



WATER MANAGEMENT PLAN – LWB1-B7

For LWB1-B3 Extraction Plan and
LWB4-B7 Extraction Plan

February 2019

Disclaimer

This document has been prepared for the sole use of the authorised recipient and this document may not be used, copied or reproduced in whole or part for any purpose other than that for which it was supplied by Umwelt (Australia) Pty Ltd (Umwelt). No other party should rely on this document without the prior written consent of Umwelt.

Umwelt undertakes no duty, nor accepts any responsibility, to any third party who may rely upon or use this document. Umwelt assumes no liability to a third party for any inaccuracies in or omissions to that information. Where this document indicates that information has been provided by third parties, Umwelt has made no independent verification of this information except as expressly stated.

©Umwelt (Australia) Pty Ltd

Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
V1	G Allan	1/08/2017	B Crossley	1/08/2017
V2	G Allan	14/09/2017	G Allan	14/09/2017
V3*	G Mounser	01/02/2019	G Allan	04/02/2019

* Updated to include shortened finishing end of LWB4. No revision to flood modelling.

Table of Contents

1.0	Introduction	1
1.1	Background	1
1.2	Purpose and Scope	1
1.3	Environmental Context	1
1.4	Plan Structure	4
2.0	Performance Objectives	5
2.1	Licences	5
2.2	Performance Objectives	6
3.0	Description of Environmental Values	8
3.1	Land Use and Topography	8
3.2	Geology and Soils	8
3.3	Water Resources	9
3.3.1	Surface Water	9
3.3.2	Groundwater	9
4.0	Predicted Impacts to Water Resources	13
5.0	Monitoring	20
5.1	Surface Water Monitoring	20
5.2	Groundwater Monitoring	20
5.3	Riparian and Groundwater Dependent Ecosystem Monitoring	23
5.4	Subsidence Monitoring	23
5.5	Summary	23
6.0	Trigger Action Response Plan	24
7.0	Roles and Responsibilities	29
8.0	Reporting	30
8.1	Incident Reporting	30
8.2	Annual and Regular Reporting	30
9.0	References	31

Figures

Figure 1.1	LWB1-B7 Water Management Plan Area	2
Figure 1.2	Catchment Context	3
Figure 3.1	Estimated Extent of Alluvium and Groundwater Monitoring and Bore Locations	11
Figure 4.1	Change in Maximum Modelled Flood Depth for 1% AEP Storm Event with LWB4-B7	15
Figure 4.2	Change in Maximum Modelled Flow Velocities for 1% AEP Storm Event with LWB4-B7	16
Figure 4.3	Change in Remnant Ponding with LWB4-B7	17
Figure 4.4	Change in Maximum Flood Hazard Categories for 1% AEP Storm Event with LWB4-B7	18
Figure 5.1	Existing and Proposed Surface Water and Groundwater Monitoring Locations	22

Tables

Table 2.1	Licence Summary	6
Table 3.1	Summary of Baseline Surface Water Quality Monitoring Data in Quorrobolong Creek and Cony Creek (SWQ1, SWQ2, SWQ3, SWC1)	9
Table 3.2	Summary of Existing Groundwater Monitoring Data (Dundon 2017)	12
Table 4.1	Summary of Potential Impacts to Water Resources of Mining LWB1-B7	13
Table 5.1	Existing Monitoring Program for the LWB1-B7 WMP Area	23
Table 6.1	WMP Trigger Action Response Plan	25
Table 7.1	Roles and Responsibilities	29

1.0 Introduction

1.1 Background

Austar Coal Mine Pty Ltd (Austar), a subsidiary of Yancoal Australia Limited (Yancoal) owns the Austar Coal Mine, an underground coal mine located approximately 10 kilometres (km) south of Cessnock in the Lower Hunter Valley in New South Wales (NSW) (refer to **Figure 1.1**). The Austar Coal Mine incorporates the former Ellalong, Southland and Bellbird South Collieries and includes coal extraction, handling, processing and rail and road transport facilities.

Extensive longwall mining has been undertaken within the Austar Coal Mine in accordance with a number of approvals. Austar is mining in the Bellbird South mining area in accordance with development consent DA 29/95 (as modified), the LWB1-B3 Extraction Plan, and the LWB4-B7 Extraction Plan.

This Water Management Plan – LWB1-B7 has been prepared as a component plan of the LWB4-B7 Extraction Plan and the LWB1-B3 Extraction Plan. Revision 3 incorporates changes resulting from the shortening of LWB4 by 279 metres. No revision to flood modelling was undertaken during the impact assessment to shorten LWB4, and therefore the results of the flood modelling have not been updated in this revision of the WMP (refer **Section 4.0**).

1.2 Purpose and Scope

The purpose of this Water Management Plan (WMP) is to detail the management strategies, controls and monitoring programs to be implemented for the management of potential impacts to surface water and groundwater arising from the extraction of Longwalls (LW) B1-B7 (refer to **Figure 1.1**). This WMP applies to the LWB1-B3 Extraction Plan Area and the LWB4-B7 Extraction Plan Area (the LWB1-B7 WMP Area) shown on **Figure 1.1**, this being the land within the predicted 20 millimetre (mm) subsidence contour for LWB1-B7. This WMP is a requirement of the conditions of development consent for extraction from Longwalls B1-B3 and Longwalls B4-B7.

1.3 Environmental Context

The LWB1-B7 WMP Area is located within the Quorrobolong Creek catchment area (refer to **Figure 1.2**). Quorrobolong Creek drains in a westerly direction through the north of LWB1-B7 WMP Area. An unnamed tributary of Quorrobolong Creek that includes a number of secondary drainage channels drains in a northerly direction through the LWB1-B7 WMP Area. A large farm dam water body is located to the north of the main channel of Quorrobolong Creek above LWB7. 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. This drainage line acts as an overland flow path for Quorrobolong Creek during high out of bank flows. Quorrobolong Creek, its unnamed tributary and the 1st order drainage line are ephemeral watercourses with flows only occurring as a result of prolonged or high rainfall periods.

The dominant land use within and surrounding the LWB1-B7 WMP Area is grazing and there are several private rural dwellings within the LWB1-B7 WMP Area. There are a small number of groundwater monitoring bores located within the LWB1-B7 WMP Area, operated by Austar Coal Mine and DPI Water. No private bores currently target the groundwater resources within the LWB1-B7 WMP Area. The LWB1-B7 WMP Area underlies Sandy Creek Road and a small section of Barbara Lane. The topography of the land is generally characterised by low undulating hills and creek flats, with no steep slopes or cliffs. Refer to **Section 3.0** for further details regarding the catchment context.

Figure 1.2 shows the watercourses and catchment boundaries within the LWB1-B7 WMP Area.

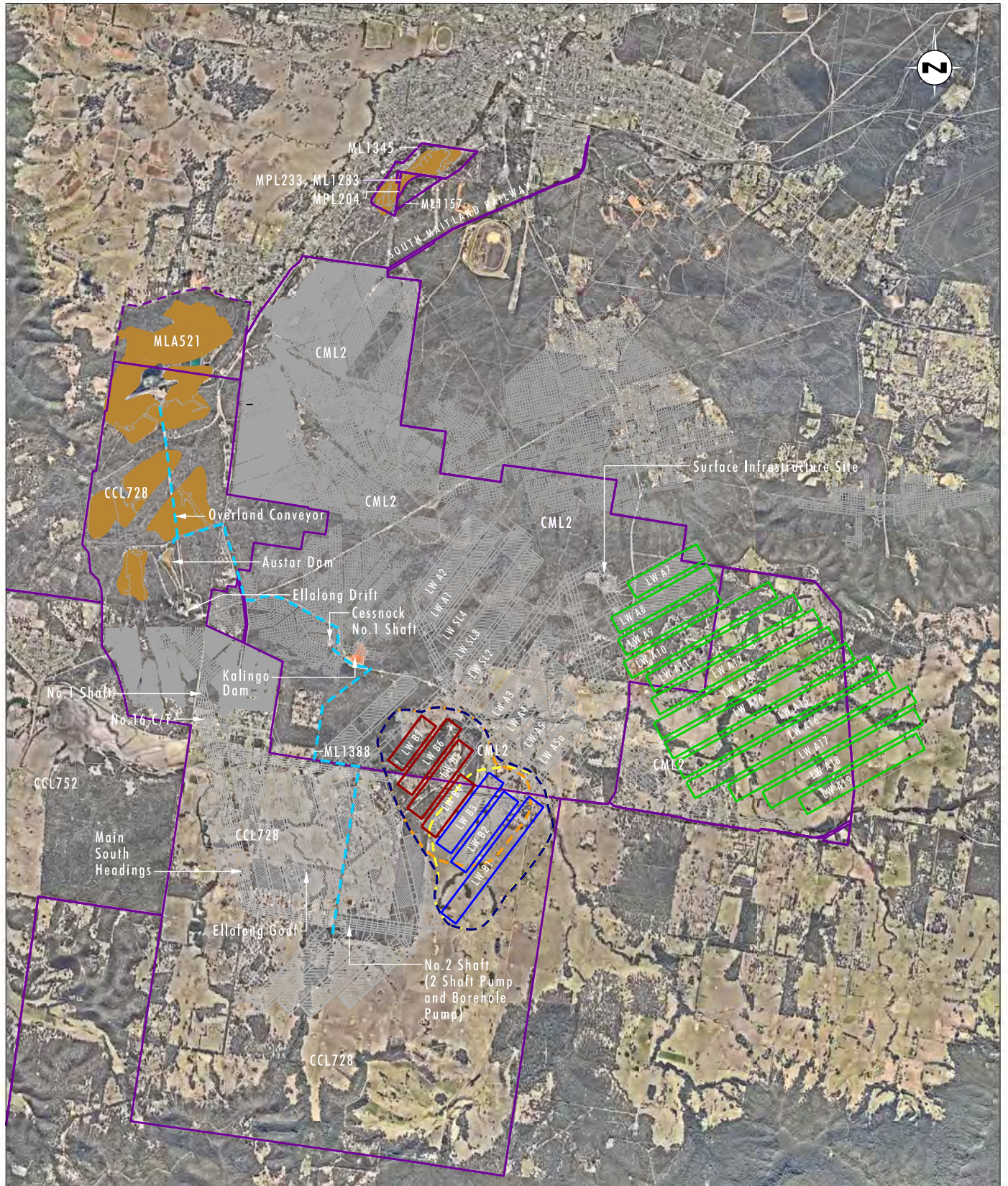


Image Source: Nearmap (2018)
Data Source: Austar Coal Mine (2018)

