 3.2**. The registered Aboriginal parties were consulted regarding the survey strategy, as outlined in Section 3 of the ACHAR.

The survey strategy was designed to ensure that a representative sample of all landforms within the LWB4-B7 Modification Area (comprising approximately 300 hectares) was surveyed. As discussed previously, the southern portion of the LWB4-B7 Modification Area (comprising approximately 140 hectares) has been subject to a previous archaeological survey and assessment (Umwelt 2015) and therefore was excluded from the survey area, leaving a total of approximately 160 hectares subject to the current survey. However, parts of the LWB4-B7 Modification Area are located on privately owned land for which the landholder has refused access. These areas (comprising approximately 25 per cent of the current survey area) were therefore unable to be surveyed however landforms comparable to those within these areas were included within the surveyed area.

Due to the presence of dense vegetation in some portions of the LWB4-B7 Modification Area, it was identified prior to the survey that visibility across much of the area was likely to be relatively low. During the survey, areas of visibility and exposure were targeted in order to obtain maximum benefit from survey effort. Consideration of the potential for additional deposits to be present but not visible was a key component of the survey, as will be discussed further in **Section 4.4**.

4.2 Information recorded during survey

Survey units were defined and named with reference to Requirement 5c of the Code of Practice, including recording track logs for the area walked by each archaeologist within the survey units using a hand-held GPS receiver (set to allow recording of data with datum MGA94) and topographic mapping (where relevant). Start and finish points/boundaries for survey units were defined based on landforms, modification area boundaries and property boundaries. The location of survey transects and the distribution of survey participants across the survey transects was discussed in the field with survey participants. Survey participants were generally spaced between 5-20 metres apart dependent on ground surface visibility, topography and vegetation.

Photographs were taken for landforms/survey units (where informative). Information recorded for each survey unit included:

- landform (in units based on those established by McDonald et al. 2009)
- gradient (where relevant)
- vegetation

- geology and soils (where suitable areas of exposure/visibility are present)
- identified Aboriginal resources
- levels of average ground surface visibility within the survey unit (in accordance with the Requirement 9 of the Code of Practice)
- extent and type of exposures within the survey unit (with reference to the factors leading to the exposure such as erosion, earth-moving activities, track establishment etc.)
- any site or area of identified archaeological potential present within the survey unit.

Aboriginal archaeological sites identified during the survey were assessed with reference to the site boundaries. Factors that were taken into consideration in defining and mapping site boundaries included the distribution of surface artefacts, landforms or physical boundaries and cultural information. Sufficient information was recorded for all sites to meet Requirement 7 of the Code of Practice.

4.3 Survey Coverage

In accordance with the Code of Practice, the survey coverage description includes landform units, the total area surveyed within a landform unit and the quantification of the level of ground surface visibility and exposure. Ground surface visibility is defined as "the amount of bare ground (or visibility) on the exposures which might reveal artefacts or other archaeological materials" (DECCW 2010:13). Exposure is defined as "the percentage of land for which erosion and exposure was sufficient to reveal archaeological material on the surface of the ground" (DECCW 2010:13). As such, exposure refers to the potential for an area to reveal subsurface artefacts or deposits rather than the mere observation of the amount of bare ground.

The calculation of effective survey coverage is undertaken in order to designate the proportion of the modification area in which it is possible to accurately assess the presence or absence of archaeological material. Survey coverage is calculated by multiplying the total survey area by the percentage of ground surface visibility and exposure within the survey unit. The survey coverage is then expressed as a percentage for the whole survey unit.

4.4 Assessment of Subsurface Archaeological Potential

The assessment was undertaken with reference to factors including the archaeological context of the local area, the evaluation of the soil profile (based on soil landscape mapping, exposed soil profiles identified during the survey and geomorphic understandings of the area) and the identification of landforms that may have greater archaeological sensitivity (such as alluvial fans, terraces, colluvial/alluvial interfaces etc.). For the purposes of consistency, the criteria for differing levels of archaeological potential utilises the definitions applied to previous assessments (refer to Umwelt 2011). The following terms will be employed to classify the archaeological potential of specific locations:

- **no archaeological potential**: areas where the natural soil profile has been removed through geomorphic processes or human action, thereby removing any archaeological resource of the location. Examples of this category would include a landslide or industrial quarry sites
- **low archaeological potential**: landscape areas that may have been utilised by Aboriginal people in the past, but at a lower intensity than all surrounding landforms. The density of artefacts deposited within these areas would therefore be low. This category also includes landscape areas of low terrain integrity, where geomorphic processes or human action may have redistributed artefacts from their deposited locations, resulting in site disturbance or destruction

- **moderate archaeological potential**: landscape areas that are predicted to have been utilised by Aboriginal people in the past, but not intensively or repeatedly. There is therefore potential for artefactual deposition, but at a lower frequency and density than in areas of high archaeological potential. Terrain integrity in these areas may be variable, but the majority of open camp sites are expected to be of low to moderate integrity only, with geomorphic processes not acting to bury deposits *in situ*

- **high archaeological potential**: landscape areas predicted to have been intensively or repeatedly utilised by Aboriginal people in the past, such as creek confluences or elevated terraces above major watercourses. Terrain integrity in these areas may be variable, but the majority of open camp sites are expected to be of low to moderate integrity only, with geomorphic processes not acting to bury deposits *in situ*

- **very high archaeological potential**: landscape areas predicted to have been more intensively or repeatedly utilised than all surrounding landforms by Aboriginal people in the past, such as major creek confluences or lagoons. Terrain integrity in these areas may be variable, but these landforms may include areas of high terrain integrity, where geomorphic processes may have acted to bury deposits *in situ*. Sites may therefore be of very high archaeological potential.

5.0 Survey Results

The survey of the LWB4-B7 Modification Area was conducted by Umwelt archaeologists and registered Aboriginal party representatives (accompanied by an Austar representative) on 9 and 10 February and 21 March 2017. Participants in the survey are listed in **Table 5.1**.

Table 5.1 On-site meeting and site visit attendees

Date	Organisation	Name
9/02/17	Austar	Josh Chadwick
	Umwelt	Nicola Roche
	Umwelt	Joshua Madden
	Culturally Aware	Maree Waugh
	Hunter Valley Cultural Surveying	Luke Hickey
	Wattaka Wonnarua	Rod Hickey
	Lower Hunter Wonnarua Consultancy Services	Tom Miller
	Lower Wonnarua Tribal Council	Barry Anderson
	Mindaribba Local Aboriginal Land Council	Jason Brown
	Awabakal Local Aboriginal Land Council	Peter Townsend
	Kawul TA Wonn1	Arthur Fletcher
	Yinarr Cultural Services	Kathy Steward Kinchela
10/02/17	Austar	Josh Chadwick
	Umwelt	Nicola Roche
	Umwelt	Joshua Madden
	Culturally Aware	Maree Waugh
	Hunter Valley Cultural Surveying	Luke Hickey
	Wattaka Wonnarua	Rod Hickey
	Lower Hunter Wonnarua Consultancy Services	Tom Miller
	Lower Wonnarua Tribal Council	Barry Anderson
	Mindaribba Local Aboriginal Land Council	Jason Brown
	Awabakal Local Aboriginal Land Council	Peter Townsend

Date	Organisation	Name
	Kawul TA Wonn1	Arthur Fletcher
21/03/17	Austar	Josh Chadwick
	Umwelt	Nicola Roche
	Tocomwall	Danny Franks

5.1 Description of Survey Transects

The information required to calculate effective coverage for survey units is provided in **Table**. Survey units and tracked survey transects (based on areas walked by archaeologists) are shown in **Figure 5.1** with reference to the identified landforms within the survey unit. This approach is undertaken as a meaningful way of identifying landforms associated with each survey unit. Plates showing views within the identified survey transects are provided as **Attachment 2**. In addition to the information presented in **Table 5.2,** key factors that affect the detectability of sites and the archaeological potential of the survey units are discussed below. The majority of landform mapping within **Figure 5.1** is consistent with the preliminary landform mapping undertaken during the development of the survey methodology, except as discussed below.

5.1.1 Landform variance – Survey Units 2, 8 and 9

Landforms that warrant further discussion include the overflow channel from Quorrobolong Creek within Survey Unit 2 (as shown in **Attachment 2**, Plate 3). This channel is bordered to the south by lower slopes exhibiting A_2 soils subject to sheetwash erosion (within which site ACM38 was identified) and to the north by an area of minor elevation bordering Quorrobolong Creek.

On the northern side of Quorrobolong Creek, this survey unit contained relatively deep alluvial deposits. Within areas of disturbance within the alluvial deposit (resulting from minor excavations undertaken as part of land management activities, as shown in **Attachment 2**, Plate 6), substantial sections of soil profile were exposed. The soil profile in this portion of Survey Unit 2 comprises undifferentiated alluvium up to one metre deep, with no evidence of stratification or the presence of buried soil profiles. On this basis, it is suggested that alluvial deposits in this landform are relatively deep but may be relatively recent (due to the lack of differentiation within the deposit). This landform continues within the adjoining section of Survey Unit 9 where it is bordered by Quorrobolong Creek and a large ponded farm dam water body. Based on the topography of the area, the presence of a former post and rail fence through the deepest section of the water body (as shown in **Attachment 2**, Plate 23) and the presence of visible earthworks, it was identified during the survey that this water body has most likely formed as a result of a former overflow channel of Quorrobolong Creek being dammed at its eastern end (where it formerly would have joined Quorrobolong Creek). Whilst the current water body is significantly larger than the overflow channel would have been prior to modification, the presence of a former overflow channel implies that that water resources may have been accessible outside the main channel of Quorrobolong Creek in this area and in Survey Unit 2.

