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.

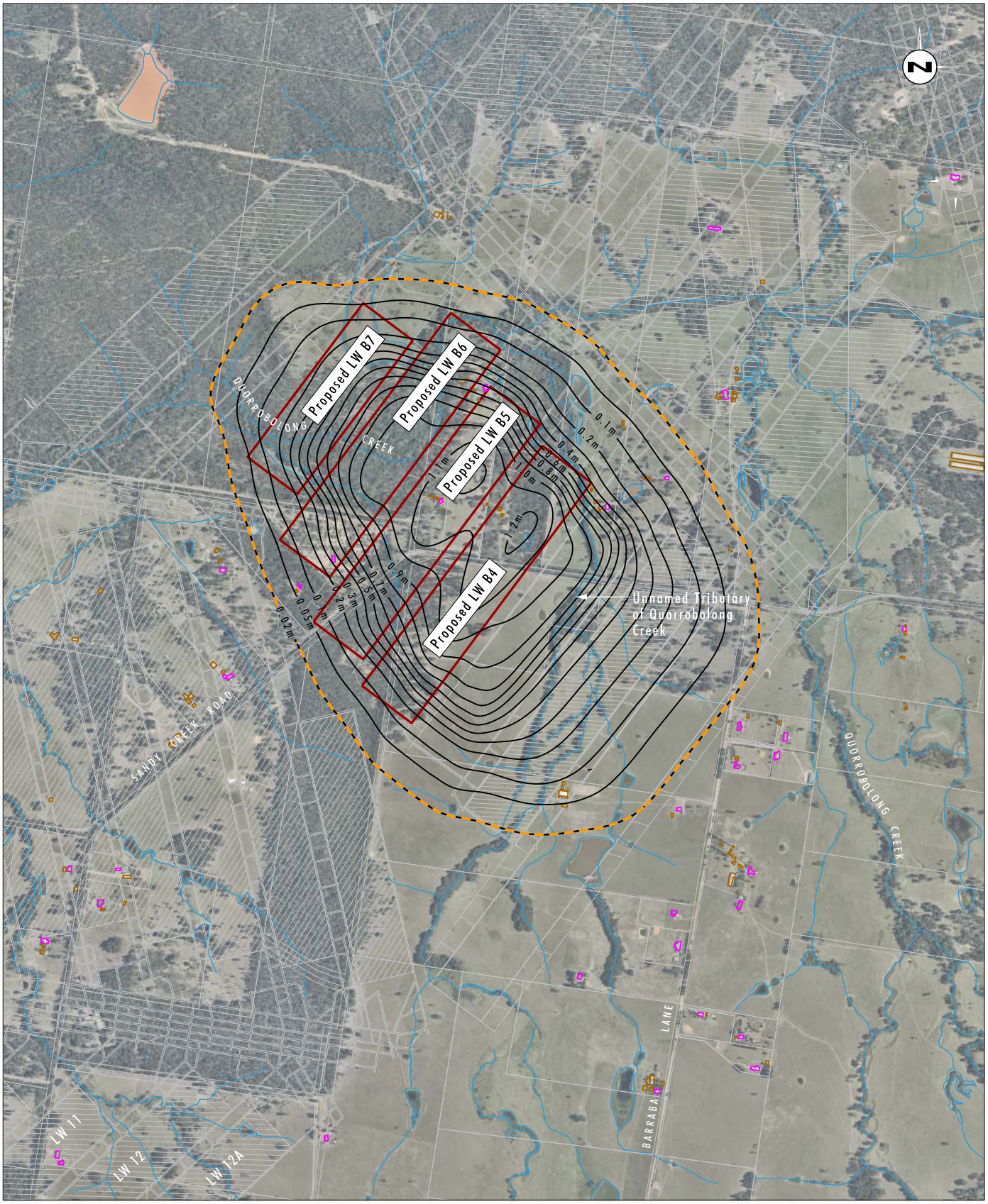

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016), MSEC (2017)
Note: Contour Interval 0.1m unless otherwise marked