0 1 2 3km
1:70 000

Legend

- LWB1-B7 LWB1-B7 Water Management Plan Area
- LWB1-B3 LWB1-B3 Extraction Plan Longwall Panels
- LWB1-B3 LWB1-B3 Extraction Plan Area
- LWB4-B7 LWB4-B7 Extraction Plan Longwall Panels
- LWB4-B7 LWB4-B7 Extraction Plan Area
- Stage 3 Stage 3 Longwall Panels (PA08_0111)
- Approved Reject Approved Reject Emplacement Area
- Completed Underground Completed Underground Workings
- Mining Lease Mining Lease Boundary
- Austar owned CHPP Land Austar owned CHPP Land
- Water Pipeline Water Pipeline

FIGURE 1.1

LWB1-B7 Water Management Plan Area

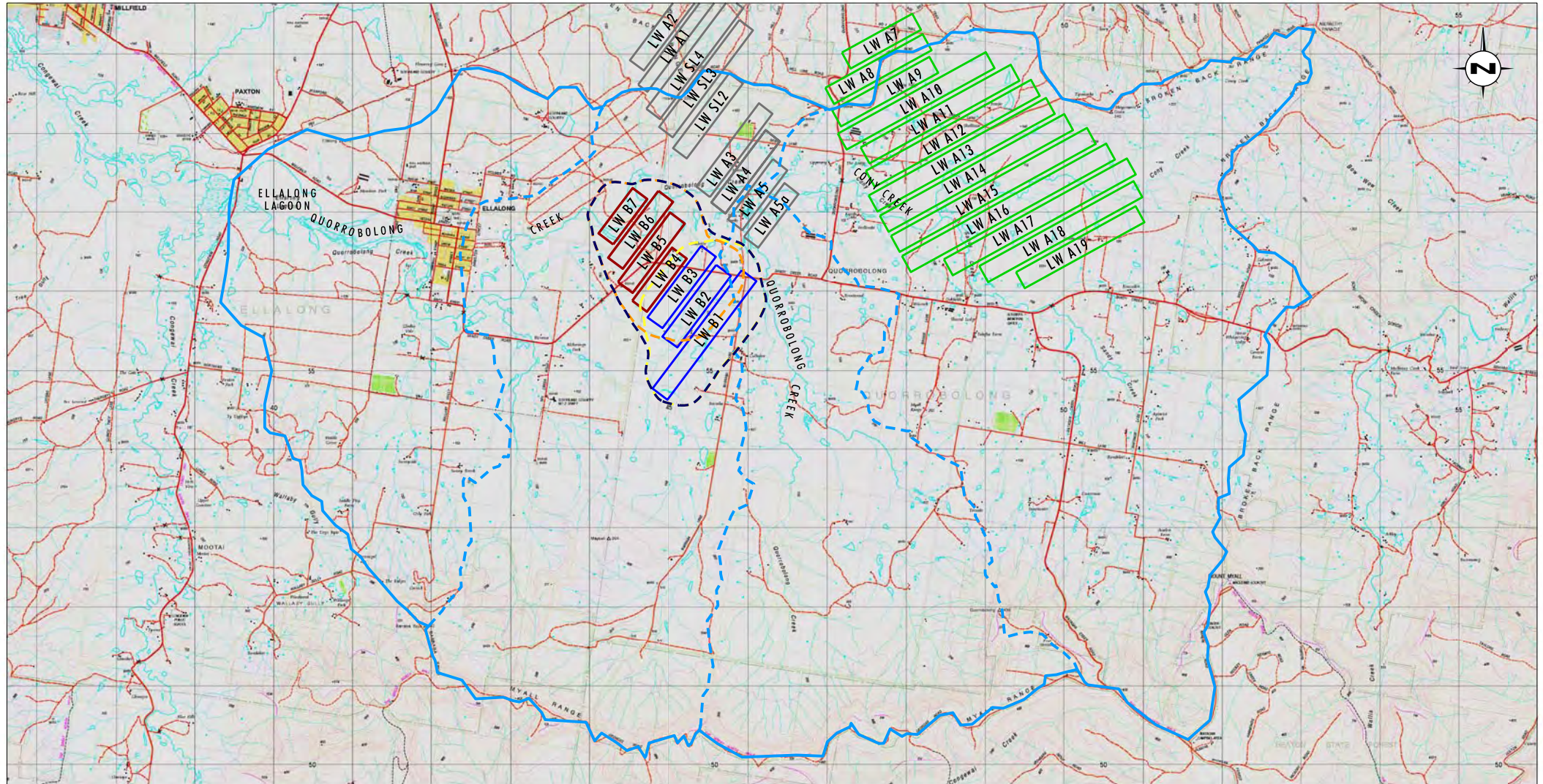


Image Source: LPI NSW 1:25 000 Topographic Map
Data Source: Austar Coal Mine

0 1 2 3 km
1:70 000

Legend

- LWB1-B7 Water Management Plan Area
- LWB1-B3 Extraction Plan Longwall Panels
- LWB1-B3 Extraction Plan Area
- LWB4-B7 Extraction Plan Longwall Panels
- LWB4-B7 Extraction Plan Area
- Bellbird South Stage 1, Stage 2 and Southland Longwall Panels (DA 29/95)
- Stage 3 Longwall Panels (PA08_0111)
- Quorrobolong Creek Catchment Boundary
- Quorrobolong Creek Sub-Catchment Boundary

File Name (A4): R12/3900_137.dgn
20190131 13.20

FIGURE 1.2

Catchment Context

1.4 Plan Structure

The WMP is structured as follows:

- **Section 1** provides an introduction to the WMP.
- **Section 2** describes the water related performance objectives relevant to the WMP.
- **Section 3** describes the existing environmental values within the LWB1-B7 WMP Area as they relate to surface water and groundwater.
- **Section 4** summarises the predicted impacts and environmental consequences associated with extraction from LWB1-B7 for surface water and groundwater.
- **Section 5** describes the surface and groundwater monitoring measures that will be implemented within the LWB1-B7 WMP Area.
- **Section 6** provides a Trigger Action Response Plan (TARP) to manage unpredicted impacts and their consequences.
- **Section 7** outlines the roles and responsibilities for the WMP.
- **Section 8** outlines the reporting requirements of the WMP.

In accordance with Condition 3A of Schedule 3 of DA29/95, this WMP has been prepared by Susan Shield of Umwelt (Australia) Pty Limited/Engeny, and reviewed by Peter Dundon of Dundon Consulting Pty Ltd. These specialists were endorsed by the Director, Resource Assessments of the Department of Planning and Environment (DPE) on 11 August 2017, and were the same specialists endorsed to prepare the Water Management Plan for LWB1-LWB3 in 2016. Both specialists also prepared/reviewed the relevant specialist studies for the LWB4-B7 Modification Environmental Assessment. Changes associated with Revision 3 were prepared by Glenn Mounser of Umwelt (Australia) Pty Limited.

Consultation regarding the proposed management and monitoring measures presented in this WMP has been undertaken with the Office of Environment and Heritage (OEH) and Department of Industry - Water (DoI-Water) during the DPE planning assessment process.

2.0 Performance Objectives

This WMP has been prepared to specifically address Condition 3A (e) of Schedule 3 of DA 29/95, as modified, which states:

3A. The Applicant must prepare an Extraction Plan for all second workings in the active mining areas to the satisfaction of the Secretary. This plan must:

(e) include a:

- *Water Management Plan, which has been prepared in consultation with OEH and DPI-Water, to monitor and manage the environmental consequences of second workings on water resources (including drainage, flooding, ponding and alluvial aquifers).*

Note: The Water Management Plan must be integrated with all relevant aspects of the Site Water Management Plan required under condition 6 of Schedule 3.

In addition, the WMP has been prepared to address relevant items of Condition 28 of Schedule 3 of DA 29/95:

28. The Applicant must rehabilitate the site to the satisfaction of DRG. This rehabilitation must be generally consistent with the proposed rehabilitation strategy described in the documents listed in condition 2 of Schedule 2, and comply with the objectives in Table 6.

Table 6: Rehabilitation Objectives (partially reproduced):

Feature	Objective
<i>All watercourses subject to mine-water discharges and/or subsidence impacts from the development</i>	• <i>Hydraulically and geomorphically stable</i> • <i>Aquatic ecology and riparian vegetation that is the same or better than prior to mining</i>
<i>Water quality</i>	• <i>Surface water retained on site is fit for the intended post mining land use(s)</i>

2.1 Licences

The LWB1-B7 WMP Area is located within the Congewai Creek Management Zone of the Upper Wollombi Brook Water Source within the Hunter Unregulated and Alluvial Water Sources Water Sharing Plan (WSP) area. The WSP regulates maximum water extractions and allocations from surface flows and alluvial aquifers. By complying with the requirements of the WSP, water take will be within the sustainable yield for the water system as determined by the NSW Government. This in turn provides for sustainable environmental flows within the water systems.

Porous rock groundwater sources are regulated under the WSP for the North Coast Fractured and Porous Rock Groundwater Sources (which commenced on 1 July 2016).

The alluvial aquifer associated with Quorrobolong Creek and its tributaries within the LWB1-B7 WMP 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 as they do not meet the relevant water quality and yield requirements for 'highly productive' groundwater sources. The lack of registered bores within the area also indicates that the alluvial aquifer in the vicinity of the LWB1-B7 WMP Area has limited use as a water supply for stock, domestic or other consumptive purpose. An assessment against the NSW Aquifer Interference Policy minimal impact considerations for less productive groundwater sources was undertaken as part of the respective Environmental Assessments for panels LWB1-B3 and LWB4-B7 (Umwelt 2015; Umwelt 2017) and found that:

- the Project will not impact any high priority groundwater dependent ecosystem or high priority culturally significant site listed in a WSP
- the potential impact of the Project on any water supply work is considered negligible
- there are no highly connected surface water sources or water sources that represent a 'reliable water supply' within proximity to the Project
- the Project is not expected to further limit potential beneficial uses of the alluvial or porous rock groundwater supply.

On this basis, it is considered that the secondary extraction of LWB1-B7 adequately satisfies the minimal impact considerations for less productive groundwater sources defined by the NSW Aquifer Interference Policy.

