YANCOAL
兖煤澳大利亚有限公司

AUSTAR COAL MINE
PART OF THE YANCOAL AUSTRALIA GROUP

Groundwater Review and Assessment Report

February 2019

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Australasian Groundwater and
Environmental Consultants Pty Ltd

Report on

Historical Groundwater Review and Assessment

Austar Coal Mine

Prepared for
Yancoal Australia Pty Limited

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Report on

Historical Groundwater Review and Assessment Austar Coal Mine

1 Introduction and background

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) have been commissioned by Austar Coal Mine Pty Ltd to assess observed groundwater conditions in comparison to predicted potential impacts at Yancoal's Austar Coal Mine (ACM). The review is required by condition 12A (Schedule 3) of the MOD7 development consent for DA29/95.

1.1 Scope and methodology

Austar's MOD7 was approved in August 2017, with the condition that an assessment be undertaken to review observed groundwater conditions compared to predicted potential impacts. The condition reads:

> *12A. By the end of February 2018, the Applicant must review the groundwater impacts of the development. This review must:*
>
> *(a) validate the impact predictions in EA (MOD 6) and EA (MOD 7) against measured groundwater impacts, including a comparison of:*
>
> - *groundwater levels and quality in both alluvial and non-alluvial aquifers; and*
> - *mine water inflow sources and volumes; and*
>
> *(b) evaluate the effectiveness of the existing groundwater model for use in current and future mining operations; and*
>
> *(c) evaluate the continued effectiveness of any approved Extraction Plan or Water Management Plan for the development and provide recommendations for any appropriate amendments to these plans.*
>
> *The review must be undertaken in consultation with DPI-Water and reported and implemented to the satisfaction of the Secretary. If the review identifies a material departure from the predictions in EA (MOD 6) and EA (MOD 7), the Applicant must prepare a revised groundwater assessment for the development, in consultation with DPI-Water, to the satisfaction of the Secretary. The assessment must include updated predictions of potential groundwater impacts from the development, based on quantitative surface and groundwater modelling, incorporating all available groundwater data.*

AGE has undertaken the assessment through the following tasks:

- a one day site visit by two Principal Hydrogeologists to review underground and surface water management, and site specific conditions;
- review and summarise three groundwater assessment reports:
    - Connell Wagner, 2007. *"Appendix 14. Future Mine Development Groundwater Impact Assessment Austar Coal Mine. October 2007."*
    - Dundon Consulting, 2015. "*Austar Coal Mine – LWB1-LWB3 Modification – Groundwater Assessment, October 2015."*
    - Dundon Consulting, 2017. *"Austar Coal Mine – LWB4-LWB7 Modification – Groundwater Assessment, May 2017."*
- review and summarise seven additional publications:
    - Aurecon, 2013. "*Groundwater review after LWA5, Austar groundwater project, Austar Mine*". Draft, Revision No.1, March 2013.
    - Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2017a. "Monitoring of Austar Colliery VWP Installation - EX01H. Project G1828C, September 2017."
    - Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2017b. *"September 2017 Groundwater Monitoring. Project G1828C, September 2017."*
    - Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2017c. *"December 2017 Groundwater Monitoring. Project G1828C, December 2017."*
    - Yancoal Austar Coal Mine, 2017a. "Site Water Management Plan. April 2017".
    - Yancoal Austar Coal Mine, 2017b. "Annual Environmental Management Report, July 2016 – June 2017. September 2017".
    - Yancoal Austar Coal Mine, 2017c. "Austar Coal Mine Longwalls B4 to B7 Extraction Plan September 2017."
- consider all groundwater level and quality data at the site;
- summarise groundwater impact predictions versus observed impacts; and
- summarise groundwater inflows to, and pumping from, the mine in relation to mining activities and potential subsidence.

1.2 Structure of this report

To address the scope of work presented in Section 1.1, the report is structured as follows:

Item	Task	Section
Setting	Summary of mining and hydrogeology	2
Background data review	Review of publications	3.1
	Review of groundwater data	4.1.2
Analysis	Verification of Measured Groundwater Impacts vs Impact Predictions	4.1
	Assessment of the effectiveness of the existing groundwater model for current and future mining	4.2
	Assessment of the effectiveness of the approved Extraction Plan Water Management Plan for the development.	4.3
Conclusions		0

2 Summary of mining and hydrogeology

A summary is provided here, based on Austar (2017b) and AGE (2017a, b and c).