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

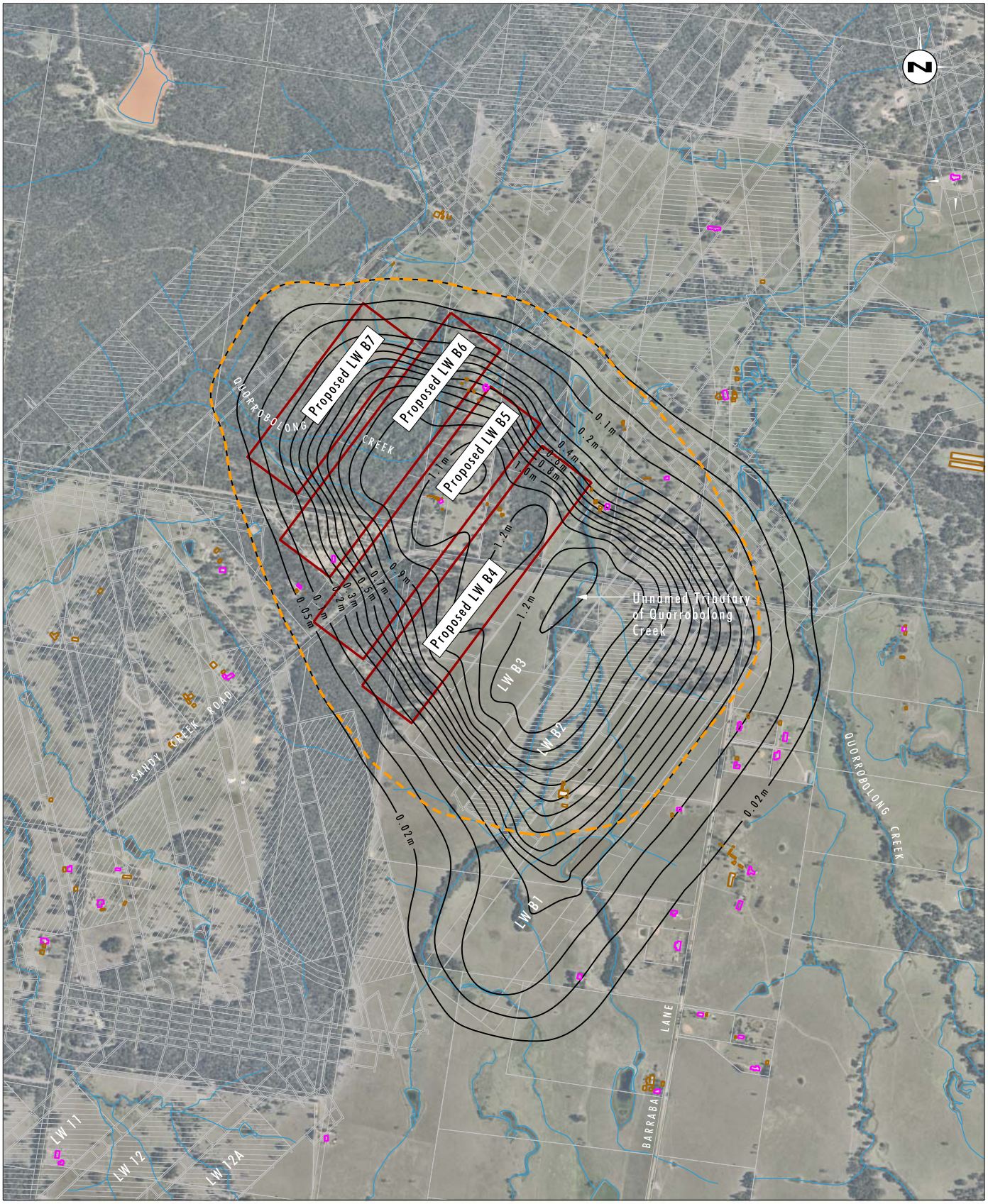

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016), MSEC (2017)
Note: Contour Interval 0.1m unless otherwise marked

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

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.