Austar Coal Mine holds Water Access Licence 19181 with 10 shares in the Upper Wollombi Brook Water Source - Congewai Creek Management Zone. Should impacts from subsidence cause passive take of surface or alluvial water, this must be accounted for via an appropriate access licence, such as WAL 19181. The low potential for impacts to surface water or alluvial water is described in **Table 4.1**. Notwithstanding there is sufficient unit shares available within this water source should additional licences be required.

Austar Coal Mine's current water take from the porous rock groundwater source is authorised under Water Access Licence 41504 with 770 units in the Sydney Basin-North Coast Groundwater Source – North Coast Fractured and Porous Rock Groundwater Sources. **Table 2.1** shows Austar Coal Mine's estimated take, with LWB1-B7, as defined by the LWB4-B7 Modification Environmental Assessment (Umwelt 2017). Notwithstanding there is sufficient unit shares available within this water source should additional licences be required.

Table 2.1 Licence Summary

WSP	Water Source	Predicted Take	Licences Held
Hunter Unregulated and Alluvial Water Sources	Upper Wollombi Water Source - Congewai Creek Management Zone	0	10 shares
North Coast Fractured and Porous Rock Groundwater Sources	Sydney Basin – North Coast Groundwater Source	730 ML	770 ML

2.2 Performance Objectives

Performance objectives in relation to impacts on water resources within the LWB1-B7 WMP Area are defined by the conditions of consent of DA29/95 and relevant commitments of the LWB1-B3 Modification Environmental Assessment (Umwelt 2015) and the LWB4-B7 Modification Environmental Assessment (Umwelt 2017). These performance objectives are presented in **Table 2.2**.

Table 2.2 Performance Objectives

Requirement	Performance Measure	Performance Indicator
DA29/95 Sch3 condition 3	Preparation of a WMP and integration of plan with all relevant aspects of the Site Water Management Plan	WMP includes actions to manage potential environmental consequences of second workings on water resources
		WMP is prepared in consultation with OEH and DPI-Water
		WMP is integrated with all relevant aspects of the Austar Site Water Management Plan
		Plan is approved by the Secretary of the DPE

Requirement	Performance Measure	Performance Indicator
DA29/95 Sch3 condition 28	Watercourses subject to mine-water discharges, subsidence impacts or any required rehabilitation activities remain hydraulically and geomorphologically stable	Rehabilitation management strategies consider pre-mining landuse and surrounding landform (addressed in Extraction Plan Land Management Plan and Biodiversity Management Plan) Monitoring indicates that the erosive risk to creeklines within the LWB1-B7 WMP Area is consistent with the pre-mining erosive risks following mining and any required rehabilitation activities Monitoring indicates no significant impact to channel stability as a result of mining and any required rehabilitation activities
	Condition of watercourses and associated riparian communities is consistent with or better than pre-mining condition	Monitoring indicates no significant impact to the channel condition of Quorrobolong Creek as a result of mining and any required rehabilitation activities
		Monitoring undertaken in accordance with LWB1-B7 Extraction Plan Biodiversity Management Plan indicates no significant adverse impact on threatened riparian communities as a result of mining and any required rehabilitation activities
	Surface water quality is suitable for post mining land use(s)	Monitoring undertaken in accordance with the Austar SWMP and this WMP indicates no significant impact to water quality as a result of mining and any required remediation activities
EA – Management Measure 7.2.2	Subsidence impacts on drainage lines are effectively remediated (where access is granted) such that there is no significant adverse impact on downstream water users and environmental flows	Monitoring indicates no significant adverse impact to bore supply or yield at privately owned bore
		Monitoring indicates no significant adverse impact to the volume of privately owned farm dams
		Monitoring of groundwater levels within the unnamed tributary of Quorrobolong Creek indicates no significant adverse impact on groundwater levels or quality as a result of mining

3.0 Description of Environmental Values

3.1 Land Use and Topography

The LWB1-B7 WMP Area is located in Quorrobolong; approximately 2 km east of the township of Ellalong in the Lower Hunter Valley of NSW.

The LWB1-B7 WMP Area is located beneath a mix of Austar owned land, privately owned rural land, and Crown landholdings. The primary land use within the LWB4-B7 Modification Area is rural and agricultural grazing including cattle and goat grazing on private landholdings. The LWB1-B7 WMP Area is located beneath Sandy Creek Road and Barraba Lane, both of which are local Council roads.

Land use surrounding the LWB1-B7 WMP Area is primarily rural and is dominated by cleared grazing land. Vegetated land to the northwest is owned by Austar and utilised for a variety of surface infrastructure associated with the mine. The villages of Kitchener and Pelton are located within four kilometres northeast and northwest respectively (refer to **Figure 1.1**). The Watagans National Park is located approximately four kilometres south of the LWB1-B7 WMP Area and the Werakata State Conservation Area is located approximately one kilometre to the north.

The topography of the LWB1-B7 WMP Area is generally characterised by low undulating hills and creek flats associated with Quorrobolong Creek and its unnamed tributaries. Elevations within the LWB1-B7 WMP Area range from approximately 115 mAHD to 160 mAHD.

3.2 Geology and Soils

One soil landscape type is found within the LWB1-B7 WMP Area, being the Quorrobolong soil landscape (Kovac and Lawrie 1991). The main soils within this landscape are prairie soils which form in alluvium and occur in drainage depressions and on lower slopes. They are generally poorly drained, have moderate permeability and the upper horizon has moderate erodibility (Kovac and Lawrie 1991). The soils are moderately fertile and the main land use is generally grazing on unimproved pasture.

The Austar Coal Mine is located in the Newcastle Coalfield and targets coal extraction from the Greta Coal Seam within the Permian Age Greta Coal Measures. The depth of cover directly above the proposed longwalls ranges from approximately 400 m in the northwest above LWB7 to approximately 555 m in the north-eastern corner of LWB1. The Greta Seam is the main economic coal seam in the Greta Coal Measures. The Greta Coal Measures are overlain by the Branxton Formation, which is comprised of a substantial thickness of sedimentary rocks and is up to 1300 m thick in some locations (Geoscience Australia, 1988).

3.3 Water Resources

3.3.1 Surface Water

The LWB1-B7 WMP Area is situated within the Quorrobolong Creek Catchment, a sub-catchment to the larger Wollombi Brook catchment and ultimately the Hunter River catchment. Quorrobolong Creek forms part of the Congewai Creek Management Zone of the Upper Wollombi Water Source within the Hunter Unregulated and Alluvial Water Sources Water Sharing Plan area. Quorrobolong Creek is located in the east and north of the LWB1-B7 WMP Area (refer to **Figure 1.1**) and flows north from the Myall Range then west into Ellalong Lagoon, approximately 3.5 km to the west of the LWB1-B7 WMP Area. An un-named tributary of Quorrobolong Creek drains in a northerly direction through the LWB1-B7 WMP Area above LWB1-B4 converging with Quorrobolong Creek upstream of LWB5 (refer to **Figure 1.1**). Both Quorrobolong Creek and its unnamed tributary are ephemeral creeks with flows only occurring as a result of prolonged or high rainfall periods. Quorrobolong Creek has an average gradient of less than 1 mm/m while the unnamed tributary has an average gradient of 5 mm/m.

A 1st order drainage line also traverses above LWB6 and LWB7 and includes an ephemeral ponded area adjacent to Quorrobolong Creek above LWB7. This drainage line acts as an overland flow path for Quorrobolong Creek during high out of bank flows. A number of farm dams are located across the LWB1-B7 WMP Area, including a large farm dam waterbody located on Austar owned land in the north of the LWB1-B7 WMP Area that drains into Quorrobolong Creek.

Monitoring has not detected any scouring or erosion issues observed within or surrounding watercourses associated with previous LWB1-B3, Stage 2 and Stage 3 mining.

Surface water quality monitoring is undertaken in Quorrobolong Creek upstream and downstream of the LWB1-B7 WMP Area. The existing surface water monitoring network is shown on **Figure 5.1**. A summary of baseline surface water monitoring data collected from the existing monitoring network within the vicinity of the LWB1-B7 WMP Area is provided in **Table 3.1**.

Table 3.1 Summary of Baseline Surface Water Quality Monitoring Data in Quorrobolong Creek and Cony Creek (SWQ1, SWQ2, SWQ3, SWC1)

Parameter	Data Collection Period	Summary of Quality	Comments
pH	2010 - 2016	6.42 – 8.03	Natural fluctuations in water quality observed over monitoring period, with sample points displaying similar trends over time. No observable impact on surface water quality from mining identified.
EC	2010 - 2016	63 – 3810 μ S/cm	
TSS	2010 - 2016	<1 – 599 mg/L	
Iron (Fe)	2011 - 2016	0.07 – 21.7 mg/L	

3.3.2 Groundwater

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 the 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 LWB1-B7 WMP Area is part of the Congewai Creek Management Zone of the Upper Wollombi Brook Water Source and is regulated by the *Water Management Act 2000* under the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*. The non-alluvial groundwater is regulated under the North Coast Fractured and Porous Rock WSP 2016.

Previous monitoring within the LWB1-B3, Stage 2 and Stage 3 areas beneath private land holdings, Quorrobolong Creek and the tributaries of Quorrobolong Creek has not identified any adverse impacts on groundwater as a result of underground longwall mining.

The existing groundwater monitoring network is shown on **Figure 3.1**. A summary of baseline groundwater monitoring data collected from the existing groundwater monitoring network within the vicinity of the LWB1-B7 WMP Area is provided in **Table 3.2**.