Table 5.2 Description of Survey Units

Survey Unit	Landforms	Survey unit area (m^2) approx.	Area accessible (m^2) approx.	Visibility %	Exposure %	Effective Coverage (m^2)	Effective Coverage (%)	Sites	Archaeological potential rating	Disturbance factors
1	Gently inclined slopes (modified)	26500	26500	10%	5%	132.5	0.5%	ACM37 ACM40 (partial)	Low	House and outbuildings, dam, vehicle access tracks
2	Gently inclined slopes, overflow channel, Quorrobolong Creek main channel, valley flat	69000	69000	10%	5%	345	0.5%	ACM38 ACM39	Moderate	Vegetation clearance and use for grazing, erosion, vehicle access tracks
3	Gently inclined slopes (modified) bordering Quorrobolong Creek	19000	19000	25%	10%	475	2.5%	ACM40 (partial)	Low	Outbuildings, use for grazing, vehicle access tracks, erosion
4	Predominantly gently inclined slopes, with area of moderate inclination bordering Quorrobolong Creek	30400	30400	10%	5%	152	0.5%	ACM41	Low to moderate	Vegetation clearance and use for grazing, erosion, vehicle access tracks

Survey Unit	Landforms	Survey unit area (m^2) approx.	Area accessible (m^2) approx.	Visibility %	Exposure %	Effective Coverage (m^2)	Effective Coverage (%)	Sites	Archaeological potential rating	Disturbance factors
5	Gently inclined slopes	71000	71000	5%	5%	177.5	0.25	ACM42, ACM43	Low	Vegetation clearance and use for grazing, erosion, vehicle access tracks
6	Gently inclined slopes from minor spur crest	149000	149000	5%	10%	745	0.5%	None	Low	Former area of quarrying (modern) with observed evidence of illegal dumping, vehicle access, vegetation clearance
7	Minor spur crest and moderate to gently inclined slopes	68000	68000	5%	10%	340	0.5%	None	Low	Vegetation clearance and use for grazing, vehicle access tracks
8	Undulating landform with a creek line	442000	442000	10%	5%	2210	0.5%	ACM44, ACM46, ACM47, ACM48, ACM49	Moderate	Vegetation clearance, construction of former motorbike track, installation of powerlines (including service easement), vehicle access tracks

Survey Unit	Landforms	Survey unit area (m^2) approx.	Area accessible (m^2) approx.	Visibility %	Exposure %	Effective Coverage (m^2)	Effective Coverage (%)	Sites	Archaeological potential rating	Disturbance factors
9	Gently inclined slopes, valley flats bordering Quorrobolong Creek and former overflow channel	210000 (of which 37000 is large water body)	173000	5%	5%	432.5	0.25	None	Moderate	Vegetation clearance and use for grazing, vehicle access tracks, damming of former overflow channel
10	Gently inclined slopes	91000	91000	5%	5%	227.5	0.5%	None	Low	House and outbuildings, dam

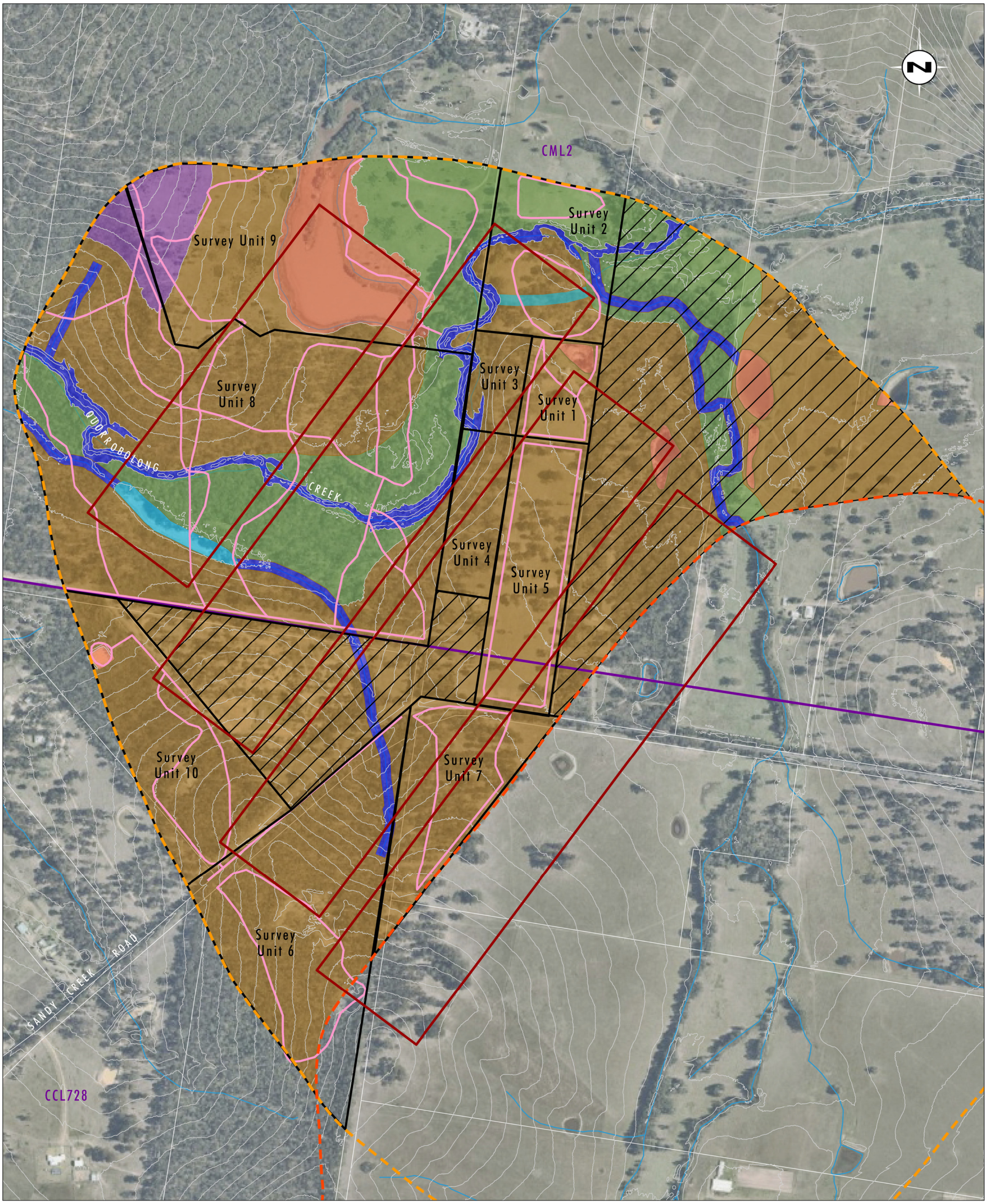

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)
Note: Contour Interval 2m

0 100 250 500m
1:10 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- LWB1-B3 Modification Area
- Mining Lease Boundary
- Modified (Dam)
- Hill Crest
- Overflow Channel
- Stream Channel (Quorrobolong Creek)
- Valley Flat
- Slopes (Gently Inclined)
- Minor Spur Crest
- Survey Transect
- Survey Unit
- Area not accessible for survey

FIGURE 5.1

Survey Units

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Within Survey Unit 9, visibility within the valley flat landform was relatively limited with no significant exposures other than those in the banks of Quorrobolong Creek (as is discussed further below). It is possible that the extent of valley flat deposits within this survey unit is narrower and more directly confined to the banks of Quorrobolong Creek however a conservative approach has been adopted and the preliminary landform mapping has been retained for assessment purposes.

The minor first order drainage channel south of Quorrobolong Creek within Survey Unit 8 is associated with an area of ponded water, as shown in **Attachment 2**, Plate 19. Based on the topographic mapping and aerial photography, this area was initially mapped as a dam however there was no evidence identified during the survey to indicate that this area has been subject to modification. Rather, there is a higher bank bordering the main channel of Quorrobolong Creek, with the mapped drainage comprising a low-lying area to the south of the creek bank within which water ponds before eventually flowing along a short section of channelling (less than 50 metres in length) into Quorrobolong Creek. This low-lying area is bordered by gently inclined slopes to the south within which significant modification has occurred as part of the former dirt bike activities, as shown in **Attachment 2**, Plate 21.

5.1.2 Quorrobolong Creek

In order to adequately assess the potential for sandstone outcrops to occur in Quorrobolong Creek, the survey strategy was designed to allow adequate access to the main channel of Quorrobolong Creek. Due to the extensive vegetation along the creek, it was not possible to survey along the entire length of the creekline but rather the main channel of the creek was accessed via a number of survey transects (refer to **Figure 5.1**). At these locations, the channel of Quorrobolong Creek was deeply incised into alluvial material, had a sandy base and did not exhibit any exposures of sandstone, as shown in **Attachment 2**, Plate 18. No exposures of sandstone were identified in any other watercourses within the LWB4-B7 Modification Area. A small section of outcropping coarse sandstone (possibly the exposed section of a boulder) was identified in Survey Unit 4 on a section of more steeply inclined slope leading to Quorrobolong Creek. There was no evidence that this sandstone was utilised for grinding and based on erosion patterns, it may only have been exposed as a result of modern erosion.