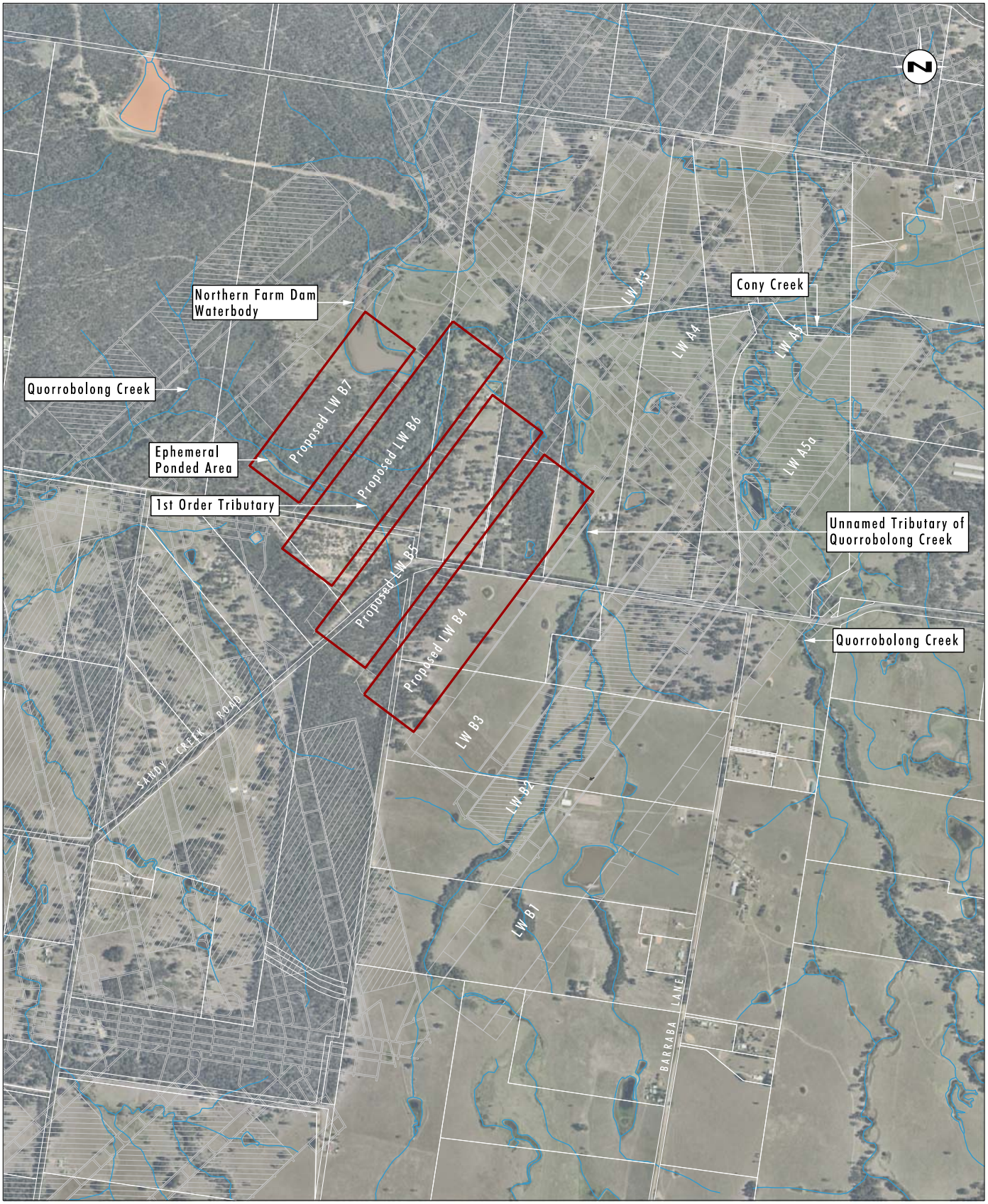

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017)

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**).