2.1 Overview of the mining operations at Austar

ACM is an underground coal mine located approximately 10 km south west of Cessnock in the South Maitland Coalfields of New South Wales (Figure 2.1). The mine is an aggregate of the former Ellalong, Pelton, Cessnock No.1 and Bellbird South Collieries. The operations, including coal extraction, handling, processing and transport, collectively form the Austar Coal Mine Complex, wholly owned and operated by Yancoal who purchased the mine in December 2004.

Underground mining commenced in 1916 at Pelton Colliery and continued until 1992. Kalingo Colliery began as an underground mine in 1921 and ceased operations in 1961. In the late 1960s the Kalingo Colliery was amalgamated into the Pelton Colliery. Longwall production commenced at the Pelton Colliery in 1983 and continued until the mine, then known as Ellalong Colliery, was closed in May 1998 by Oakbridge.

Southland Coal then acquired the assets of Ellalong and Pelton Collieries and amalgamated those with Bellbird South, which was also owned by Southland Coal. In December 2003, spontaneous combustion in longwall panel SL4 resulted in Southland Coal ceasing mining activities. The site of the underground fire was sealed and the mine was placed in care and maintenance for 18 months.

Yancoal purchased the mine in December 2004 and changed the name to Austar Coal Mine. ACM commenced mining operations in the Stage 1 mining area in April 2005 under development consent Bellbird South DA29/95. Modifications to the development consent DA29/95 allowed the use of Longwall Top Coal Caving (LTCC) method in the Bellbird South Stage 2 mining area. Longwall mining in the Stage 2 area commenced in February 2009 and was completed in February 2013.

Project approval (PA08_0111) for the Stage 3 area was granted on 6 September 2009, which approved LTCC technology in the Stage 3 area and construction of new surface facilities. Modifications to PA08_0111 were approved in May 2010, March 2012, and December 2013, primarily to allow more efficient and safer extraction of coal through reorientation of the longwall panels and to optimise the length of the longwalls. The Stage 3 project includes longwall panels A7 to A19.

Mining in the second Stage 3 panel (Longwall A8) commenced on 16 June 2014 and was completed on 24 June 2015. Austar relocated development operations to the Bellbird South and Ellalong Colliery areas in 2015 with the aim to return to mining in the Stage 3 area in the medium term, with mining in this area approved until 2030.

Mining within the Bellbird South and Ellalong Colliery recommenced in June 2015 with development of first workings of existing approved coal reserves to allow future extraction of longwall panels LWB1 to LWB3 (Figure 2.1). A modification to DA 29/95 extending the area and life of the consent and permitting transfer and processing of coal from longwall panels LWB1 to LWB3 was approved under delegation of the Minister for Planning on 29 January 2016. The modified consent contemporised subsidence management conditions requiring an approved Extraction Plan to be in place prior to extraction of longwall panels LWB1 to LWB3. Longwall extraction of LWB2 commenced 7 July 2016.

Austar was granted approval to modify the DA29/95 on 25 August 2017 under Section 75W of the *Environmental Planning and Assessment Act 1979* to permit the transfer and processing of coal from four proposed longwall panels (LWB4 to LWB7) via the existing Bellbird South main.

The Austar Site Water Management Plan (SWMP) has been prepared in accordance with the requirements of development consent DA29/95 and project approval PA08_0111. The conditions from DA29/95 and PA08_0111 are outlined within the SWMP dated April 2017. The location of approved operations is shown in Figure 2.1.