5.1.3 Effective Coverage

As documented in **Table 5.2**, the overall level of effective coverage within the survey units was low and did not exceed 2.5 per cent in any one survey unit. This reflects the fact that levels of visibility and exposure were typically low across all survey units. This is largely due to the presence of vegetation (grass and/or leaf litter) across the majority of the survey units, which in turn obscured visibility. The exception to this was Survey Unit 3. This survey unit contained holding yards for goats which had been intensively used, resulting in increased visibility and subsequent sheetwash erosion. Levels of exposure within the survey units did not exceed 10% and primarily reflected the effects of sheetwash erosion and the presence of vehicle access tracks.

Due to the low level of effective coverage within the survey units, the assessment of archaeological potential in **Section 5.4** is a key aspect of this assessment of the LWB4-B7 Modification Area. However, despite the low levels of visibility and exposure, archaeological sites were identified within the survey units. These sites are additional to site #37-6-3398 (ACM35), which was previously identified within the LWB4-B7 Modification Area.

5.2 Newly Identified Archaeological Sites

All newly identified archaeological sites within the LWB4-B7 Modification Area consist of artefact scatters or isolated artefacts. A total of 13 new sites were identified, as described below and shown in **Figure 5.2,** with images of sites and artefacts provided in **Attachment 2**. AHIMS site cards have been submitted for all sites in accordance with OEH requirements.

5.2.1 ACM37

ACM37 is an artefact scatter consisting of two artefacts identified at two loci on privately owned land, as described in **Table 5.3**. The artefacts are present within an exposure bordering a small farm dam that includes the overflow channel from the dam leading towards Quorrobolong Creek. The loci within AC37 are 40 metres apart and despite good visibility and consistency of exposure between the loci, no further artefacts were visible. The area has been modified by the construction of the dam and ongoing erosion, resulting in the exposure of B horizon soils within the site area. Based on the absence of additional artefacts despite good visibility, the high level of exposure and the level of disturbance within the site area, it is assessed that the potential for additional artefacts to be present within a sub-surface context is low.

5.2.2 ACM38

ACM38 is an artefact scatter consisting of 37 artefacts identified within an area of approximately 40 metres east-west by 30 metres north-south located on privately owned land. Based on the relatively consistent distribution of artefacts across this area, it was assessed as a single locus centred on MGA 345040 6357110. Individual artefacts within ACM38 are documented in **Table 5.3** and include a broken grindstone and three broken backed flakes**.** Artefacts are manufactured from a range of raw materials, of which silcrete is the most common.

Artefacts within ACM38 are all present within an area of increased visibility and exposure resulting from ongoing sheetwash erosion on a gently inclined lower slope bordering a former overflow channel of Quorrobolong Creek. Exposed soils consist of a compacted and bleached yellowish sandy loam (A_2 soil horizon) overlying a brown to red sandy clay (B horizon). While the depth of A horizon soils within the portion of this landform containing artefacts appears to be relatively shallow, it is considered likely that the remaining portion of the landform (which currently has lower levels of exposure and visibility), has potential for additional artefacts that are currently not visible or exposed. However, the likely limited depth of A horizon soils within the landform dictates that it is unlikely that any such deposits will be extensive or will retain stratigraphic integrity. On this basis, the site boundary is extended to cover the remainder of the landform, which is assessed as having low-moderate archaeological potential, as will be discussed further in **Section 5.4**.

5.2.3 ACM39

ACM39 is an isolated artefact (silcrete flake) located within a small exposure on a small localised rise to the north of the former overflow channel of Quorrobolong Creek and south of the main channel of Quorrobolong Creek on privately owned land. Exposed soils consist of a mid-brown sandy loam (A soil horizon) however based on the limited visibility and exposure, it was not possible to further assess the depth of soil within this landform. The archaeological potential of this landform is further discussed in **Section 5.4.**

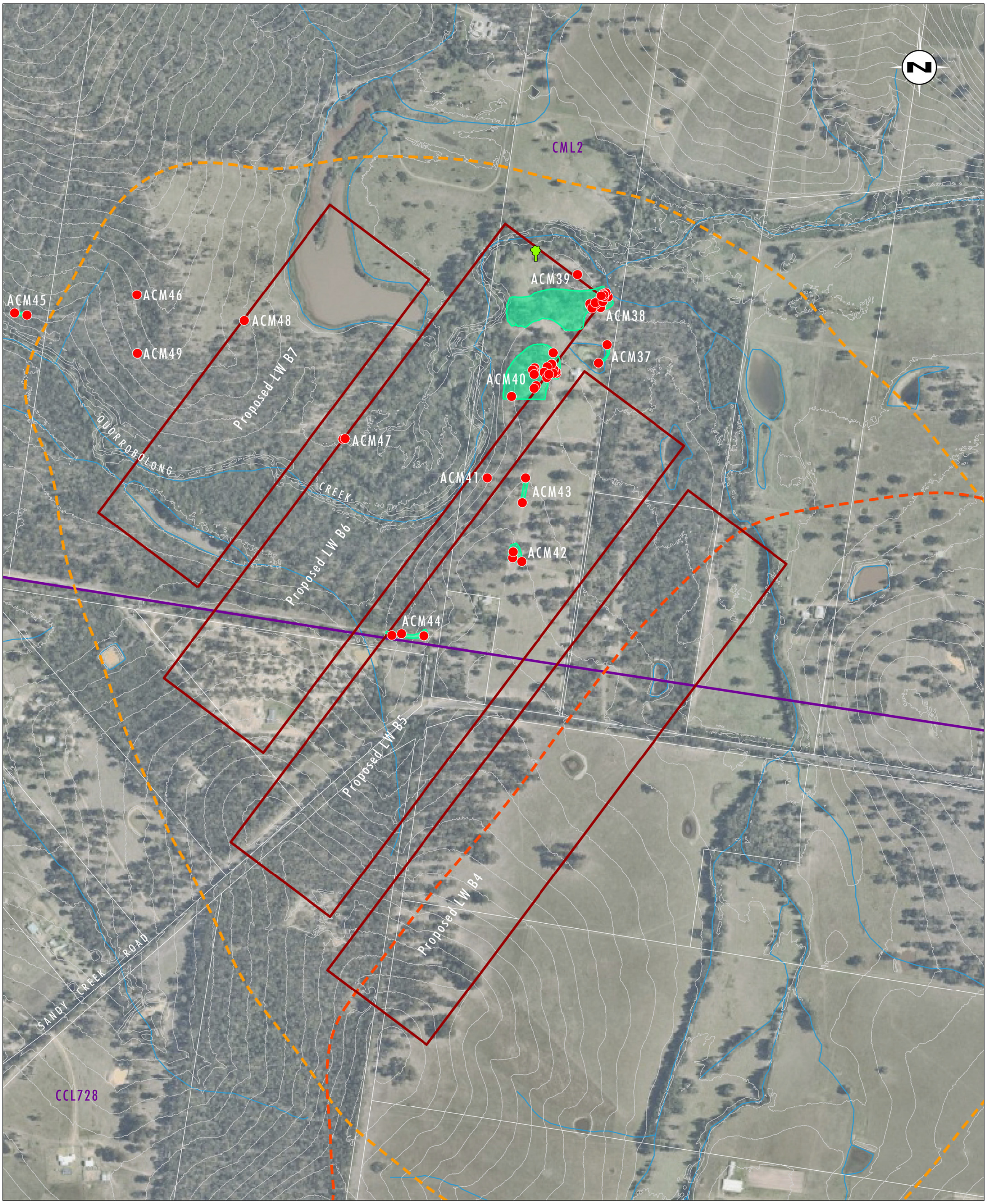

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)
Note: Contour Interval 2m

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area (Proposed)
- LWB1-B3 Modification Area
- Mining Lease Boundary
- Archaeological Site Area
- Artefact Location
- Tree with Non-cultural Scarring

FIGURE 5.2

Location of Newly Identified Sites

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5.2.4 ACM40

ACM40 is an artefact scatter containing 29 artefacts dispersed across three loci over an area of approximately 40 metres east-west by 25 metres north-south on a gently inclined mid slope landform. Individual artefacts within ACM40 are documented in **Table 5.3** and include two broken backed flakes. Artefacts are manufactured from a range of raw materials of which mudstone and silcrete are the most common.

The site is located on privately owned land within fenced yards used for grazing goats and has been subject to significant disturbance as a result of construction of outbuildings, vehicle traffic and ongoing sheetwash erosion due to grazing and trampling by goats. The majority of artefacts are located in a large locus centred on MGA 344935 6356985, with this area exhibiting the greatest amount of exposure. The additional two loci are also within areas of minor exposure. Exposed soils consist of a very thin layer of yellow-brown sandy loam (A_2 soil horizon) overlying a brown to red sandy clay (B horizon).

Based on the identification of relatively high numbers of artefacts in areas of enhanced visibility and exposure, it is assessed that additional artefacts may be present within the adjoining sections of the mid slope landform. On this basis, the site boundary is extended to cover the remainder of the landform, which is assessed as having low-moderate archaeological potential (outside disturbed exposures), as will be discussed further in **Section 5.4**.

5.2.5 ACM41

ACM41 is an isolated artefact (quartzite flake) in an area of low visibility and exposure on a very gently inclined slope approximately 30 metres from Quorrobolong Creek. The archaeological potential of the landform containing this artefact will be discussed further in **Section 5.4** however based on limited nature of the visible evidence; site boundaries have not been extended.