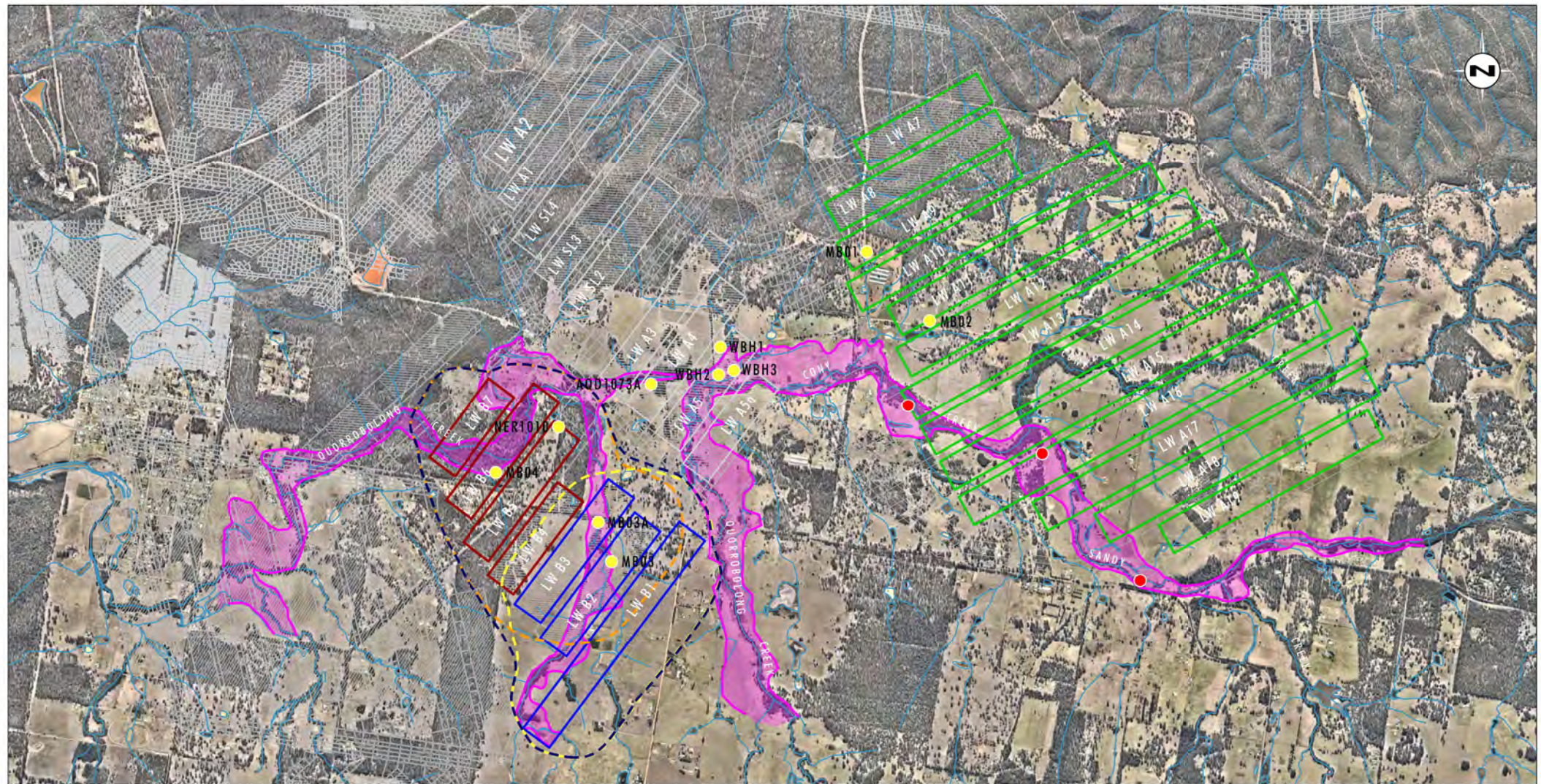


Image Source: Nearmap (2018)
Data Source: Austar Coal Mine (2018)

0 0.5 1.0 2.0 km
1:40 000

Legend

- LWB1-B7 Water Management Plan Area
- LWB4-B7 Extraction Plan Longwall Panels
- LWB4-B7 Extraction Plan Area
- LWB1-B3 Extraction Plan Longwall Panels
- LWB1-B3 Extraction Plan Area
- Stage 3 Longwall Panels (PA08_0111)
- Completed Underground Workings
- Estimated Alluvial Area
- Existing Austar Monitoring Location
- Approved Future Stage 3 Groundwater Monitoring Site

File Name (A4): R12/3900_138.dgn
20190204 11.45

FIGURE 3.1

Estimated Extent of Alluvium and
Groundwater Monitoring
and Bore Locations

Table 3.2 Summary of Existing Groundwater Monitoring Data (Dundon 2017)

Bore ID	Data Collection Period	Summary of Levels	Summary of Quality	Comments
GW080974	2010 - 2014	0.5-2.3 mbgl	Conductivity 33-2,632 $\mu\text{S}/\text{cm}$	Variable level and quality
AQD1073	Jul 2010 – Dec 2016 (quality) Aug 2011 – Dec 2016 (levels)	0-4.7 mbgl	Conductivity 75-8,491 $\mu\text{S}/\text{cm}$ pH 5.8-10.5	Variable level and quality
WBH1	Jul 2010 – Dec 2016 (quality) Aug 2011 – Dec 2016 (levels)	5.7-7.4 mbgl	Conductivity 63-4,430 $\mu\text{S}/\text{cm}$ pH 6.2-9.0	Variable level and quality
WBH2	Jul 2010 – Dec 2016 (quality) Aug 2011 – Dec 2016 (levels)	0-2.3 mbgl	Conductivity 282-3,567 $\mu\text{S}/\text{cm}$ pH 6.5-8.9	Variable level and quality
WBH3	Jul 2010 – Dec 2016 (quality) Aug 2011 – Dec 2016 (levels)	0-2.3 mbgl	Conductivity 33-3,862 $\mu\text{S}/\text{cm}$ pH 6.6-8.9	Variable level and quality
MB03	Sept 2016 – Dec 2016	1.4 – 1.7	Conductivity 4,293-4,629 $\mu\text{S}/\text{cm}$ pH 6.4-7.0	Limited monitoring period indicates high salinity

Note – Both water level and water quality in all bores varies in response to episodic rainfall recharge.

4.0 Predicted Impacts to Water Resources

Potential changes in the ground surface resulting from subsidence associated with the approved extraction have been assessed by Mine Subsidence Engineering Consultants (MSEC 2017). The subsidence assessment findings conclude that due to the depth of mining (minimum 400 m), the small magnitude of predicted ground curvatures and strains and the absence of any steep slopes or cliffs within the LWB1-B7 WMP Area, the potential for surface cracking is low.

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 m, with discontinuous fracturing above LWB1-B7 predicted to extend to between 235 to 355 m above the seam. With depths of cover above the seam of 400 to 555 m, 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 extraction of LWB1-B7.

Based on worst case predictions, it is possible that discontinuous fracturing may extend marginally into the shallow water bearing zones within the uppermost 100 m of the Branxton Formation where the depth of cover is less than 455 m. 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.

A summary of the potential subsidence impacts and their likely environmental consequences on hydrological features within the LWB1-B7 WMP Area as stated in the LWB1-B3 Modification Environmental Assessment (Umwelt 2015) and LWB4-B7 Modification Environmental Assessment (Umwelt 2107) is provided in **Table 4.1** below.

Table 4.1 Summary of Potential Impacts to Water Resources of Mining LWB1-B7

Potential Subsidence Impact	Environmental Consequence	Likelihood of Environmental Consequence
Surface cracking	Erosion causes impacts to surface water quality from cracks	Unlikely
	Subsidence crack remediation causes surface water quality impact	Unlikely
	Loss of surface flows to the subsurface	Unlikely
	Loss of water from dams due to cracking	Unlikely
	Impacts to near surface groundwater within alluvium and shallow water-bearing zones	Unlikely
	Surface cracking increases connectivity between alluvium and underlying bedrock, causing groundwater to drain into bedrock	Unlikely
Landform changes by tilts and/or localised buckling of strata	Changes to hydraulic regime of Quorrobolong Creek and its unnamed tributary	Unlikely
	Erosion causes impacts to surface water quality	Unlikely
	Changes to flood response within LWB1-B7 WMP Area*	Minor temporary changes to depth, velocity and out of channel flooding likely (refer to Figure 4.1 and Figure 4.2)

Potential Subsidence Impact	Environmental Consequence	Likelihood of Environmental Consequence
	Increase of surface water ponding*	Some minor increases likely (refer to Figure 4.3)
	Increased scour/erosion in channel	Unlikely
	Flood hazard increased at dwellings and access roads*	Not predicted to occur (refer to Figure 4.4)
	Change in freeboard and storage capacity of farm dams	Very minor changes likely
	Impacts to groundwater levels within the alluvial aquifer or shallow water bearing zones of porous rock aquifer	Minor changes likely where subsidence troughs coincide with shallow alluvium
	Adverse impact on groundwater quality within alluvium or shallow water-bearing zones	Unlikely
	Adverse impact on groundwater quality or yield affecting other users	Unlikely
	Adverse impact on groundwater extraction infrastructure, including DPI Water monitoring bores within the LWB1-B7 WMP Area (refer to Figure 3.1)	Possible
	Increase in mine water inflows	Minor and temporary increase likely
	Adverse impact on groundwater levels in near-surface aquifer system adversely impacting groundwater dependent ecosystems	Unlikely
	Loss of near surface groundwater due to fracturing extending to the surface	Unlikely
Secondary impacts to hydrological values	Substantial loss of vegetation due to dieback	Unlikely
	Impacts to groundwater dependent ecosystems	Unlikely

* Note: No revision to flood modelling was undertaken during the impact assessment to shorten LWB4. Hence, the results of the flood modelling presented on Figures 4.1 to 4.4 remain unmodified from Revision 2 of this Water Management Plan. Refer to the discussion following Figure 4.4 on the likely impact to the flood modelling results from a 279 metre shortening of LWB4.