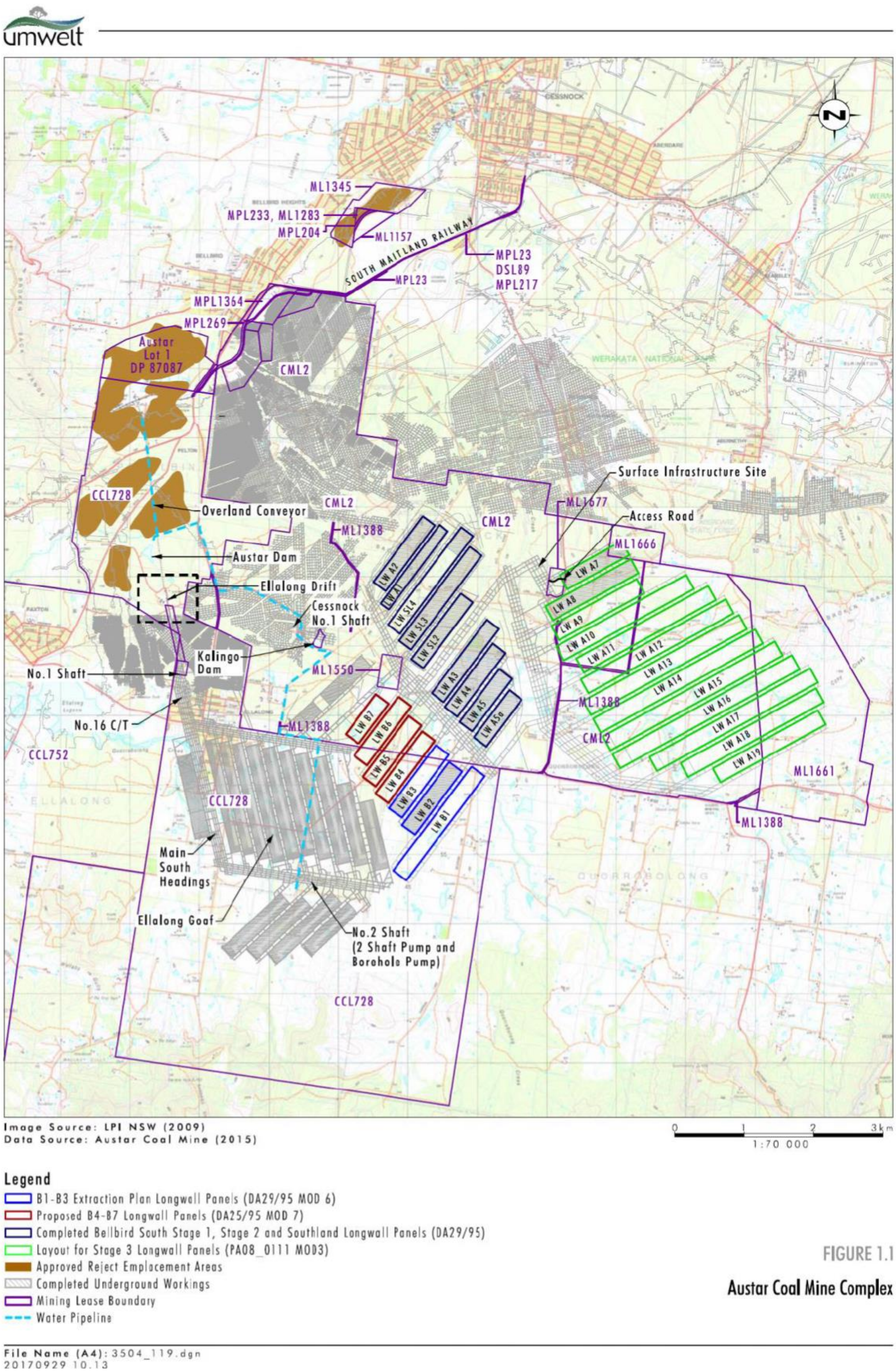


Figure 2.1 Austar approved mining operation (Austar, 2017b)

2.2 Conceptual hydrogeology

The summary of hydrogeology, provided here, is based on Connell Wagner (2007) and Dundon Consulting (2015 and 2017).

ACM is located the lower Hunter Valley. The climate is warm temperate, with seasonal variations from hot wet summers to mild dry winters. The average rainfall (from BOM Nulkaba O'Connors Road weather station ID 61295) of 785 mm/year, is generally summer dominant, and rainfall is less than potential evaporation for most months of the year.

The Quorrobolong Creek / Cony Creek drainage system flows in a westerly direction across the mine area, eventually flowing into Wollombi Brook which in turn flows into the Hunter River. The main drainages of the Quorrobolong Valley are Quorrobolong Creek, Cony Creek and Sandy Creek. These creeks are largely ephemeral and are often present as a series of disconnected pools during the dry season.

The surface elevations within the valley floor are around 130 mAHD, while the elevation rises to around 440 mAHD at the Myall Range to the south and to around 200 mAHD at the Broken Back Range to the north.

2.2.1 Geology

ACM extracts coal from the Greta Coal Seam (GS) of the late Permian aged Greta Coal Measures (GCM). The GCM comprises the Neath Sandstone, Kurri Kurri Conglomerate, Kitchener Formation (including the GS) and the Paxton Formation, and all units are predominantly sandstone, conglomerate and coal (Table 2.1).

The GCM is overlain by a thick sequence of sedimentary rock including conglomerate, sandstone and siltstone of the Branxton Formation (and other higher units of the Maitland Group). The Permian stratigraphy is summarised in Table 2.1 and the surface geology of the area is presented in Figure 2.2.