5.2.6 ACM42

ACM42 is an artefact scatter containing four artefacts in an area of exposure associated with a vehicle track on a gently inclined slope approximately 150 metres from the main channel of Quorrobolong Creek. The site has been subject to significant disturbance as a result of vehicle traffic, grazing and trampling by goats and ongoing sheetwash erosion. Exposed soils consist of a very thin layer of yellow-brown sandy loam (A_2 soil horizon) overlying a brown to red sandy clay (B horizon).

The site boundary has been established to include the recorded artefacts. Based on the absence of additional artefacts within the adjoining portions of the landform (despite comparable levels of visibility and exposure) and the relatively thin nature of A horizon soils, it is assessed that it is unlikely that this site is associated with sub-surface deposits and it is assessed as having low archaeological potential.

5.2.7 ACM43

ACM43 is an artefact scatter containing four artefacts in a vehicle track exposure on a gently inclined slope approximately 100 metres from the main channel of Quorrobolong Creek. The artefacts include a broken cobble that exhibits evidence of grinding on one surface and is a possible muller (top grindstone).

The site has been subject to significant disturbance as a result of establishment and use of the vehicle track. Exposed soils consist of a very thin layer of yellow-brown sandy loam (A_2 soil horizon) overlying a brown to red sandy clay (B horizon).

As with ACM42, the site boundary has been established to include the recorded artefacts. Based on the absence of additional artefacts within the adjoining portions of the vehicle track (despite comparable levels of visibility and exposure) and the relatively thin nature of A horizon soils, it is assessed that it is unlikely that this site is associated with sub-surface deposits and it is assessed as having low archaeological potential.

5.2.8 ACM44

ACM44 is an artefact scatter containing four artefacts (including a broken retouched flake) located in a vehicle track exposure within a powerline easement on a gently inclined slope approximately 200 metres from the main channel of Quorrobolong Creek and 100 metres from the ephemeral drainage line containing the area of ponding.

The site has been subject to significant disturbance as a result of establishment and use of the vehicle track and the associated establishment of powerlines. Exposed soils consist of a very thin layer of yellow-brown sandy loam (A_2 soil horizon) overlying a yellow-brown sandy clay (B horizon).

As with ACM42 and ACM43, the site boundary has been established to include the recorded artefacts. Based on the absence of additional artefacts within the adjoining portions of the vehicle track (despite comparable levels of visibility and exposure) and the relatively thin nature of A horizon soils, it is assessed that it is unlikely that this site is associated with sub-surface deposits and it is assessed as having low archaeological potential.

5.2.9 ACM45

ACM45 is an artefact scatter located on a vehicle track outside the LWB4-B7 Modification Area. This site was identified whilst attempting to find a suitable location to cross Quorrobolong Creek. The site consists of three artefacts on a lower slope landform approximately 50 metres from the main channel of Quorrobolong Creek. Based on the absence of additional artefacts within the adjoining portions of the vehicle track (despite comparable levels of visibility and exposure) and the relatively thin nature of A horizon soils, it is assessed that it is unlikely that this site is associated with sub-surface deposits and it is assessed as having low archaeological potential.

As this site is located outside the LWB4-B7 Modification Area, it is not subject to further consideration in this report.

5.2.10 ACM46

ACM46 is an isolated artefact (mudstone flake) located on a vehicle track on a gently-moderately inclined section of slope leading to the minor spur crest on the northern border of the modification area. The track has been heavily eroded, with a very thin layer of sandy loam overlying B horizon soils.

Based on the absence of additional artefacts within the adjoining portions of the vehicle track (despite comparable levels of visibility and exposure) and the relatively thin nature of A horizon soils, it is assessed that it is unlikely that this site is associated with sub-surface deposits and it is assessed as having low archaeological potential.

5.2.11 ACM47

ACM47 is an artefact scatter containing three artefacts within a vehicle track on a lower slope approximately 100 metres from the main channel of Quorrobolong Creek. The site has been subject to disturbance as a result of establishment and use of the vehicle track. Exposed soils consist of a very thin layer of bleached and compacted yellow-brown sandy loam (A_2 soil horizon).

The site boundary has been established to include the recorded artefacts. Based on the absence of additional artefacts within the adjoining portions of the vehicle track (despite comparable levels of visibility and exposure) and the relatively thin nature of A horizon soils, it is assessed that it is unlikely that this site is associated with sub-surface deposits and it is assessed as having low archaeological potential.

5.2.12 ACM48

ACM48 is an isolated artefact (silcrete flake) in an area of low visibility and exposure on a gently inclined section of slope leading to the minor spur crest on the northern border of the modification area. The archaeological potential of the landform containing this artefact will be discussed further in **Section 5.4** however based on limited nature of the visible evidence; site boundaries have not been extended.

5.2.13 ACM49

ACM49 is an isolated artefact (silcrete flaked piece) located on a vehicle track on a gently inclined section of slope approximately 100 metres from the main channel of Quorrobolong Creek. The track has been heavily eroded, with a very thin layer of sandy loam overlying B horizon soils.

Based on the absence of additional artefacts within the adjoining portions of the vehicle track (despite comparable levels of visibility and exposure) and the relatively thin nature of A horizon soils, it is assessed that it is unlikely that this site is associated with sub-surface deposits and it is assessed as having low archaeological potential.

Table 5.3 Artefacts within newly identified sites

Site Name	Locus	E_MGA	N_MGA	Raw material	Artefact class
ACM37	1	345058	6357038	Mudstone	Flake
	2	345042	6357004	Quartz	Flake
ACM38		345046	6357107	Sandstone	Broken grindstone
		345051	6357120	Quartz	Flake
		345051	6357120	Silcrete	Broken flake
		345031	6357114	Tuff	Flake
		345026	6357112	Silcrete	Broken flake
		345026	6357114	Silcrete	Broken backed flake
		345036	6357112	Mudstone	Broken flake

Site Name	Locus	E_MGA	N_MGA	Raw material	Artefact class
		345044	6357118	Silcrete	Broken flake
		345041	6357119	Silcrete	Broken flake
		345041	6357119	Silcrete	Broken flake
		345041	6357119	Silcrete	Flake
		345041	6357117	Mudstone	Flake
		345037	6357113	Mudstone	Flake
		345037	6357113	Silcrete	Broken flake
		345030	6357106	Silcrete	Broken flake
		345036	6357116	Silcrete	Broken backed flake
		345050	6357118	Silcrete	Broken backed flake
		345060	6357127	Mudstone	Flake
		345056	6357135	Quartz	Broken flake
		345052	6357127	Silcrete	Flaked piece
		345051	6357133	Silcrete	Heat shatter
		345052	6357131	Mudstone	Flake
		345047	6357129	Quartz	Flake
		345047	6357129	Silcrete	Flaked piece
		345047	6357129	Quartz	Flake
		345047	6357129	Silcrete	Broken flake
		345047	6357129	Silcrete	Flake
ACM39		345003	6357169	Silcrete	Flake
ACM40	1	344958	6357023	Mudstone	Broken backed flake
		344958	6357023	Quartz	Broken flake
	2	344956	6357002	Silcrete	Broken flake
		344950	6356998	Quartz	Flaked piece
		344950	6356998	Mudstone	Flake

Site Name	Locus	E_MGA	N_MGA	Raw material	Artefact class
		344950	6356998	Silcrete	Flake
		344948	6356994	Silcrete	Flake
		344948	6356994	Mudstone	Broken flake
		344950	6356983	Mudstone	Flake
		344964	6356985	Mudstone	Retouched flake
		344963	6356988	Silcrete	Broken backed flake
		344963	6356988	Mudstone	Flake
		344963	6356988	Silcrete	Flake
		344963	6356988	Chert	Broken flake
		344959	6356992	Quartzite	Flake
		344959	6356992	Mudstone	Broken flake
		344958	6356985	Silcrete	Broken flake
		344955	6357002	Quartz	Flake
		344955	6357002	Silcrete	Broken flake
		344947	6356997	Silcrete	Broken flake
		344941	6356987	Mudstone	Broken flake
		344923	6356995	Mudstone	Flake
		344946	6356977	Quartzite	Flake
		344922	6356990	Mudstone	Broken flake
		344919	6356991	Silcrete	Broken flake
		344922	6356983	Petrified wood	Retouched flake
		344926	6356962	Mudstone	Flake
		344922	6356957	Quartz	Flake
	3	344880	6356942	Quartz	Core
ACM41		344835	6356790	Quartz	Flake
ACM42	1	344899	6356634	Quartzite	Flake

Site Name	Locus	E_MGA	N_MGA	Raw material	Artefact class
	2	344882	6356641	Quartzite	Broken flake
		344882	6356641	Silcrete	Broken flake
	3	344883	6356652	Quartzite	Core
ACM43	1	344900	6356744	Unknown	Grindstone (muller)
		344900	6356744	Silcrete	Retouched flake
		344900	6356744	Silcrete	Broken flake
	2	344906	6356790	Silcrete	Broken flake
ACM44	1	344675	6356500	Silcrete	Retouched flake
	2	344657	6356497	Quartzite	Broken flake
	3	344717	6356496	FGS	Broken retouched flake
ACM45	1	343977	6357093	Mudstone	Retouched flake
		343977	6357093	Silcrete	Broken flake
	2	343954	6357097	Silcrete	Broken flake
ACM46		344182	6357131	Mudstone	Flake
ACM47	1	344566	6356862	Mudstone	Broken flake
	2	344570	6356863	Silcrete	Broken flake
	3	344570	6356863	Silcrete	Broken flake
ACM48		344382	6357083	Silcrete	Flake
ACM49		344183	6357022	Silcrete	Flaked piece

5.3 Tree exhibiting scarring

During the survey, a large living red gum exhibiting two large scars was identified on the bank of Quorrobolong Creek at MGA 344925 6357211. One scar is located approximately two metres from the base of the tree, is not symmetrical in shape and exhibits uneven scar margins, as shown in **Attachment 2**, Plate 56. Based on the lack of symmetry to the scar, the uneven margins, the height of the scar on the tree and the presence of another minor scar higher up the tree that had resulted from limb tear, this scar is considered highly unlikely to be of Aboriginal cultural origin. This conclusion was discussed and agreed with Aboriginal party representatives present during survey.