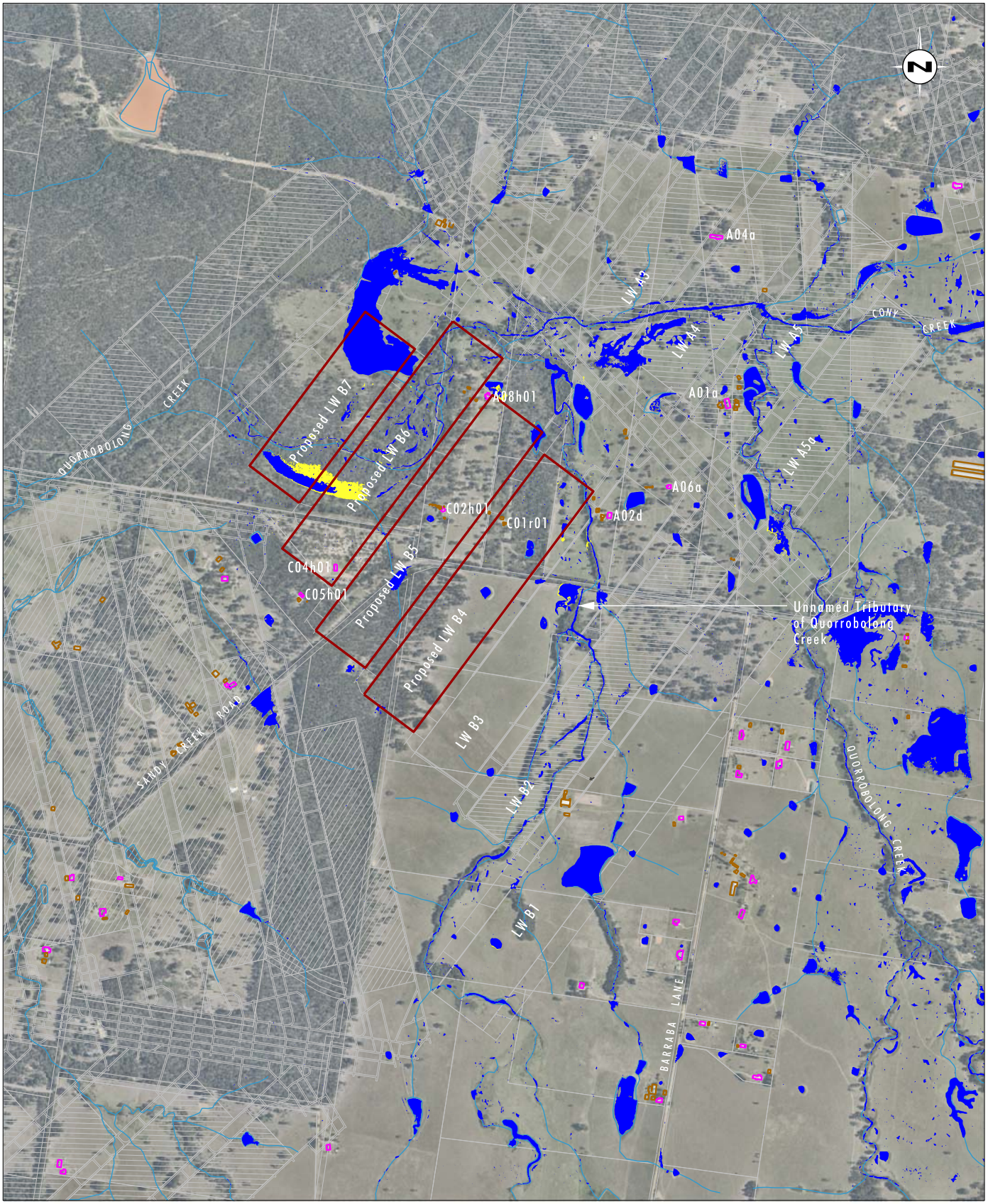

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017), MSEC (2017)

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
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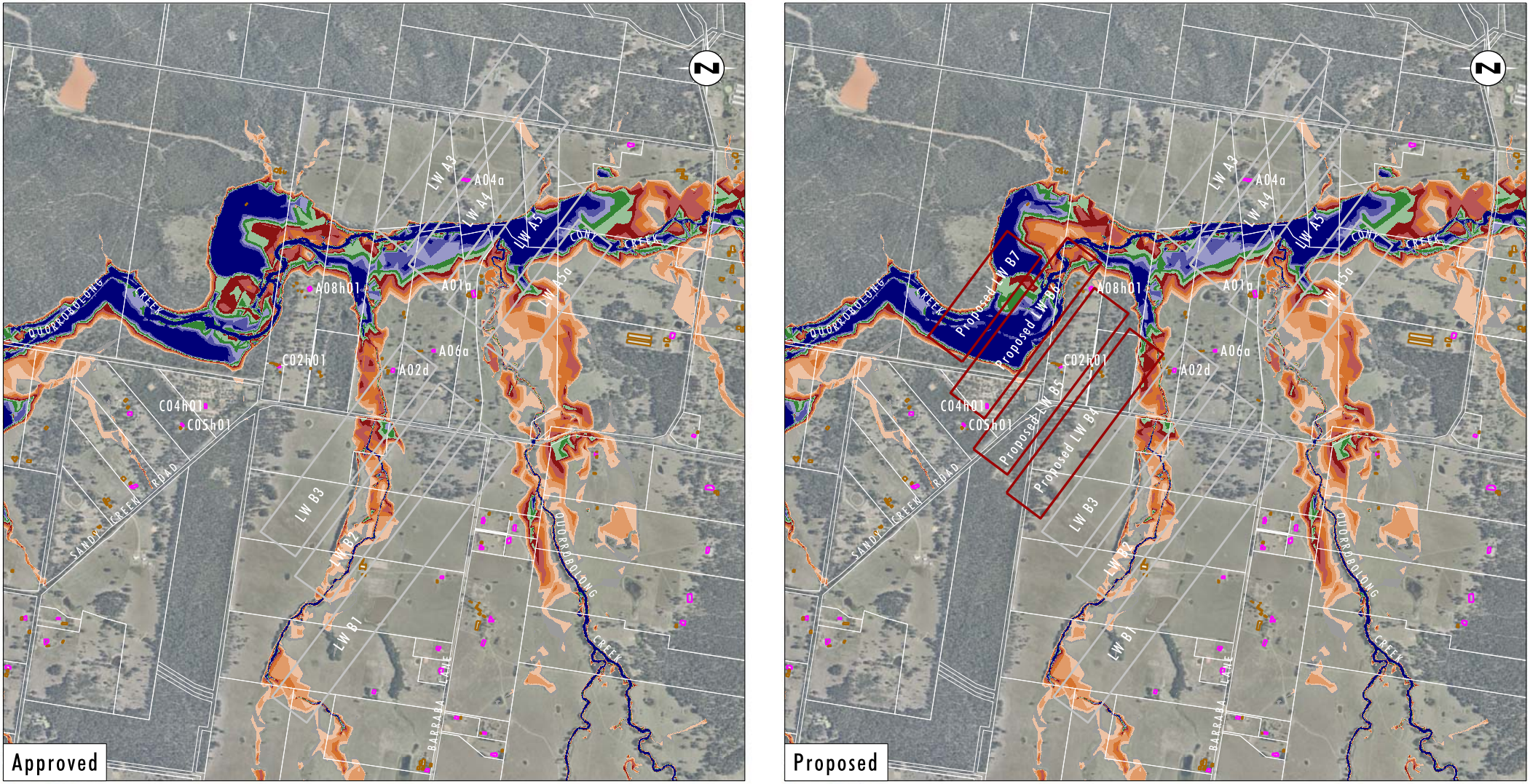

Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017), MSEC (2017)

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
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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