Table 2.1 Stratigraphy (Dundon Consulting [2015] after Hawley and Brunton [1995])

Age	Stratigraphy		Lithology
Late Permian	Maitland Group	Mulbring Siltstone	Siltstone with minor claystone and sandstone lenses.
		Muree Sandstone	Sandstone with minor conglomerate and siltstone
		Branxton Formation	Conglomerate and sandstone towards base, siltstone becoming more common towards top
	Greta Coal Measures	Paxton Formation	Conglomerate and micaceous sandstone with minor claystone and siltstone beds. Coal (Pelton Coal Member) and coaly shale.
		Kitchener Formation (including the Greta Seam)	Coal with minor claystone, siltstone and sandstone
		Kurri Kurri Conglomerate	Orthoconglomerate, minor sandstone, siltstone, claystone and coal near base.
		Neath Sandstone	Sandstone, minor conglomerate siltstone and claystone

Age	Stratigraphy		Lithology
Early Permian	Dalwood Group	Farley Formation	Fossiliferous silty sandstone
		Rutherford Formation	Siltstone and minor sandstone, with thin limestone and marl horizons (Pokolbin area)
		Allandale Formation	Lithic sandstone and conglomerate containing abundant invertebrate fossils
		Lochinvar Formation	Poorly fossiliferous siltstone, claystone and sandstone and interbedded basalt flows.