The second scar on the tree is generally symmetrical (sub-ovoid) in shape, is located approximately 3.5 metres from the base on the tree, exhibits an estimated 15-20 centimetres of callus regrowth (not measurable due to height from ground surface) and is approximately 1.5-2 metres in length by 0.8 metres in width (refer to **Attachment 2**, Plate 57). No evidence of scarring associated with the cutting of footholds was present on the tree trunk below the scar and there were no disconformities (such as burls) that would render the section of the tree trunk accessible from the ground unsuitable for use. This scar exhibits some characteristics associated with Aboriginal scarred trees (namely that it is a suitable species, is a mature tree, has a scar that is symmetrical and is relatively old based on the extent of callus regrowth). However, the scar is located a considerable distance off the ground surface, meaning that if it was made by an Aboriginal person, he or she would have been required to climb up to 5-5.5 metres to reach the top of the scar. The absence of footmarks in the tree truck indicates that this climbing would have been done by some other means (which is not unknown within accounts of Aboriginal scarring practices). In contrast the tree trunk immediately below the scar and directly accessible from the ground does not exhibit any evidence that it would have been unsuitable for use. In addition, the tree exhibits other clear evidence of damage from limb tears.

Based on the available evidence, this scar does not present sufficient evidence to warrant the recording of the tree as an archaeological site. This conclusion was discussed with the Aboriginal party representatives present during survey. Several of the Aboriginal party representatives indicated that they felt that the scar may be of cultural origin and requested that the above information be included within the report.

5.4 Assessment of Archaeological Potential

As discussed throughout this section, levels of visibility and exposure within the LWB4-B7 Modification Area were low. This fact, along with the presence of landforms within which artefactual deposits may be present at considerable depth and not detectible during survey, dictates that it is critical to consider the archaeological potential of the LWB4-B7 Modification Area with reference to the criteria established in **Section 4.4**.

The valley flat landforms that adjoin Quorrobolong Creek within the modification area include areas containing alluvial deposits that may extend deeper than 1.5 metres (particularly within Survey Unit 9) and it is anticipated that alluvial deposits (of varying depth) may be present within these landforms. Based on the nature of alluvial deposition, it is possible that archaeological deposits may be capped by subsequent layers of alluvial material, potentially resulting in the formation of stratified or partially stratified deposits (should artefacts be present) below depths of current disturbance and recent alluvium deposition.

The valley flat landforms also provide direct access to Quorrobolong Creek and its current and past overflow channels. Aboriginal people using these areas would have had access to water resources within Quorrobolong Creek, with the potential that water was retained within pools along this watercourse for considerable periods of time following rain. However, it is recognised that Ellalong Lagoon (which is and would have been a permanent or near permanent source of water and associated animal and plant resources) is located within 3-4 kilometres of the modification area and is likely to have been the focus of occupation in the local area. On this basis, the valley flat landforms bordering the main channel of Quorrobolong Creek are assessed as having moderate archaeological potential. It is noted that this excludes the valley flat landforms bordering the unnamed tributary of Quorrobolong Creek within the LWB1-B3 modification area as these have been previously assessed as having low archaeological potential (Umwelt 2015).

The slopes within 100 metres of the main channel of Quorrobolong Creek and the overflow channels identified in this assessment provide a similar resource context to the valley flats. In addition, the minor spur crest with Survey Unit 2 provides similar access to water resources (within overflow channel) with an excellent vantage point. However, A horizon soils within these landforms have been subject to substantial erosion, therefore reducing the potential that any artefacts that may be present will be in their original depositional context. Thus while additional artefactual deposits may be present, the level of integrity and intactness within any such deposits is likely to be low. These landforms (including sites ACM38, ACM39 and ACM40) are therefore assessed as having low to moderate potential.

The remaining portions of the LWB4-B7 Modification Area are assessed as having low archaeological potential due to the levels of disturbance, lack of access to suitable water resources and the skeletal nature of A horizon deposits.

5.5 Discussion

The survey of the LWB4-B7 Modification Area comprised pedestrian survey in accordance with the sampling strategy. During the survey, it was noted that the modification area has been subject to a range of disturbance factors associated with historical land use however the potential for deep alluvial soils to exist in areas along Quorrobolong Creek was identified. A total of 13 new sites were identified, of which one is located outside the LWB4-B7 Modification Area. These sites consisted of isolated artefacts and artefact scatters, with only two sites (ACM38 and ACM40) containing more than five artefacts. The distribution and contents of these sites is relatively comparable to the outcomes of previous archaeological investigations within the Austar Coal Mine and surrounds, as documented in **Section 3.0**. No grinding grooves or scarred trees were identified within the LWB4-B7 Modification Area and no areas of outcropping sandstone were present within Quorrobolong Creek.

Based on the criteria for the assessment of archaeological potential, the majority of the LWB4-B7 Modification Area has low archaeological. The exceptions to this are the valley flats bordering Quorrobolong Creek (moderate potential), slopes within 100 metres of the main channel of Quorrobolong Creek and identified overflow channels and the spur crest in Survey Unit 9 (all of which have low to moderate archaeological potential).

6.0 Scientific Value Significance Assessment

The Burra Charter: the Australia ICOMOS Charter for Places of Cultural Significance (Australia ICOMOS 2013) (the Burra Charter) defines cultural significance as the sum of the qualities or values that a place embodies. The Burra Charter identifies the values – aesthetic, historic, archaeological, social or cultural and spiritual – that contribute to cultural significance.

- **Aesthetic** value refers to the sensory and perceptual experience of a place. It may consider form, scale, texture and material of the fabric or landscape and may also include smell and sounds associated with the place (OEH 2011:9).

- **Historic** value encompasses all aspects of history and as such is often underlying other values. A place may have historic value because it has influenced, or been influenced by, an historic event, phase, movement or activity, person or group of people.

- **Archaeological** value refers to the potential physical remains and the ability of those remains to provide an understanding about an aspect of the past.

- **Social** or **cultural** value refers to the spiritual, traditional, historical and contemporary associations and attachments of a place (OEH 2011:8). It is noted that a consensus as to the cultural value of an object or place is not always possible as people experience places and events differently.

- **Spiritual** value refers to the intangible values embodied in a place, which give it importance in the spiritual identity.

In accordance with the Code of Practice and the Burra Charter, this section assesses the archaeological significance of the LWB4-B7 Modification Area only. The ACHAR, to which this report is appended, addresses the cultural significance of the LWB4-B7 Modification Area.

6.1 Archaeological Significance Assessment

Archaeological significance is determined by the assessment against a number of archaeological criteria as set out by the OEH in the Code of Practice, with the key criteria for the assessment of archaeological assessment outlined in below.

Table 6.1 Criteria for the Assessment of Archaeological Significance

Criterion	Low	Moderate	High
Rarity	The site within the surrounding landscape, its integrity, contents and/or potential for subsurface artefacts, are common within the local and regional context.	The site within the surrounding landscape, its integrity, contents and/or potential for subsurface artefacts, are common within the local context but not the regional context.	The site within the surrounding landscape, its integrity, contents and/or potential for subsurface artefacts, are rare within the local and regional context.
Representativeness	This site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts is common within a local and regional context and sites of similar nature (or in better condition) are already set aside for conservation within the region.	This site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts, is uncommon within a local context but common in a regional context and sites of similar nature (or in better condition) are already set aside for conservation within the region.	This site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts is uncommon within a local and regional context and sites of similar nature (or in better condition) are not already set aside for conservation within the locality or region.
Research potential	The site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts has limited potential to contribute to a greater understanding of how Aboriginal people lived within this area or region.	The site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts has moderate potential to contribute to a greater understanding of how Aboriginal people lived within this area or region.	The site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts has high potential to contribute to a greater understanding of how Aboriginal people lived within this area or region.

Criterion	Low	Moderate	High
Education potential	The site is not readily accessible and/or when viewed in relation to its contents, integrity and location in the landscape has limited suitability to be used for educational purposes. Other sites with higher education potential are known to be present in the local area and region.	The site is not readily accessible and/or when viewed in relation to its contents, integrity and location in the landscape provides a tangible example that is suitable to assist in educating people regarding how Aboriginal people lived in this area or region. However, other sites with higher education potential are known or expected to be present in the local area or region.	The site is readily accessible and/or when viewed in relation to its contents, integrity and location in the landscape, provides a very good tangible example that is suitable to assist in educating people regarding how Aboriginal people lived in this area or region. Other sites of higher education potential are generally not known to exist in the local area or region.
Integrity	Stratigraphic integrity of the site has clearly been destroyed due to major disturbance/loss of topsoil. The level of disturbance is likely to have removed all spatial and chronological information.	The site appears to have been subject to moderate levels of disturbance, however, there is a moderate possibility that useful spatial information can still be obtained from subsurface investigation of the site, even if it is unlikely that any useful chronological evidence survives.	The site appears relatively undisturbed and there is a high possibility that useful spatial information can still be obtained from subsurface investigation of the site, even if it is still unlikely that any useful chronological evidence survives.