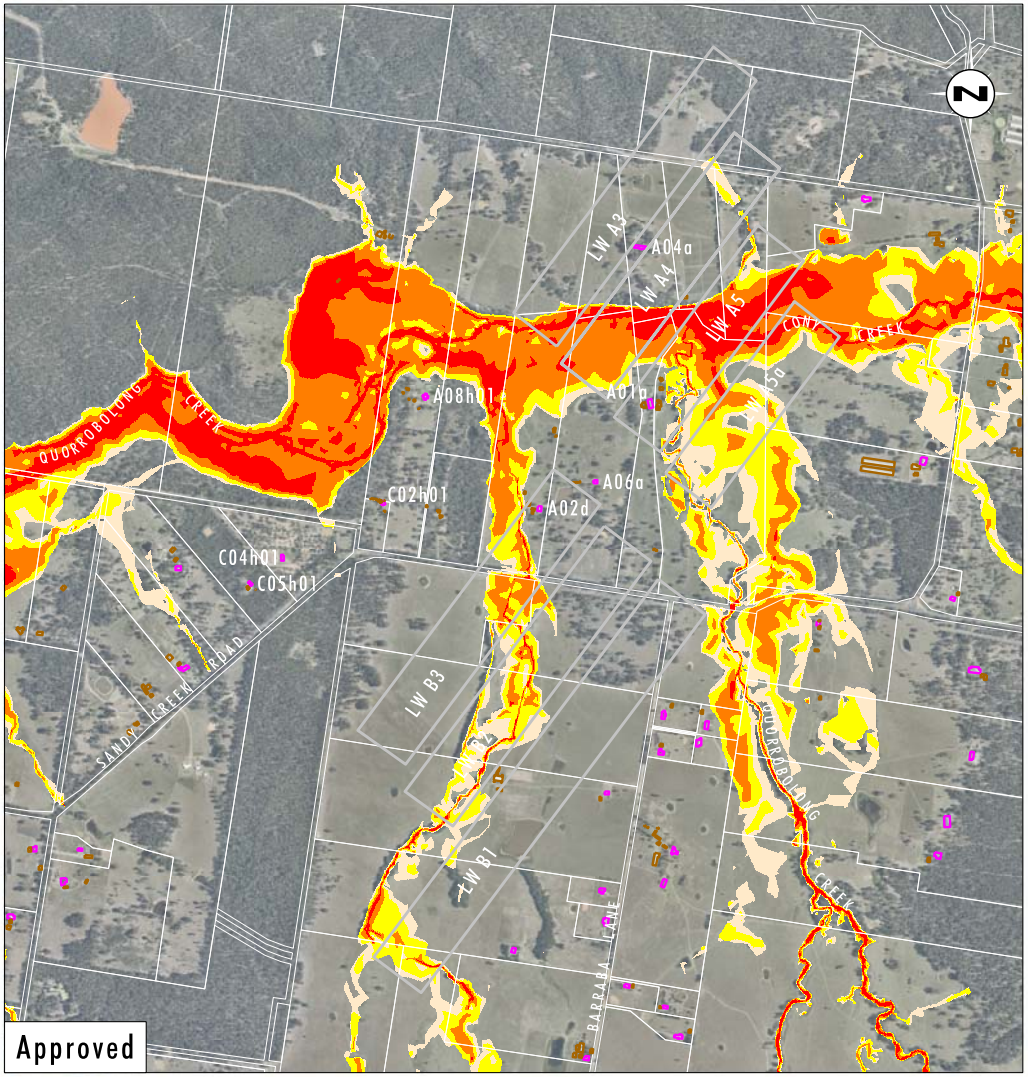
The modelled changes to flood hazard categories and flood extents as a result of the LWB4-B7 Modification are considered to be negligible (refer to **Figure 6.6**). No access routes to private properties will be adversely affected as a result of the proposed modification for the 1% AEP flood event. A 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.