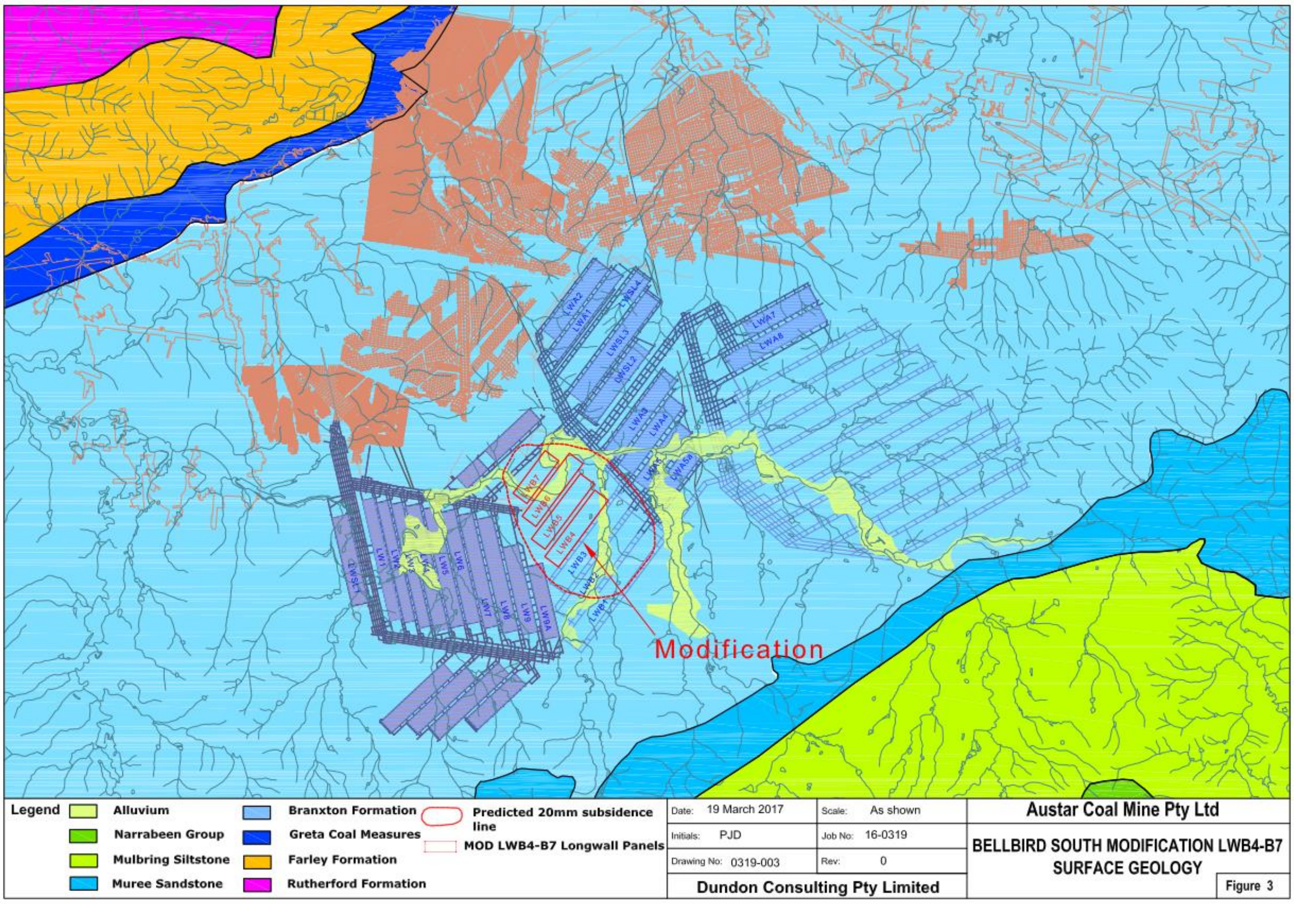


Figure 2.2 Surface geology (after Dundon Consulting, 2017)

Structurally, the mine is situated on the south-eastern limb of the Lochinvar Anticline. The GCM outcrop to the north near Cessnock, and dip variably to the south-east with a general dip of around 5 to 6 degrees. Within the current mining area, the seam occurs at depths ranging up to 740 m below ground level (mbgl). Seam thickness generally increases eastward with thicknesses of up to 7 m in the Stage 3 mining area. Extensive faulting and deformation is associated with the Lochinvar Anticline, with a number of prominent fault zones controlling the longwall panel layouts, notably the Swamp Fault Zone, Quorrobolong Fault and the Abernethy Fault Zone (Figure 2.3).

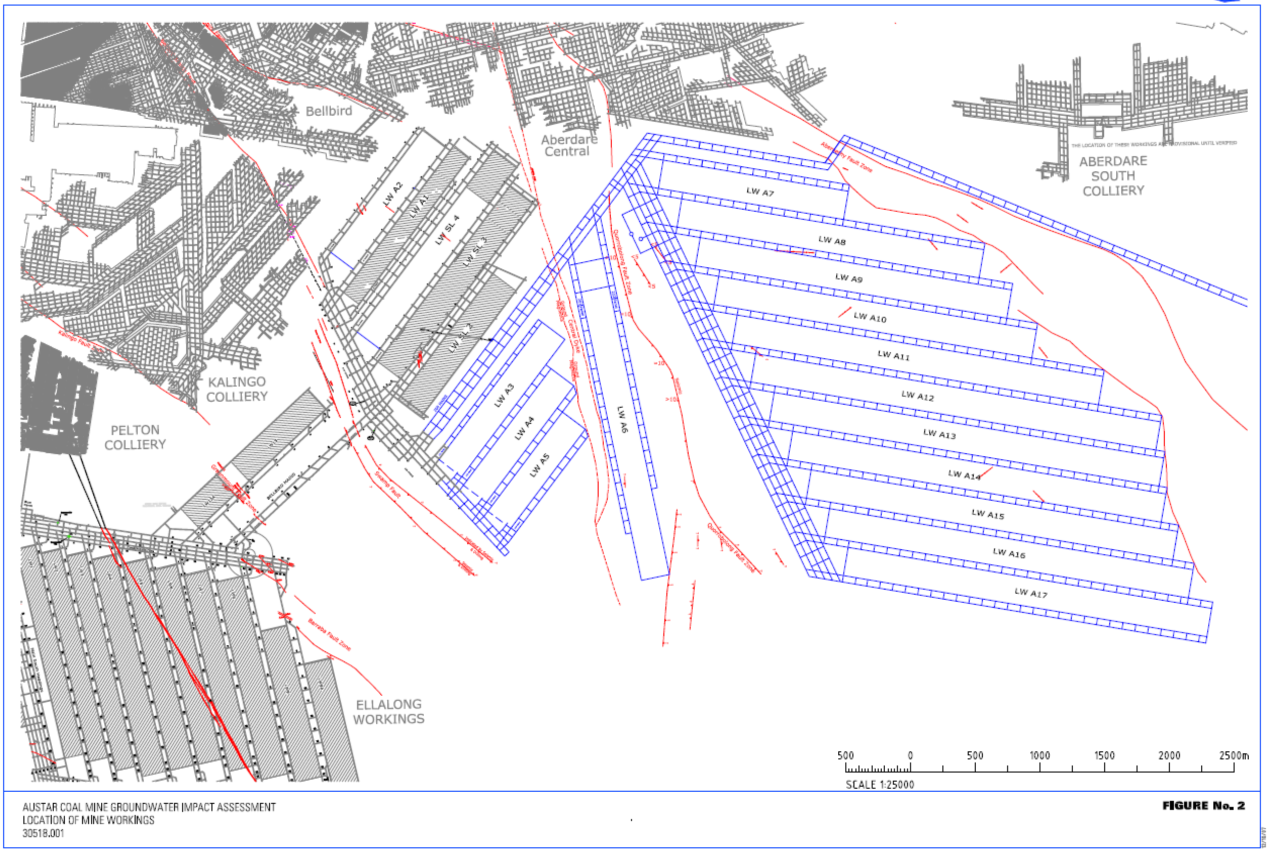


Figure 2.3 Fault zones (after Connell Wagner, 2007)