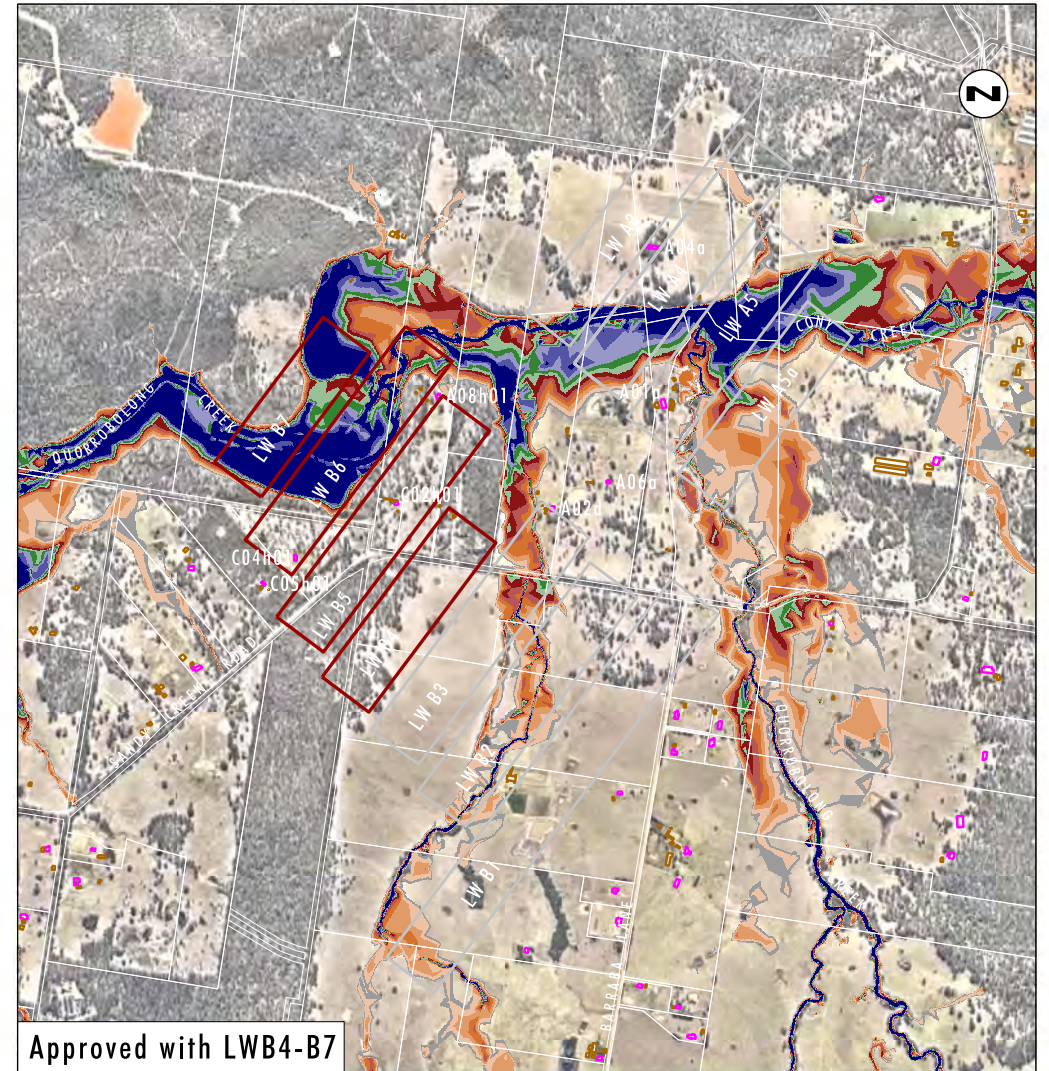
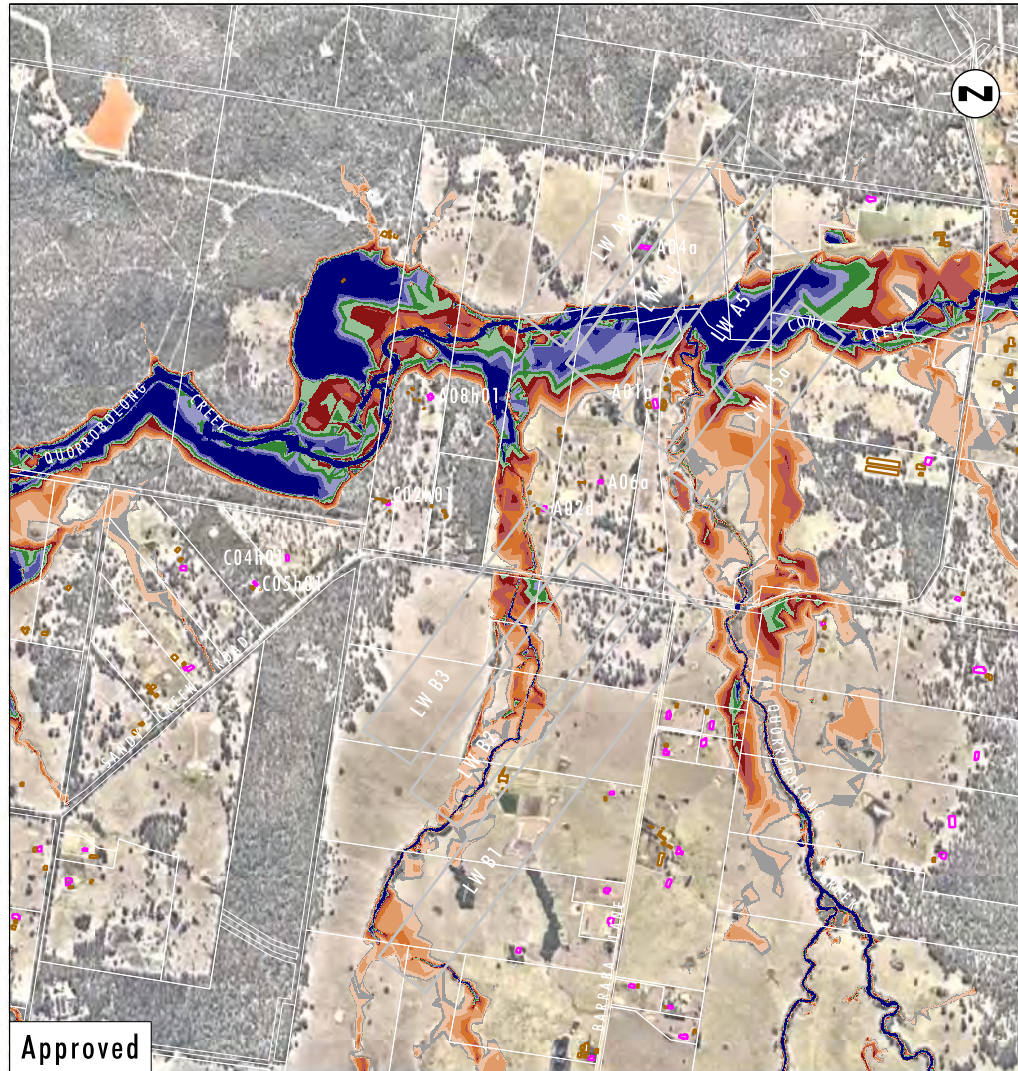


Image Source: Nearmap (2018) Data Source: Austar Coal Mine (2018), MSEC (2017)

Note: This figure incorporates changes resulting from the shortening of LWB4 by 279m. No revision to flood modelling was undertaken during the impact assessment to shorten LWB4, and therefore flood modelling has not been updated on this figure.

Legend

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

Water Depth (m)

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

0 0.5 1.0 1.5 km
1:30 000

FIGURE 4.1

Change in Maximum Modelled Flood Depth
for 1% AEP Storm Event with LWB4-B7

Change in Maximum Modelled Flow Velocities for 1% AEP Storm Event with LWB4-B7

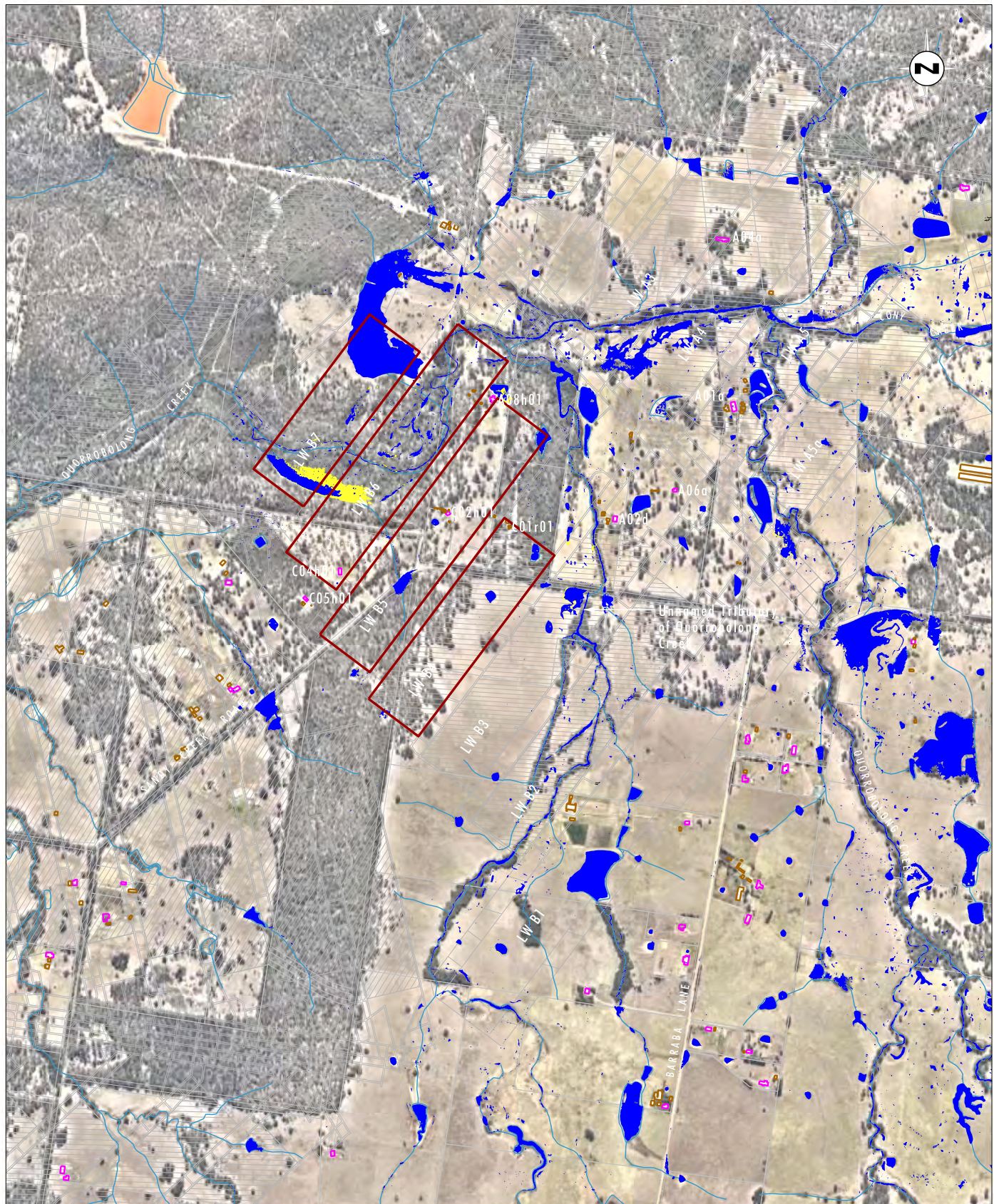


Image Source: Nearmap (2017) Data Source: Austar Coal Mine (2017)
 Note: This figure incorporates changes resulting from the shortening of LWB4 by 279m. No revision to flood modelling was undertaken during the impact assessment to shorten LWB4, and therefore flood modelling has not been updated on this figure.