umwelt



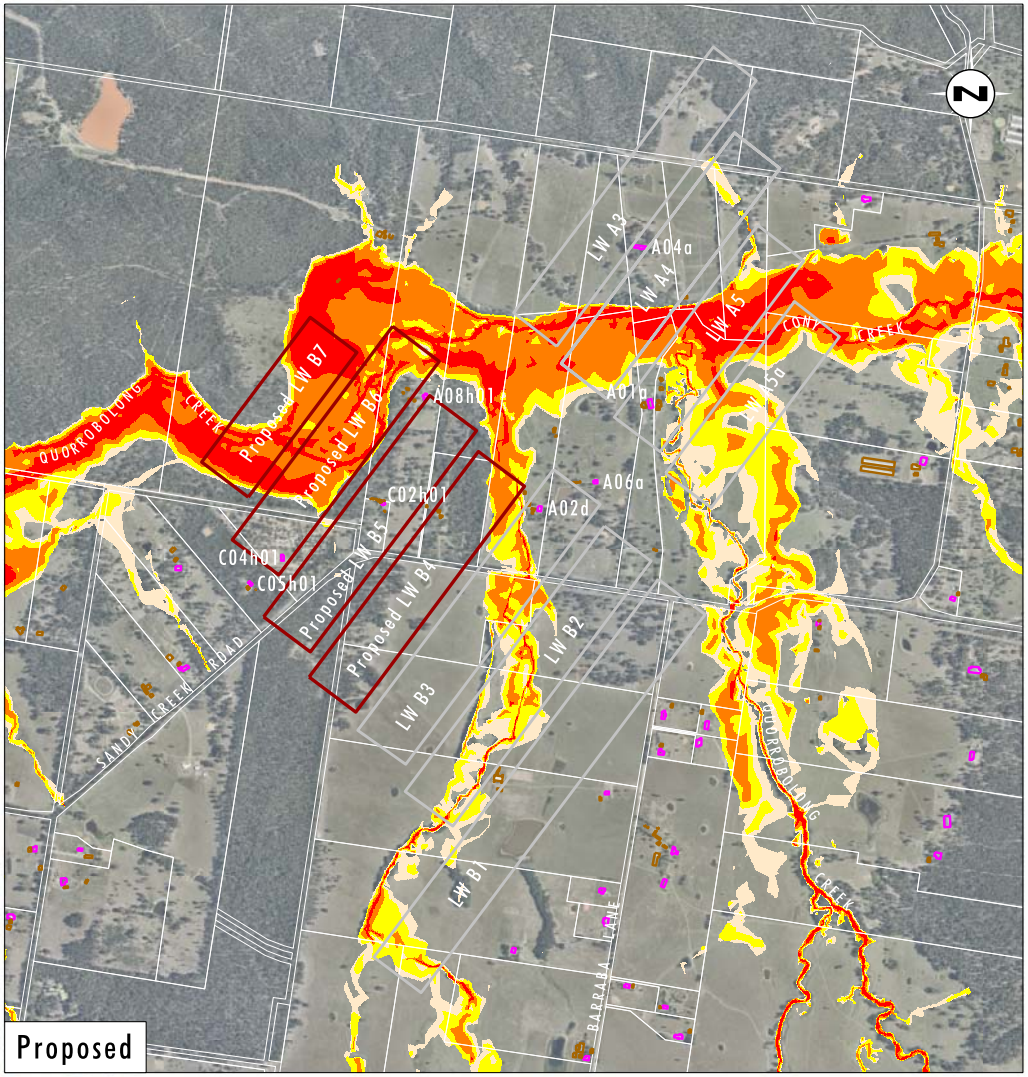


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2017), MSEC (2017)

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

File Name (A4): R01/3900_091.dgn
20170515 14.20

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.