2.2.2 Hydrostratigraphy

Within the ACM area, two aquifer systems have been identified, the unconsolidated surficial material that includes alluvium, colluvium and weathered bedrock, and secondly the Permian hard rock aquifer system. A third potential source of water is the water stored in surrounding abandoned mine voids.

2.2.3 Quaternary alluvium

Potentially, the most important natural groundwater resource in the Newcastle/Cessnock area is found in the alluvial sediments, which cover the low-lying areas, and fill the broad valleys of the creeks that form the tributaries of the Hunter River. Numerous bores and wells draw water from these sediments, which usually comprise a fine-grained surface layer underlain by sand and gravel deposits. Flows from these wells mostly range from 0.1 L/s to 9 L/s, and water quality is generally reasonable.

Quorrobolong Creek and its tributaries flow in a general westerly direction across the Austar lease area. The tributaries that cross the Austar lease, including Sandy Creek and Cony Creek, are second or third order streams, and comprise a series of intermittent creeks, which only flow after consistent or heavy rainfall. These creeks have shallow alluvium-filled valleys ranging in width up to 400 m. They flow ultimately to the west of the Austar lease area into the Wollombi Brook, a tributary of the Hunter River that contains a significant alluvial aquifer.

The groundwater in the alluvium is derived largely from infiltration of rainfall and runoff, although some is derived from lateral infiltration during high flows in the adjacent creeks. Normally, the groundwater discharges into the creeks during periods of low surface water flows. There is also a general, gradual movement of groundwater in a downstream direction within the alluvium, which contributes to the alluvial aquifers further downstream. Due to the very low vertical hydraulic conductivity (Connell Wagner, 2007) of the underlying Permian rock strata, there is very little potential for vertical leakage of groundwater from the alluvium under natural gradients.

2.2.4 Permian fractured rock units

2.2.4.1 Branxton Formation

The Branxton Formation is part of the non-coal bearing marine sequence of the Maitland Group which overlies the GCM. The sandstone is generally strong and massive contains few if any major water bearing zones and is not likely to provide a viable source of groundwater (Connell Wagner, 2007). Nevertheless, zones of jointing or fracturing associated with major faults may form localised aquifers. The sequence has very low vertical hydraulic conductivity, and there is very little potential for leakage between any water-bearing zones or aquifers.

Drilling at ACM indicates potential water-bearing zones in the Branxton Formation at a depth of around 100 mbgl to 130 mbgl and at 170 mbgl at bore locations across the mine area. Connell Wagner (2007) concluded that the importance of these water bearing zones as a water resource is likely to be minimal, since the water quality is poor (with electrical conductivity [EC] generally greater than 10,000 µS/cm) and the yield is low (generally less than 1 L/s).

2.2.4.2. Greta Coal Measures

The GCM also have low rock mass hydraulic conductivity ($<10^{-3}$ m/d), but they contain coal seams and occasional cleats and fracture or bedding plane features which have slightly higher hydraulic conductivity.

The coal seams are more permeable than the interburden, and are therefore the main water-bearing zones in the GCM due to the presence of cleats and fractures in the coal. For this reason, the coal seams represent the aquifer units purely by comparison with the much less permeable interburden strata. As per the Branxton Formation, the importance of the coal seams within the GCM as an aquifer is generally minimal due to the poor quality groundwater as well as limited yield potential.

2.2.5 Recharge and discharge

Recharge/discharge is interpreted to occur as follows:

- The groundwater in the alluvium is derived largely from infiltration of rainfall and runoff, although some is derived from lateral infiltration during high flows in the adjacent creeks. Normally, the alluvial groundwater discharges into the creeks during periods of low flows.
- Recharge may also occur from infiltration of rainfall, and downward percolation into and through the alluvium/colluvium and weathered rock into the underlying Branxton Formation. Recharge to relatively more permeable zones within the Branxton Formation and the GCM likely occurs at some distance up-dip from the mine area, where those particular zones occur in subcrop beneath the surficial lithologies (Dundon Consulting, 2015).