Legend

- LWB4-B7 Extraction Plan Longwall Panels
- Completed Underground Workings
- Dwelling
- Other Structure
- Remnant Ponding after LWB1-B3 Extraction
- Remnant Ponding after LWB4-B7 Extraction

File Name (A4): R12/3900_141.dgn
 20180131 15.50

FIGURE 4.3

Change in Remnant Ponding with LWB4-B7

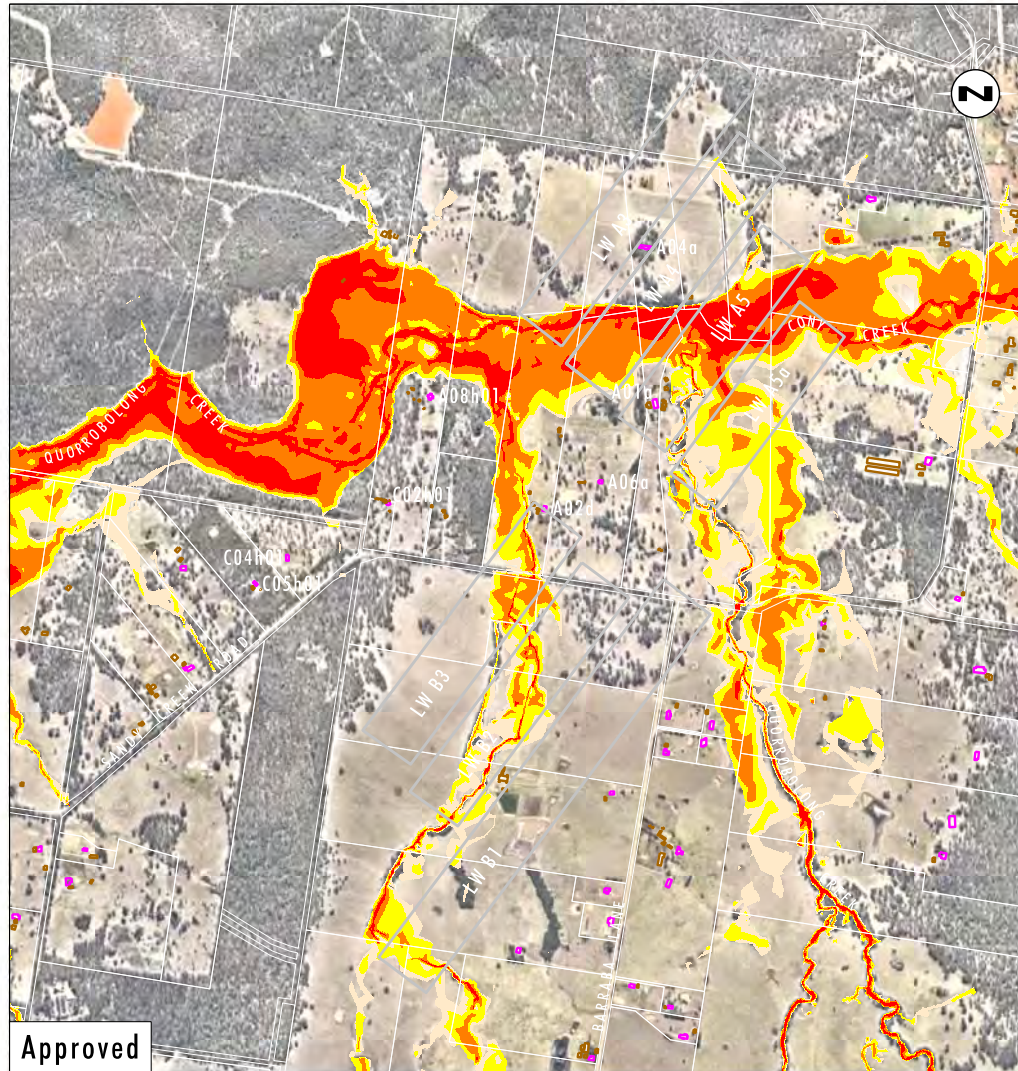


Image Source: Nearmap (2017) Data Source: Austar Coal Mine (2017)

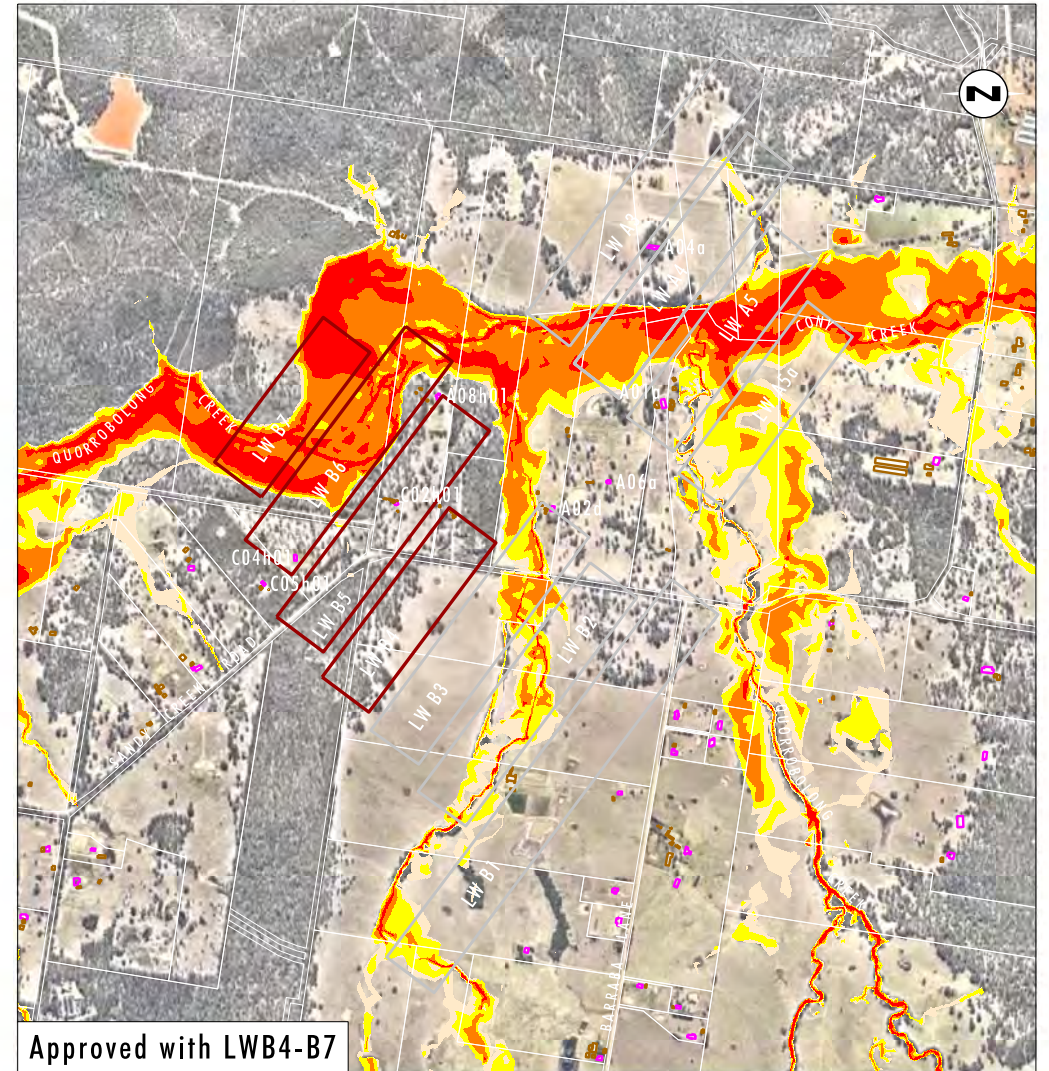
Note: This figure incorporates changes resulting from the shortening of LWB4 by 279m. No revision to flood modelling was undertaken during the impact assessment to shorten LWB4, and therefore flood modelling has not been updated on this figure.

Legend

- LWB4-B7 Extraction Plan 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



Approved with LWB4-B7

0 0.5 1.0 1.5 km
1:30 000

FIGURE 4.4

Change in Maximum Flood Hazard Category
for 1% AEP Storm Event with LWB4-B7

Shortening of LWB4 by 279 m will likely result in changes relative to the approved impacts for LWB1-LWB7, as follows:

- LWB4 will no longer directly undermine Drainage Line 1;
- Minor reduction in flood depths in Drainage Line 1 and minor increase in velocities;
- No change or minimal change to hazard categories and ponding impacts;
- Upstream and downstream impacts are likely to be limited to minor changes to flood depths and velocities; and
- Overall, the proposed change is not likely to result in significant increased environmental consequences relative to the approved impacts for LWB1-LWB7, and as such the flood modelling has not been updated at this time.

5.0 Monitoring

Austar currently implements a range of surface water and groundwater management and monitoring measures across the Austar Coal Mine, as outlined in the Austar Site Water Management Plan (SWMP) (Austar 2018). Results of monitoring are reviewed as they are received from their respective monitoring programs, with further review and analysis undertaken annually and reported in the Annual Review.

5.1 Surface Water Monitoring

Water quality samples are taken monthly within Quorrobolong Creek in accordance with the Austar SWMP. Locations are shown on **Figure 5.1**. The first sample location (SWQ1) is upstream of Austar's Stage 2 mining area, the second location (SWQ2) is within the LWB1-B7 WMP Area on the eastern boundary of Austar's land holding where Quorrobolong Creek enters Austar owned land. The third location is a downstream sample site (SWQ3) on Austar's southern boundary where the creek exits the site. These existing locations are considered sufficient to monitor impacts from the secondary extraction of LWB1-B7, as all the land area above and potentially impacted by the LWB1-B7 extraction are within or drain into Quorrobolong Creek between SWQ1 and SWQ3.

Water quality analysis includes the same parameters as those required for other surface water sampling sites as specified in EPL 416 i.e. iron, pH, total suspended solids and electrical conductivity. Flows in Quorrobolong Creek and bank stability are also visually assessed during monthly monitoring.

Austar will continue this program in order to monitor the impacts of extraction within longwall panels LWB1-B7 on Quorrobolong Creek and its unnamed tributary; an expanded monitoring program is not required for the LWB1-B7 WMP Area.