6.1.1 Assessment of Archaeological Significance

The assessment of archaeological significance for all sites within the LWB4-B7 Modification Area is presented in **Table 6.2**. To provide context to this assessment, all sites identified within the LWB4-B7 Modification Area are within landscape contexts and have contents that are common within the local context and are represented at other locations within the Austar Coal Mine. Consequently, all sites have low value for rarity and representativeness. This has some flow on effect for educational value. In addition, all sites other than ACM38 and ACM40 contain less than five artefacts. ACM38 and ACM40, while containing slightly higher numbers of artefacts, are located on privately owned land with no public access. All sites are therefore assessed as having low educational potential.

In terms of research potential, ACM38 and ACM40 are identified as having potential to be associated with additional sub-surface deposits however the extent of disturbance within these sites is such that it is unlikely that these deposits will retain stratigraphic integrity. These sites are therefore assessed to have low-moderate potential to contribute to our understanding of how Aboriginal people lived in this area.

On this basis, all sites within the LWB4-B7 Modification Area are assessed as having low archaeological significance, with the exception of ACM38 and ACM40, which have low to moderate significance.

Table 6.2 Assessment of Archaeological Significance

Site	Rarity	Representativeness	Research Potential	Education Potential	Integrity	Overall
ACM35[1]	Low	Low	Low	Low	Low	Low
ACM37	Low	Low	Low	Low	Low	Low
ACM38	Low	Low	Low-moderate	Low	Low	Low-moderate
ACM39	Low	Low	Low	Low	Low	Low
ACM40	Low	Low	Low-moderate	Low	Low	Low-moderate
ACM41	Low	Low	Low	Low	Low	Low
ACM42	Low	Low	Low	Low	Low	Low
ACM43	Low	Low	Low	Low	Low	Low
ACM44	Low	Low	Low	Low	Low	Low
ACM46	Low	Low	Low	Low	Low	Low
ACM47	Low	Low	Low	Low	Low	Low
ACM48	Low	Low	Low	Low	Low	Low
ACM49	Low	Low	Low	Low	Low	Low

[1] Site identified and assessed by Umwelt (2015)

The assessment of significance for areas of archaeological potential (within which there are no visible Aboriginal objects) is inherently difficult as any such assessment can only be based on the nature of the evidence that the area may contain. For this reason, the assessment of significance of areas of archaeological potential remains a provisional assessment of potential significance only and is linked almost entirely to the research potential of the site. That is, areas of moderate archaeological potential have a provisional assessment of moderate archaeological significance, with areas of low-moderate potential having low to moderate significance.

7.0 Impact Assessment

The purpose of this section is to identify whether there is risk of harm to the identified Aboriginal sites within the LWB4-B7 Modification Area.

7.1 Subsidence Predictions

The maximum predicted subsidence parameters for all identified Aboriginal archaeological sites within the LWB4-B7 Modification Area have been determined by MSEC (2017) and are summarised in **Table 7.1**. The values presented in **Table 7.1** represent the maximum cumulative subsidence associated with the extraction of approved LWB1-B3 and proposed LWB4-B7.

Table 7.1 Maximum predicted subsidence parameters for Aboriginal archaeological sites within the LWB4-B7 Modification Area

Longwall	Max. Predicted Total Subsidence (mm)	Max. Predicted Total Tilt (mm/m)	Max. Predicted Total Hogging Curvature (km^{-1})	Max. Predicted Total Sagging Curvature (km^{-1})
After LWB4	125	1.5	0.03	<0.01
After LWB5	400	3.0	0.03	0.01
After LWB6	1025	3.5	0.03	0.04
After LWB7	1225	4.5	0.04	0.04

The subsidence predictions outlined in **Table 7.1** for the LWB4-B7 Modification Area are less than those for the previously approved Stage 2 and Stage 3 mining areas, where there has been no significant or visible surface cracking observed and no requirement for remediation of any ground surface cracking.

7.2 Potential Impacts of the Proposed Modification

The LWB4-B7 Modification does not involve any additional surface development and therefore will have no direct impact on archaeological sites as a result of land clearing or disturbance. The potential impacts of the proposed modification on archaeological sites are therefore limited to indirect impacts associated with subsidence, including potential surface cracking, subsidence remediation works or hydrological changes.

7.2.1 Subsidence Related Surface Cracking and Remediation

Potential changes in the ground surface resulting from subsidence have been assessed by MSEC (2017). MSEC notes that surface cracking in soils as the result of conventional subsidence movements is not commonly observed where the depths of cover are greater than 400 metres, as is the case for the proposed modification. The subsidence assessment findings indicate that due to the depth of mining within the proposed modification area (minimum 400 metres), the massive nature of the Branxton Formation sandstones overlying the coal seam resulting in the small magnitudes of predicted ground curvatures and strains and the absence of steep slopes or cliffs within the modification area, the potential for surface cracking is low.

This conclusion is supported by subsidence monitoring evidence within the Stage 2, Stage 3 and LWB1-B3 mining areas, where there has been no significant or visible surface cracking above previously extracted longwalls A3 to A8 or LWB2.

Any surface cracking that does occur is expected to be minor and isolated and unlikely to directly or adversely impact the Aboriginal archaeological sites or areas of archaeological potential identified within the LWB4-B7 Modification Area. Based on previous experience within the broader Austar Coal Mine, remediation of surface cracking is unlikely to be required within the LWB4-B7 Modification Area.

7.2.2 Hydrological Changes

Flood modelling has been undertaken by Umwelt (2017c) to assess the potential changes in flooding and surface water flows resulting from predicted subsidence associated with the extraction of LWB4-B7. The flooding and drainage assessment concludes that the proposed modification is unlikely to have a significant impact on runoff regimes, bank stability or channel alignment and will not result in scouring or increased erosion of the landscape. The assessment predicts minor changes to remnant ponding around some existing flow paths and farm dams. These minor changes to the extent of remnant ponding occur within low lying areas that are already subject to periodic inundation during periods of high rainfall. Therefore additional periods of inundation in these locations are highly unlikely to result in any additional impact to Aboriginal archaeological sites or areas of archaeological potential that may be present.

7.2.3 Summary

Based on the outcomes of assessments undertaken by MSEC (2017) and Umwelt (2017c), the proposed LWB4-B7 Modification is unlikely to result in direct or indirect impacts to the identified archaeological sites or on the identified areas of low-moderate or higher archaeological potential.

8.0 Recommendations

The following recommendations have been developed in light of the archaeological context of the LWB4-B7 Modification Area; the findings of the current survey and the previous survey of the LWB1-B3 Modification Area; the low likelihood of impact of the proposed modification on identified archaeological sites and areas of archaeological potential and current cultural heritage legislation.

- The Austar Coal Mine should continue to implement the management strategies currently in place at the Austar Coal Mine, including those in the Austar Aboriginal Cultural Heritage Management Plan (ACHMP). Consistent with existing management strategies, in the unlikely event that subsidence remediation works are required that will impact on the identified sites or areas of low-moderate or higher archaeological potential, an Aboriginal Heritage Impact Permit (AHIP) will be sought for the portion of the site or area of potential to be impacted prior to the commencement of any remediation works in proximity to the recorded site or area of potential (noting that, in some instances, it may be necessary to undertake test excavation to inform the requirement for an AHIP). Appropriate mitigation measures for the site or area of potential to be impacted by the remediation works will be developed as part of the AHIP application process in consultation with the registered Aboriginal parties and in accordance with OEH requirements. The ACHMP includes provision for pre and post subsidence monitoring of recorded sites to provide comparative data on site condition and to allow for the identification of any unexpected subsidence impacts.

- The Austar ACHMP should be reviewed to incorporate the outcomes of this assessment and to include provisions for the monitoring of identified archaeological sites within the LWB4-B7 Modification Area in accordance with the management strategies currently implemented within the Austar Coal Mine.

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Umwelt (Australia) Pty Limited (Umwelt). 2017a. LWB4-B7 Modification Ecological Assessment. Report to Austar Coal Mine.

Umwelt (Australia) Pty Limited (Umwelt). 2017b. LWB4-B7 Modification Environmental Assessment. Report to Austar Coal Mine.

Umwelt (Australia) Pty Limited (Umwelt). 2017c. LWB4-B7 Modification Flooding and Drainage Assessment. Report to Austar Coal Mine.

Zola, N. and Gott, B. 1992. Koorie Plants Koorie People. Traditional Aboriginal Food, Fibre and Healing Plants of Victoria. Koorie Heritage Trust, Melbourne, Victoria.