2.2.6 Groundwater flow

The groundwater impact assessment reports (Connell Wagner, 2007; and Dundon Consulting, 2015 and 2017) and groundwater review report (Aurecon 2013) do not contain groundwater head/elevation contour maps, presumably because of the lack of such information and underlying data. Groundwater elevations, both proximal to, and surrounding ACM, appear to be heavily influenced by groundwater in the surrounding abandoned workings and indicate compartmentalisation.

Groundwater heads, in the vertical sense, are shown for multi-piezometer sites AQD 1077 (Connell Wagner, 2007 and Dundon Consulting, 2015) and AQD1121 (now called EX01H; Dundon Consulting, 2015 and 2017). These figures indicate significant depressurisation due to mining in the GS, with gradually decreasing depressurisation effects through the lower Branxton Formation; and insignificant changes in the upper Branxton Formation.

3 Background data review

3.1 Summary of publications

Within this section, summaries of selected publications are presented in chronological order. General comments about each publication are presented, followed by a tabular presentation of predictions (if applicable) and actual impacts (if applicable) to the following:

- key environmental values/receptors;
- drawdown in the alluvium, Branxton Formation and the GCM; and
- inflows to the underground mine.

3.1.1 Connell Wagner (2007) – Groundwater impact assessment

Connell Wagner, 2007. *"Appendix 14. Future Mine Development Groundwater Impact Assessment Austar Coal Mine. October 2007."*

This is the 'original' ACM groundwater impact assessment and developed the existing conceptual hydrogeology, including the location, extents and characteristics of the alluvium and fractured rock aquifers, including hydrogeological parameters applicable to the site coal, coal measures and overburden. The report also discussed the concept of groundwater-surface interaction and hydraulic isolation of the coal measures and overlying geology.

The report also makes an important statement about hydraulic gradients and recharge of groundwater from adjacent abandoned mines: Section 5.3 - "*The hydraulic head in these collieries is significantly higher (~160m) than the level of the existing Austar workings, and this is responsible for most of the groundwater inflow to the mine. …This groundwater source will continue to provide the bulk of the groundwater inflow to the Austar workings into the future, and this needs to be taken into account in determining the likely future water inflows.*"

The report presents the concept that the hydraulic conductivity of the Branxton Formation, that separates the alluvium from the GS, is low and hence impact at the surface is likely to be low.

Section 8 describes the assessment of groundwater inflow to the mine. "*Currently most of the groundwater entering the Austar mine originates from the water in the adjacent abandoned mine workings. Without this contribution to the mine water inflows, the groundwater inflow would be minimal, and in line with most other mines in the Newcastle Coalfield, which are generally reasonably dry.*" Using groundwater inflows to the A2 panel, and assuming that most of the flow comes from the abandoned workings (nearby Kalingo, Bellbird and Aberdare Central collieries), Connell Wagner (2007) estimated the hydraulic conductivity for the GS as approximately 0.1 m/d. Note that the figure of 0.9 m/d in page 25 of Connell Wagner (2007) should have been 0.09 m/d. The 0.1 m/day hydraulic conductivity at 400 m depth was further assumed to decrease to 0.001 m/day at 700 m depth. This assumption of reducing hydraulic conductivity with depth is valid.

A summary of the impact assessment findings is shown in Table 3.1.

Table 3.1 Summary of impact assessment by Connell Wagner (2007)

Environment	Predicted impact	Notes
Subsidence	Assumes a fractured zone height/extraction thickness ratio of 33 that produces a fractured zone height between 165 m and 231 m (with an extraction thickness of 5 m to 7 m). A conservative figure of about 231 m should be assumed for the fracture zone height above the stage 2 and 3 longwall panels. As a result, the fractured zone is likely to be restricted to the upper part of the Greta Coal Measures and the lower part of the Branxton Formation. Large scale surface cracking will be unlikely over the longwall panels, given the low level of tensile strain predicted to occur and no impacts from valley bulging effects will be observed.	Section 6.
Alluvium	*"Minimal, since the fractured zone above the mine is not expected to reach the ground surface and hence vertical drainage should not occur."*	
Branxton Formation	Any water-bearing zones which occur within the fractured zone above the GS will most likely drain into the mine opening during extraction of the longwalls. The impact of the proposed mining on the water-bearing zone at a depth of 70 m to 100 m will be negligible since it is located well above the zone of interconnected fracturing.	
Greta Coal Seam	*"Extraction of the Greta Seam will drain groundwater from the seam into the mine and lower the hydraulic head in the seam in the area to the south of the development. Since the incremental drawdown will be minimal, the groundwater quality is poor, the seam is very deep, and there are no known users of the resource, the impact is judged to be negligible."*	Section 7.1.3.
Mine Inflows	1.1 ML/d to 1.3 ML/d for Stage 2 (A3 - A5) 0.54 ML/d for A6 1.74 ML/d to 2.47 ML/d for Stage 3 (A7-A17)	Section 8.2.1, using Walton (1983) formulae but does not provide input parameter values; hence the analysis and re-creation of the 2007 calculations is not traceable.