Impacts on privately-owned farm dams within the LWB1-B7 WMP Area will be monitored during and following undermining, where access is granted, to ensure they remain in a safe and serviceable condition, and identify any significant loss of volume associated with mining. Specific monitoring requirements will be established in consultation with the landowner as part of the Built Features Management Plan.

Specific channel stability monitoring will be undertaken in an area of Quorrobolong Creek where velocity and tractive stress changes have been predicted by modelling. This monitoring will be undertaken as a visual inspection supported by photographic recording to monitor for potential impacts as a result of velocity induced scouring or erosion. The monitoring location is shown on **Figure 5.1**.

5.2 Groundwater Monitoring

Groundwater is monitored within the Stage 2 and 3 mining areas in accordance with the existing SWMP (Austar, 2018), EL6598 Groundwater Monitoring and Modelling Plan (RPS, 2014) and Environmental Monitoring Program (Austar, 2018). The existing and proposed groundwater monitoring network is shown on **Figure 5.1**.

The following groundwater monitoring is undertaken in relation to the LWB1-B3 Extraction Plan Area:

- monitoring of groundwater levels and water quality (electrical conductivity) in one shallow groundwater monitoring bore (MB03) in the alluvial area of the unnamed tributary of Quorrobolong Creek above LWB2 (refer to **Figure 5.1**). As appropriate, the results are compared with other similar monitoring bores in the area to be used as a pseudo-baseline. Note that MB03 is no longer accessible and has been replaced by MB03A, in which monitoring commenced in Q4 2018.

- Water NSW provide monitoring data for monitoring bore GW080974 and GW080975 (when available)
- groundwater monitoring data is reconciled against rainfall records to assess whether groundwater level changes are the result of longwall mining impacts
- the results of the above monitoring is reviewed at three monthly intervals and reported in the Annual Review.

The following additional groundwater monitoring is undertaken in relation to the LWB4-B7 Extraction Plan Area:

- monitoring of MB04, a shallow groundwater monitoring bore in the alluvial area of Quorrobolong Creek located above LWB6 (refer to **Figure 5.1**). Monitoring of water level using a data logger capable of continuous (daily) recording, and electrical conductivity (EC) is completed quarterly.
- reconcile groundwater monitoring data against rainfall records to assess whether groundwater level changes are the result of longwall mining impacts
- review of the results of groundwater monitoring against predictions on a three-monthly basis and report results annually in accordance with Annual Review requirements, consistent with the requirements of the existing SWMP (Austar 2018).

Where groundwater impacts are within predicted levels, monitoring will continue for a minimum of 2 years following the completion of mining and any required remediation works within the LWB1-B7 WMP Area.

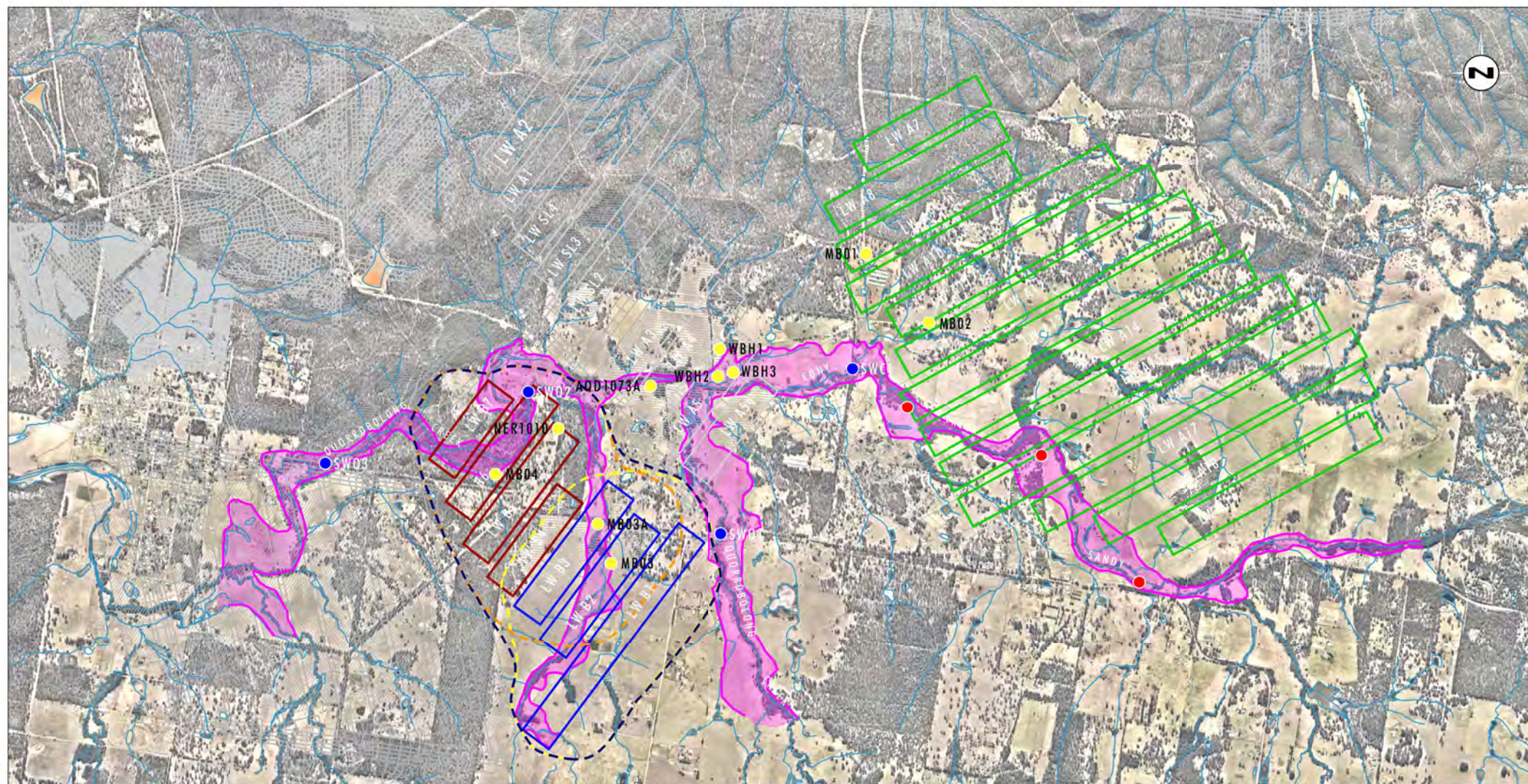


Image Source: Nearmap (2018)
Data Source: Austar Coal Mine (2018)

0 0.5 1.0 2.0 km
1:40 000

Legend

- | | | |
|--|--|--|
| LWB1-B7 Water Management Plan Area | Stage 3 Longwall Panels (PA08_0111) | ● Existing Surface Water Monitoring Location |
| LWB4-B7 Extraction Plan Longwall Panels | Completed Underground Workings | ● Existing Groundwater Monitoring Location |
| LWB4-B7 Extraction Plan Area | Estimated Alluvial Area | ● Approved Future Stage 3 Groundwater Monitoring Site |
| LWB1-B3 Extraction Plan Longwall Panels | | |
| LWB1-B3 Extraction Plan Area | | |

File Name (A4): R12/3900_143.dgn
20190204 11.40

FIGURE 5.1

Existing and Proposed Surface Water
and Groundwater Monitoring Locations

5.3 Riparian and Groundwater Dependent Ecosystem Monitoring

Ecological monitoring for the LWB1-B7 WMP Area is detailed in the Biodiversity Management Plan-LWB1-B7. Ecological monitoring is proposed to monitor potential effects of subsidence on Endangered Ecological Communities and Groundwater Dependent Ecosystems within the LWB1-B7 WMP Area, including the Riparian Cabbage Gum Open Forest community associated with the alluvium of the unnamed tributary of Quorrobolong Creek, and the predicted ponding area above LWB6/B7 where River-flat Eucalypt Forest is present in order to more closely monitor the influence of any changes in ponding on the understorey vegetation composition of this community. The BMP notes that historical monitoring has not identified any adverse impact on water quality, riparian vegetation or stream condition within the Austar Coal Mine as a result of mining, aquatic monitoring within Quorrobolong Creek is not proposed in the BMP.

5.4 Subsidence Monitoring

Subsidence monitoring measures for the LWB1-B7 WMP Area are detailed in the LWB1-B3 Extraction Plan Subsidence Monitoring Program and the LWB4-B7 Extraction Plan Subsidence Monitoring Program, and include measures such as subsidence monitoring lines and 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, damage to structures, changes in drainage patterns resulting in scour, or loss of water from drainage structures, where access is granted.

5.5 Summary

Table 5.1 summarises the monitoring program for the LWB1-B7 WMP Area.

Table 5.1 Existing Monitoring Program for the LWB1-B7 WMP Area

Aspect	Existing Monitoring
Surface water	Monthly water quality sampling at 3 locations along Quorrobolong Creek (SWQ1, SWQ2 and SWQ3). Monthly visual inspections of bank stability and flows within Quorrobolong Creek and the unnamed tributary of Quorrobolong Creek. Photographic recording of channel stability at each monitoring location within Quorrobolong Creek.
Groundwater	Monitoring of groundwater level using data loggers and 3-monthly logger download and electrical conductivity testing in bores located within the alluvium associated with Quorrobolong Creek and the unnamed tributary of Quorrobolong Creek (e.g. MB03, MB30A, MB04, WBH1, WBH2, WBH3 and AQD1073A). Water NSW provides monitoring data for bores GW080974/GW080975 (where available). Reconciliation of groundwater monitoring data with rainfall records to account for natural variations.
Riparian	Monitoring of Endangered Ecological Communities and Groundwater Dependent Ecosystems, including the Riparian Cabbage Gum Open Forest within the LWB1-B7 WMP Area, and the predicted ponding area above LWB6/B7 where River-flat Eucalypt Forest is present as specified in the Biodiversity Management Plan – LWB1-B7.

6.0 Trigger Action Response Plan

The Trigger Action Response Plan (TARP) identifies response measures for environmental consequences of subsidence impacts on surface water and groundwater in response to triggers based on the review of monitoring information or other sources. The TARP includes management measures and contingency measures based on different trigger levels. The TARP for the WMP for the LWB1-B7 WMP Area is shown in **Table 6.1** below.