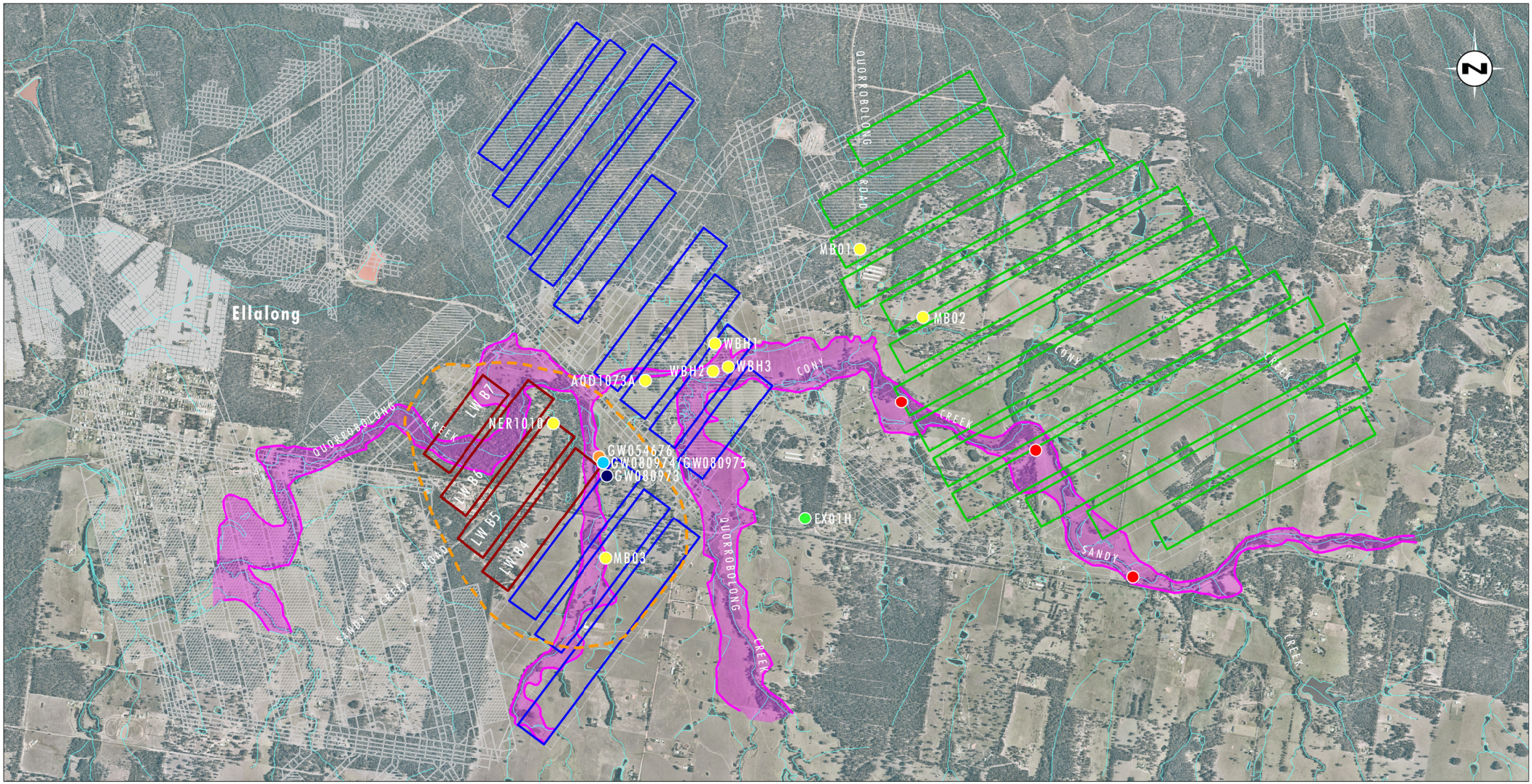


Image Source: Nearmap (Jan 2017)
Data Source: Austar Coal Mine (2015)

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**.

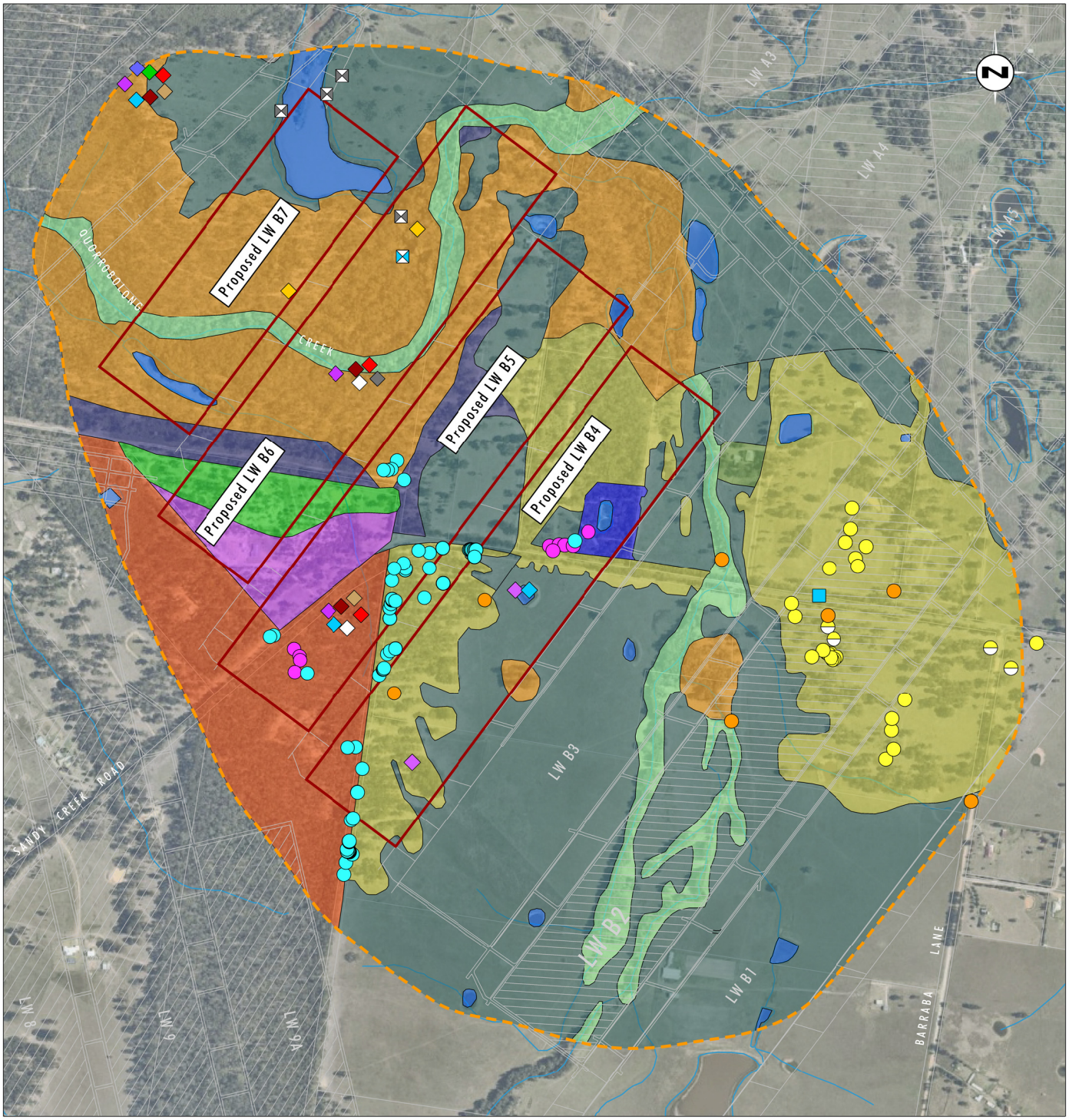


Image Source: Nearmap (2017)
Data Source: Austar Coal Mine (2016)
Note: PR - Probable, SG - Species Group, D - Definite