ATTACHMENT 1

Search Results

AHIMS Web Services (AWS)
Search Result

Purchase Order/Reference : 3900

Client Service ID : 265453

Umwelt (Australia) Pty Limited

75 York Street
Teralba New South Wales 2284

Attention: Joshua Madden

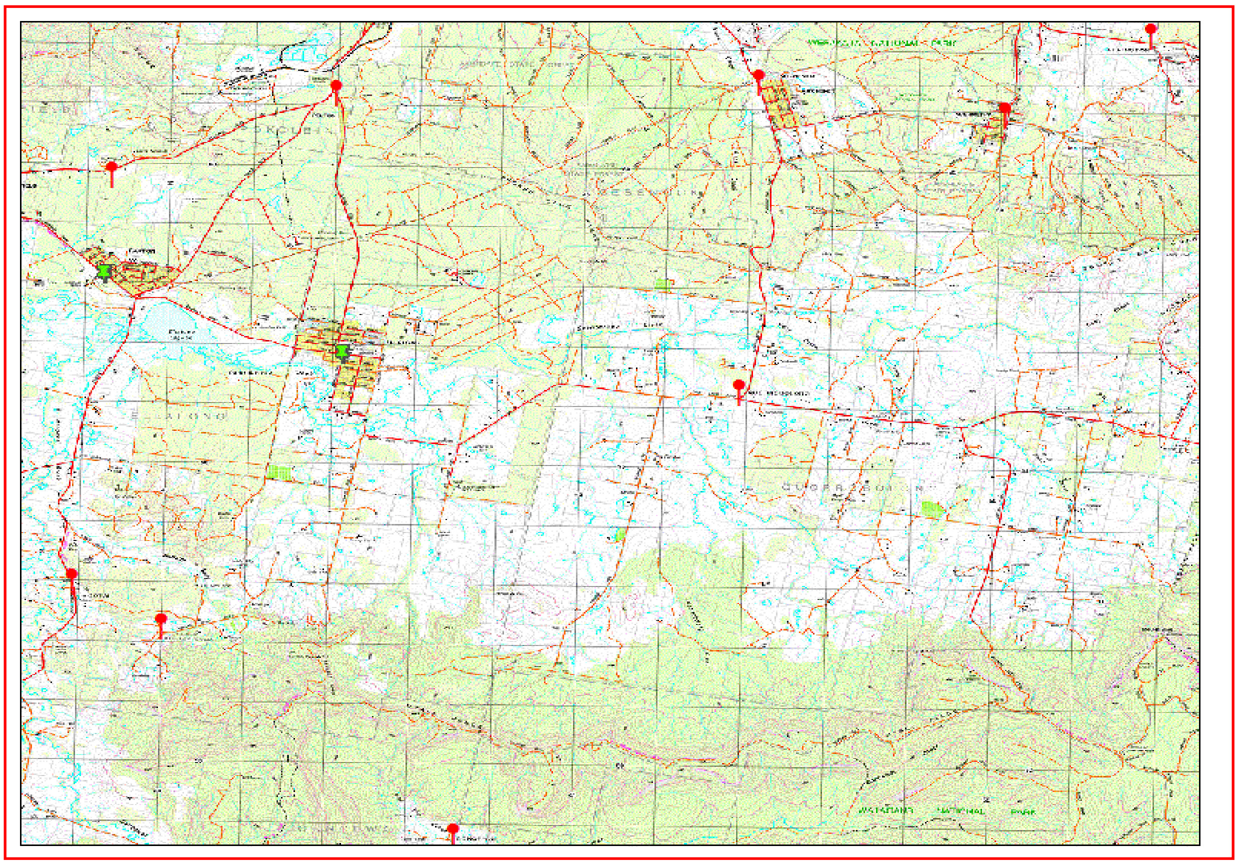
Email: jmadden@umwelt.com.au

Date: 07 February 2017

Dear Sir or Madam:

AHIMS Web Service search for the following area at Datum :GDA, Zone : 56, Eastings : 338400 - 352341, Northings : 6349919 - 6361183 with a Buffer of 50 meters, conducted by Joshua Madden on 07 February 2017.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.



A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

84	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (http://www.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Office of Environment and Heritage's Aboriginal Heritage Information Unit upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Office of Environment and Heritage and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date .Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

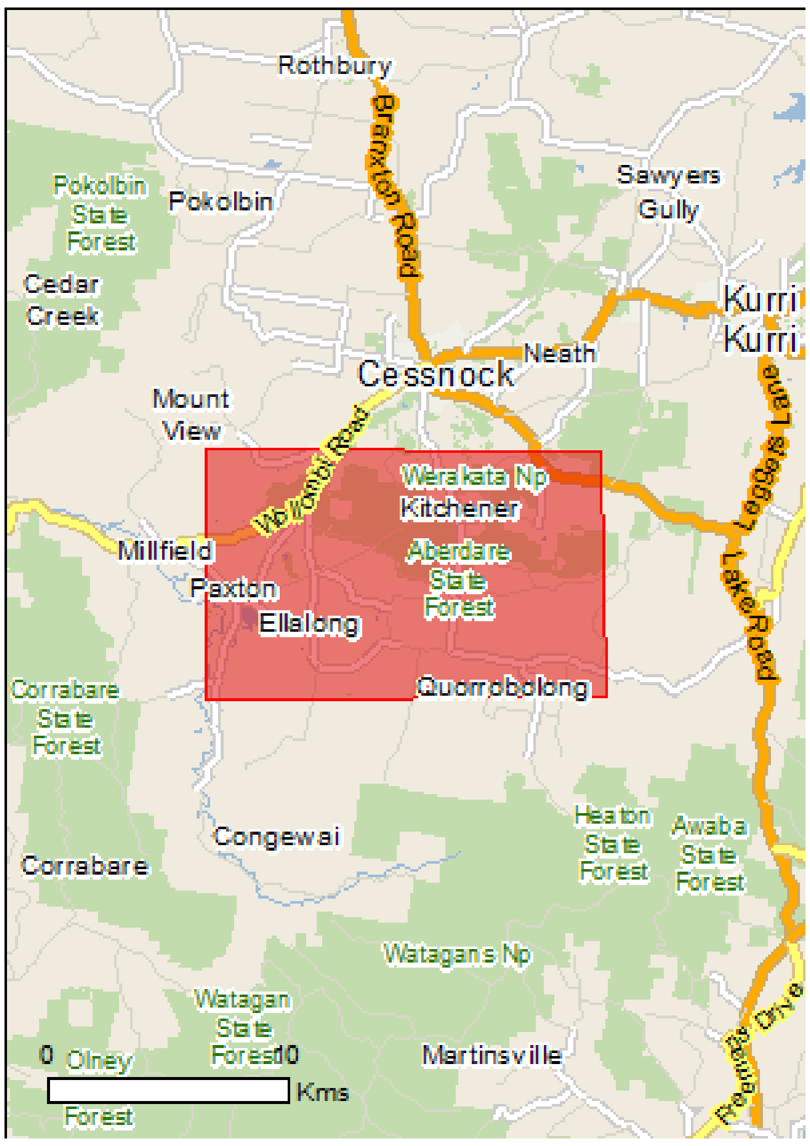
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

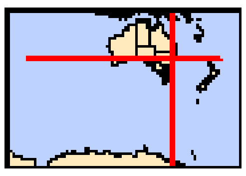
Report created: 07/04/17 16:29:35



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	37
Listed Migratory Species:	13

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	3
Commonwealth Heritage Places:	None
Listed Marine Species:	19
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	2
Regional Forest Agreements:	1
Invasive Species:	43
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar)	[Resource Information]
Name	Proximity
Hunter estuary wetlands	20 - 30km upstream

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Central Hunter Valley eucalypt forest and woodland	Critically Endangered	Community may occur within area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia		
Regent Honeyeater [82338]	Critically Endangered	Species or species habitat known to occur within area
Botaurus poiciloptilus		
Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Dasyornis brachypterus		
Eastern Bristlebird [533]	Endangered	Species or species habitat likely to occur within area
Grantiella picta		
Painted Honeyeater [470]	Vulnerable	Species or species habitat likely to occur within area
Lathamus discolor		
Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Frogs		
Heleioporus australiacus		
Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Litoria aurea Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat known to occur within area
Litoria littlejohni Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat likely to occur within area
Mixophyes balbus Stuttering Frog, Southern Barred Frog (in Victoria) [1942]	Vulnerable	Species or species habitat likely to occur within area
Mixophyes iteratus Giant Barred Frog, Southern Barred Frog [1944]	Endangered	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat known to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat likely to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat likely to occur within area
Petrogale penicillata Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE mainland) [66645]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat known to occur within area
Pseudomys oralis Hastings River Mouse, Koontoo [98]	Endangered	Species or species habitat likely to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Plants		
Acacia bynoeana Bynoe's Wattle, Tiny Wattle [8575]	Vulnerable	Species or species habitat known to occur within area
Allocasuarina glareicola [21932]	Endangered	Species or species habitat may occur within area
Asterolasia elegans [56780]	Endangered	Species or species habitat may occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area
Eucalyptus glaucina Slaty Red Gum [5670]	Vulnerable	Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Eucalyptus parramattensis subsp. decadens Earp's Gum, Earp's Dirty Gum [56148]	Vulnerable	Species or species habitat known to occur within area
Euphrasia arguta [4325]	Critically Endangered	Species or species habitat may occur within area
Grevillea parviflora subsp. parviflora Small-flower Grevillea [64910]	Vulnerable	Species or species habitat known to occur within area
Pelargonium sp. Striatellum (G.W.Carr 10345) Omeo Stork's-bill [84065]	Endangered	Species or species habitat may occur within area
Prostanthera cineolifera [11233]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis gibbosa Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood [4562]	Endangered	Species or species habitat may occur within area
Rutidosis heterogama Heath Wrinklewort [13132]	Vulnerable	Species or species habitat likely to occur within area
Tetratheca juncea Black-eyed Susan [21407]	Vulnerable	Species or species habitat likely to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Hoplocephalus bungaroides Broad-headed Snake [1182]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Australian Telecommunications Commission
Commonwealth Land - Commonwealth Trading Bank of Australia