Table 6.1 WMP Trigger Action Response Plan

Trigger Source	Normal Conditions (Predicted Impacts)	Level 1 Trigger and Response (Management Measures)	Level 2 Trigger and Response (Contingency Management Phase)
Review of monitoring results on surface water	Impacts are as described in Section 4.0. ACTION Continue monitoring in accordance with WMP and SWMP.	Impacts for Quorrobolong Creek and the unnamed tributary are outside those described in Section 4.0. Deterioration trend on stream health and/or stability. ACTION Assess if exceedances are due to mining related activities within the LWB1-B7 WMP Area. If not due to mining related impacts – continue monitoring. If attributable to mining proceed to Level 2 Response.	The cause of exceedances of predicted impacts are related to mining activities within LWB1-B7 WMP Area. ACTION Trigger incident reporting protocols, and remediate as required (Section 8.1): Notify stakeholders. Develop an appropriate course of action in consultation with relevant stakeholders. Implement the approved course of action. Review monitoring program.

Trigger Source	Normal Conditions (Predicted Impacts)	Level 1 Trigger and Response (Management Measures)	Level 2 Trigger and Response (Contingency Management Phase)
Review of monitoring results on groundwater	Impacts are as described in Section 4. ACTION Continue monitoring program.	Monitoring results including inflows to the mine outside impact predictions, but sufficiently benign to cause no immediate adverse impact and within current licenced entitlement. ACTION Increase monitoring frequency of logger download and review to monthly whilst monitoring results are outside impact predictions and continue to assess.	Increased frequency of monitoring shows continual exceedance outside the range of impact predictions (i.e. during 3 or more consecutive monitoring events in previous 12 months). Monitoring results outside impact predictions and cause immediate adverse impact. Monitoring results indicate potential groundwater take in excess of current licenced entitlement. ACTION Trigger incident reporting protocols (Section 8.1). Notify stakeholders. Conduct an investigation to determine extent of the incident's impacts and identify contributing factors. Develop an appropriate course of action in consultation with relevant stakeholders and DoI-Water. Implement the approved course of action. Review monitoring program and this WMP. Review monitoring results of Groundwater Dependent Ecosystems from the LWB1-B7 BMP. Review groundwater assessment and update monitoring and management plans. Where exceedance of currently licenced entitlement is identified, seek to procure additional licences for the relevant water source.

Trigger Source	Normal Conditions (Predicted Impacts)	Level 1 Trigger and Response (Management Measures)	Level 2 Trigger and Response (Contingency Management Phase)
Review of subsidence monitoring results on remnant ponding	Impacts are as described in Section 4 . ACTION Continue monitoring program.	Monitoring results identify remnant ponding in excess of impact predictions and the ponding area does not infiltrate back to alluvial soils over a period of one year. ACTION Seek to quantify water take from Upper Wollombi Brook Water Source - Congewai Creek Management Zone. If quantifiable water take in excess of current licenced entitlement is identified, proceed to Level 2 response.	A quantifiable water take from the Upper Wollombi Brook Water Source - Congewai Creek Management Zone in excess of current licenced entitlement is identified. ACTION Land remediation be undertaken in accordance with the Land Management Plan to remediate the unplanned ponding (where access is granted) OR Seek to procure additional licences (where required) for the relevant water source.
Impacts to Water NSW monitoring bore	No significant adverse impact to monitoring bore condition. ACTION Nil.	Monitoring of bore condition indicates damage to bore during or post mining. ACTION Determine if impact is due to mining. If not due to mining related impacts – liaise with Water NSW and continue monitoring if agreed. If damage attributable to mining proceed to Level 2 Response.	Bore is damaged due to mining impacts and cannot be used. ACTION Liaise with Water NSW and, if required, bore be repaired/replaced in accordance with the respective Built Features Management Plan.
Feedback from landholders regarding impacts to farm dams	No significant adverse impact to farm dam condition or volume. ACTION Nil.	Minor impact to farm dam volumes detected – no interruption to water supply. ACTION Farm dam to be repaired in accordance with the respective Built Features Management Plan.	Significant loss of water from farm dam detected. ACTION Austar to supply alternate water supply until farm dam can be repaired in accordance with the respective Built Features Management Plan.

Trigger Source	Normal Conditions (Predicted Impacts)	Level 1 Trigger and Response (Management Measures)	Level 2 Trigger and Response (Contingency Management Phase)
Subsidence remediation works	Subsidence monitoring program indicates no significant adverse impact which requires remediation. ACTION Nil	Subsidence monitoring program review triggers Land Management Plan or Public Safety Management Plan subsidence impact remediation works. Works are not in area considered to be “Waterfront Land”. ACTION Restrict access to area in accordance with Public Safety Management Plan processes (where required). Remediation process is followed in the Land Management Plan and Biodiversity Management Plan. Nil further requirements from the WMP.	Subsidence monitoring program review triggers Land Management Plan or Public Safety Management Plan subsidence impact remediation works. Works are in area considered to be “Waterfront Land”. ACTION Restrict access to area in accordance with Public Safety Management Plan processes (where required). Consult with DoI-Water regarding works on “Waterfront Land”. Remediation process is followed in the Land Management Plan and Biodiversity Management Plan, and including any requirements of DoI-Water.

7.0 Roles and Responsibilities

The key responsibilities of personnel in relation to the LWB1-B7 WMP are summarised in **Table 7.1**. Responsibilities may be delegated as required and in line with regulatory limitations.

Table 7.1 Roles and Responsibilities

Responsibility	Accountabilities
Operations Manager	Ensure appropriate resources are available for the implementation of this WMP.
Technical Services Manager	Ensure the Subsidence Monitoring Program is implemented. Facilitate timeliness and quality of monitoring processes.
Environment and Community Superintendent	Review and seek approval for this WMP in accordance with the requirements of this WMP and other legal requirements and operational standards. Ensure any incident is reported in accordance with the WMP and other legal requirements. Instigate response in the event the performance indicators, TARP and/or Contingency Plan are triggered. Allocate resources for monitoring and review of subsidence survey results.
Environment and Community Coordinator	Implement monitoring programs as required by this WMP and conduct review of results against performance indicators as described in this WMP. Assist in the preparation of reports as identified in reporting framework. Assess any triggers as described in performance indicators and provide advice to implementation of TARPS and the Contingency Plan to Austar Management.
External Groundwater Specialist	Review WMP monitoring and management measures and advise on consistency with impact assessment predictions.

8.0 Reporting

8.1 Incident Reporting

Exceedances of surface water and groundwater criteria stated in this WMP that have occurred as a result of Austar operations will be classified as environmental incidents and will be managed in accordance with the incident management process as detailed within the Austar Environmental Management Strategy. Austar's Environmental Management Strategy includes an environmental incident management process to:

- manage environmental hazards and incidents to minimise damage to people, environment, community and other assets
- facilitate reporting of environmental incidents
- identify factors that contributed to incidents through an investigation process and to learn from those events and prevent reoccurrence.

Significant adverse impacts to water resources as a result of Austar operations that exceed the performance criteria of the consent will be treated as an environmental incident, and a written report will be provided to any relevant government agencies in accordance with the Austar Environmental Management Strategy.

In accordance with Condition 4, Schedule 5 of DA 29/95, within 7 days of the incident, Austar will provide the Secretary and any relevant agencies with a report on the incident, and such further reports as may be requested. Incidents will also be reported in accordance with EPL conditions and in accordance with the Austar Pollution and Incident Response Management Plan (PIRMP) where relevant.

8.2 Annual and Regular Reporting

Condition 5 of Schedule 5 of DA 29/95 requires Austar to prepare an Annual Review of environmental performance to the satisfaction of the Secretary of DPE. Annual Review reports are placed on the Austar website and include:

- a description of works carried out during the previous year, planned works for the upcoming year
- a review of monitoring results and against baseline data, statutory requirements and performance criteria, including a discussion of any trends
- identification of any non-compliances and remedial actions
- identification of any discrepancies between predicted and actual project impacts and
- a description of any environmental improvement measures or initiatives proposed for the coming year.

9.0 References

Austar Coal Mine, 2018. *Environmental Management Strategy*.

Austar Coal Mine, 2018. *Site Water Management Plan*.

Austar Coal Mine, 2018. *Consolidated Environmental Monitoring Program*.

Dundon Consulting, 2015. *Austar Coal Mine – LWB1-LWB3 Modification – Groundwater Assessment*.

Dundon Consulting, 2017. *Austar Coal Mine – LWB4-B7 Modification – Groundwater Assessment*.

Geoscience Australia. 1988. *Australian Stratigraphic Units Database*. [ONLINE] Available at: http://dbforms.ga.gov.au/pls/www/geodx.strat_units.sch_full?wher=stratno=2498. [Accessed 25 August 2015].

Kovac, M. and Lawrie, J., 1991. *Soil Landscapes of Singleton 1:250,000 Sheet*. Soil Conservation Service of NSW, Sydney.

Mine Subsidence Engineering Consultants (MSEC), 2011. *Austar Coal Mine: Stage 3 – Longwalls A7-A19 Subsidence Predictions and Impact Assessments for Natural Features and Surface Infrastructure in Support of a Modification to the Development Consent*.

Mine Subsidence Engineering Consultants (MSEC), 2015. *Austar Coal Mine: Longwalls B1 to B3 Subsidence Predictions and Impact Assessments for the Natural Features and Built Features in Support of the Environmental Assessment for a Section 75W Modification Application for the Inclusion of the Proposed Longwalls B1 to B3 at the Austar Coal Mine*.

Mine Subsidence Engineering Consultants (MSEC), 2017. *Austar Coal Mine: Longwalls B4 to B7 Subsidence Predictions and Impact Assessments for the Natural Features and Built Features in Support of Modification Application for Longwalls B4 to B7 at the Austar Coal Mine*.

Mine Subsidence Engineering Consultants (MSEC), 2018. *Austar Coal Mine – Modified Finishing End of LWB4. Review of Subsidence Effects, Subsidence Impacts and Environmental Consequences*.

NSW Department of Planning and Environment, 2016. *Assessment Report Austar Coal Mine Additional Longwalls Modification (DA 29/95 MOD 6)*.

RPS, 2014. *Austar Coal Mine – EL6598, Groundwater Monitoring and Modelling Plan*. Dated March 2014.

Umwelt, 2015. *LWB1-B3 Modification Environmental Assessment Austar Coal Mine*.

Umwelt, 2017. *LWB4-B7 Modification Environmental Assessment Austar Coal Mine*.