0 200 400 600m
1:12 000

Legend

- Proposed LWB4-B7 Longwall Panels
- LWB4-B7 Modification Area
- Completed Underground Workings
- 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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20170515 14.50

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.

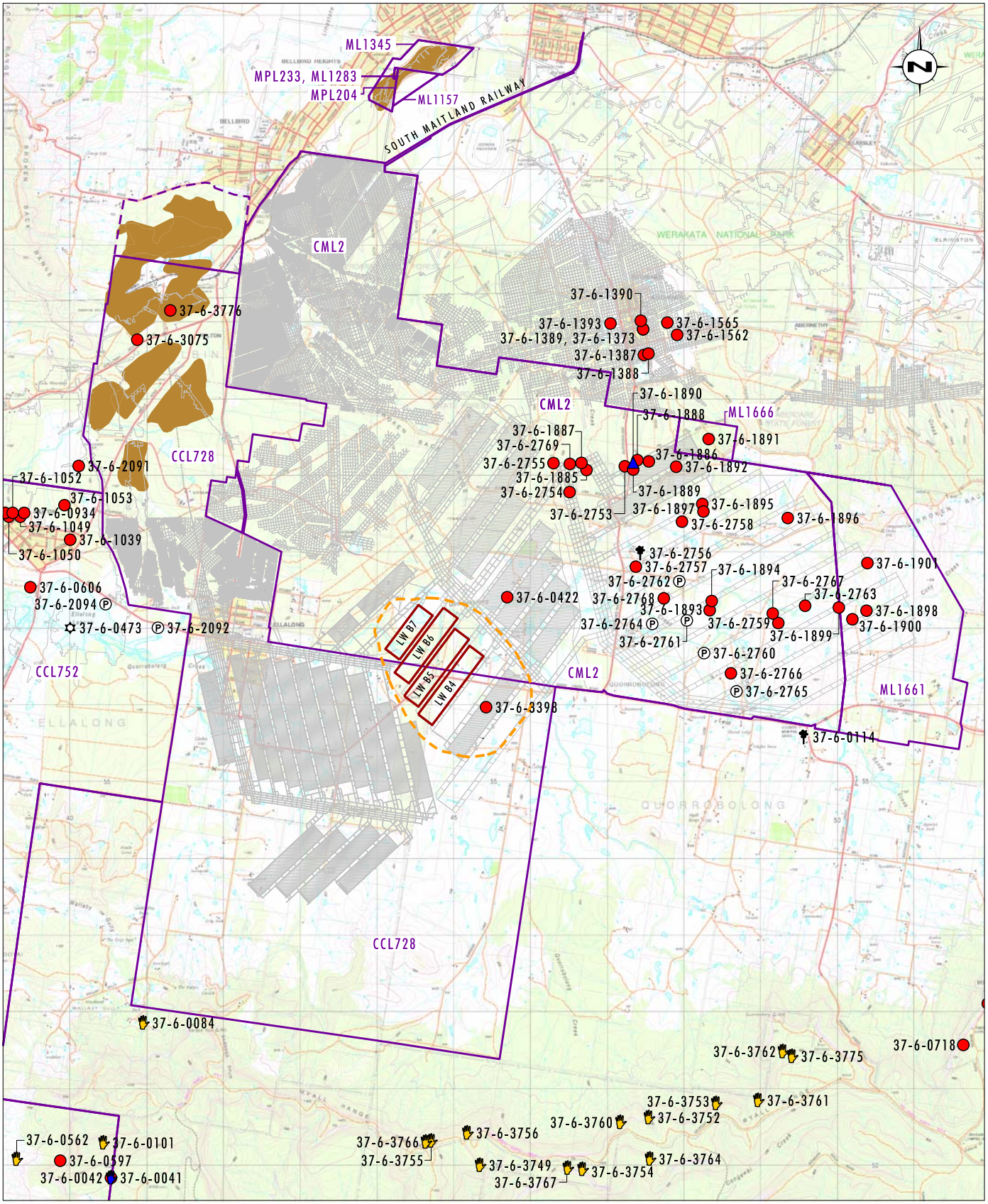

Image Source: LPI NSW (2009)
Data Source: Austar Coal Mine (2016), AHIMS (2017)

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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.