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Cuculus saturatus Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Werakata	NSW
Werakata	NSW

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State

Name	State
North East NSW RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Cytisus scoparius Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Sage, Wild Sage [10892]		
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Protasparagus densiflorus Asparagus Fern, Plume Asparagus [5015]		Species or species habitat likely to occur within area
Protasparagus plumosus Climbing Asparagus-fern, Ferny Asparagus [11747]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Ellalong Lagoon	NSW

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-32.85816 151.272704,-32.859169 151.419818,-32.936281 151.422221,-32.937289 151.277682,-32.937001 151.272532,-32.937001 151.272532,-32.937001 151.272532,-32.85816 151.272704

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
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Canberra ACT 2601 Australia
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ATTACHMENT 2

Plates

Attachment 2 – Plates

Plate 1 Survey unit 1
© Umwelt, 2017

Plate 2 Survey unit 1 showing dam, house and associated buildings
© Umwelt, 2017

Plate 3 Survey unit 2 showing overflow channel

Plate 4 Survey unit 2 facing south from Quorrobolong Creek

Plate 5 Survey unit 2 showing alluvial deposits north of Quorrobolong Creek

Plate 6 Survey unit 2 showing exposure of alluvium in area of earthworks

Plate 7 Survey unit 3 showing high levels of exposure

Plate 8 Survey unit 3 showing increased visibility due to grazing and use

Plate 9 Survey unit 4 with Quorrobolong Creek in right of plate

© Umwelt, 2017

Plate 10 Survey unit 4 showing area of moderately inclined slope bordering Quorrobolong Creek

© Umwelt, 2017

Plate 11 Survey unit 5 facing north

Plate 12 Survey unit 5 showing small dam adjacent to access road

Plate 13 Survey unit 6 showing existing access track

Plate 14 Survey unit 6 showing disturbance at former quarry location

Plate 15 Survey unit 7 facing north

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Plate 16 Survey unit 7 facing south-west

© Umwelt, 2017

Plate 17 Survey unit 8 showing access track and powerline easement

Plate 18 Survey unit 8 – view along channel of Quorrobolong Creek

Plate 19 Survey unit 8 view along area of ponding on minor drainage

Plate 20 Survey unit 8 showing level of vegetation adjacent to Quorrobolong Creek

Plate 21 Survey unit 8 showing former motorbike track

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Plate 22 Survey unit 9 showing view from minor crest to large ponded farm dam water body

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Plate 23 Survey unit 9 showing post and rail fence within farm dam water body

Plate 24 Survey unit 9 showing view across valley flat landform

Plate 25 Survey unit 10

Plate 26 Survey unit 10 showing dense tea-tree scrub with access track as only area of visibility

Plate 27 ACM 37 locus 1

Plate 28 ACM37 locus 1 – mudstone flake

Plate 29 ACM38

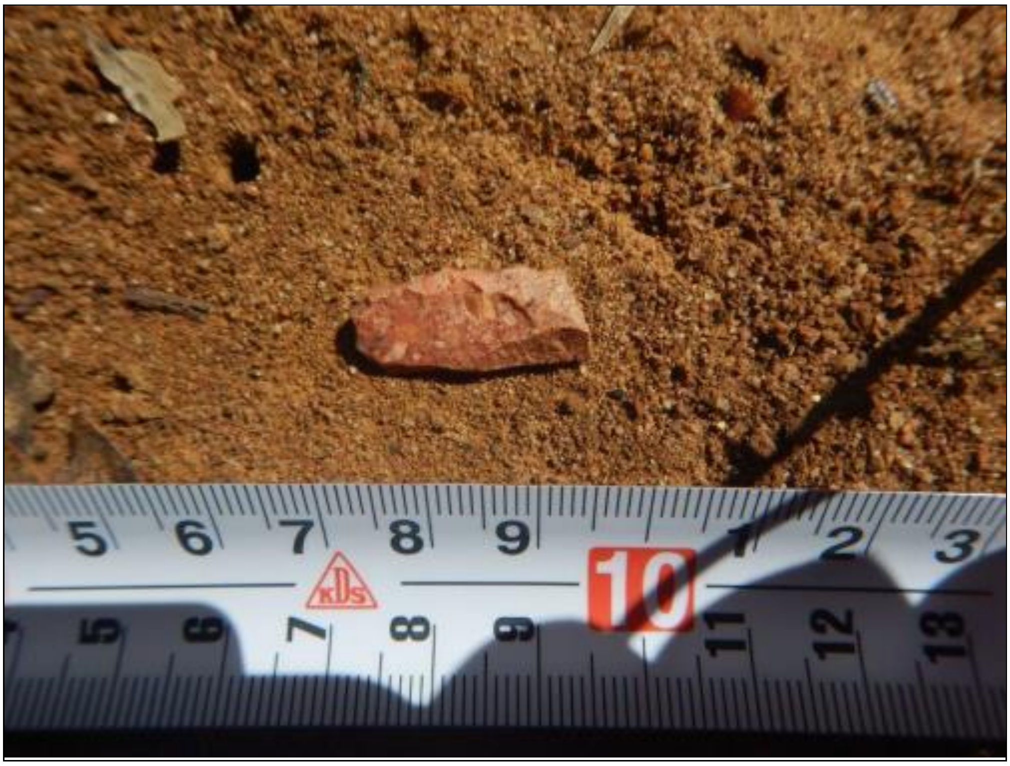

Plate 30 ACM38 – silcrete broken backed flake

Plate 31 ACM38 – partial grindstone

Plate 32 ACM39 facing north-west

Plate 33 ACM39 – silcrete flake

Plate 34 ACM40 locus 1

Plate 35 ACM40 locus 1 – mudstone broken backed flake

Plate 36 ACM40 locus 2

Plate 37 ACM40 locus 2 -mudstone retouched flake

Plate 38 ACM41

Plate 39 ACM41 quartz flake

Plate 40 ACM42

Plate 41 ACM42 – quartzite flake

Plate 42 ACM43

Plate 43 ACM43 – partial grindstone

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Plate 44 ACM44 locus 2

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Plate 45 ACM44 locus 2 – quartzite broken flake

Plate 46 ACM45 locus 1

Plate 47 ACM45 locus 1 – mudstone retouched flake

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Plate 48 ACM46

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Plate 49 ACM46 – mudstone flake

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Plate 50 ACM47 locus 1

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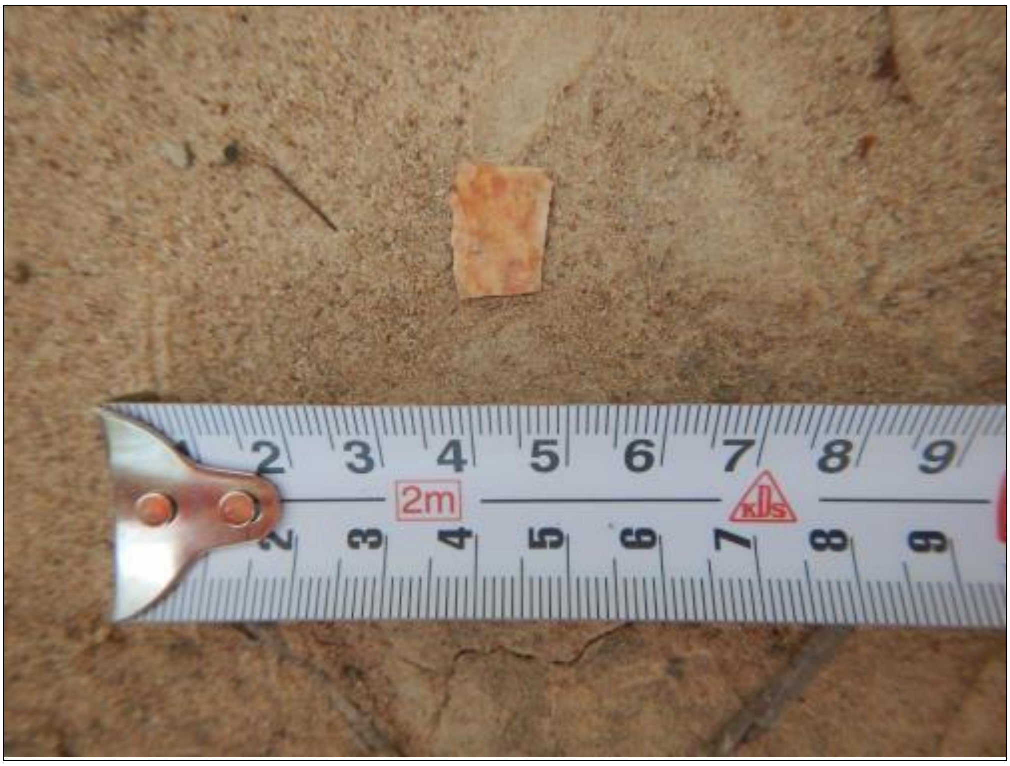

Plate 51 ACM47 locus 1 – mudstone broken flake

Plate 52 ACM48

Plate 53 ACM48 – silcrete flake

Plate 54 ACM49

Plate 55 ACM49 – silcrete flaked piece

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Plate 56 Red gum at MGA 344925 6357211 – scar 1

Plate 57 Red gum at MGA 344925 6357211 – scar 2

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