3.1.2 Aurecon (2013)

Aurecon, 2013. "*Groundwater review after LWA5, Austar groundwater project, Austar Mine*". Draft, Revision No.1, March 2013.

This report is a part of the Groundwater Verification Program as required by the SWMP, upon the completion of mining in LWA5; Austar completed extraction of LWA5 at the end of March 2012. The report reviews groundwater monitoring data, mine inflows and subsidence. The report concludes:

- *"There is no identifiable impact as longwall extraction approaches and passes the shallow alluvial piezometers.*
- *Mine water level data show that previously established trends in groundwater movement have generally continued without significant change.*
- *Mine pumping data indicate a net long term water make of approximately 3 ML/day for the whole mine. This is expected to continue at about this level, without significant increase, in the future.*
- *The original water make predictions were reviewed by mine staff to account for changes in mine plan. The prediction of 3.7 ML/day for whole of mine are more than, but consistent with, measured water make of 3 ML/day.*
- *No adverse outcomes have been identified. Consequently, no remedial measures are required. Similarly, there are no identifiable changes to operational procedures required."*

A summary of the Groundwater Verification Review findings is shown in Table 3.2.

Table 3.2 Summary of Groundwater Verification Review by Aurecon (2013)

Environment	Predicted impact	Notes
Subsidence	The empirical ACARP method for estimating the height of continuous fracturing over a longwall panel predicts that mining-induced fracturing over LWA5 will not reach to the base of the alluvium.	Section 4 of Aurecon (2013) provides the details
Alluvium and Regolith	*Mine water level data show that previously established trends in groundwater movement have generally continued without significant change.*	
Branxton Formation	*Mine water level data show that previously established trends in groundwater movement have generally continued without significant change.*	
Greta Coal Seam	*n/a*	
Mine Inflows	0.54 ML/d for A6 2.36 ML/d for Stage 3 (A7-A17) 0.8 ML/d structures 3.7 ML/d total	Section 2 of Aurecon (2013).

3.1.3 Dundon Consulting (2015) – MOD 6

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

This report is the groundwater impact assessment prepared to support the MOD6 application and is based primarily on the Connell Wagner (2007) impact assessment. The report provides a comprehensive environmental setting and description of the conceptual hydrogeological model. This report qualitatively predicts no impact on the top 100 m of the Branxton Formation and surface water, systems while the GCM will be already dewatered in the proximity of the LWB1 to LWB3 and significantly depressurised "*for some distance away*" but no beneficial users will be affected. No impacts were predicted on groundwater recharge, or groundwater quality, users or GDEs.

The report concludes **"***The additional impacts from the proposed LWB1-LWB3 Modification overall are anticipated to be quite small, and all water takes would be able to be accounted through existing licensing held by Austar."*

A summary of the impact assessment findings is shown in Table 3.3.

Table 3.3 Summary of impact assessment by Dundon Consulting (2015)

Environment	Predicted impact	Notes
Subsidence	The disturbed or fractured zone above extracted longwall panels is expected to be similar to those at panels LWA1 and LWA2, 85 m for LWA1 and 150 m for LWA2. The height of discontinuous fracturing above LWB4-B7 (i.e. the constrained or aquiclude zone) could extend to between 235 m and 355 m above the seam, well short of the ground surface (between 480 m and 555 m above the seam). Surface cracking in the soils above the proposed longwalls is not expected to be observed. Any surface cracking that might occur in the creek beds is expected to be minor and to infill naturally with subsequent streamflow events. Hence, the zone of discontinuous fracturing is not expected to reach the ground surface.	Section 5.1 of Dundon Consulting (2015)
Alluvium and Regolith	*"it is expected that the proposed Modification will have no adverse effect on groundwater levels in the surficial aquifer system."* *"Impacts on surface streamflows are predicted to be negligible. … the surficial groundwater will not be affected by the proposed Modification. Hence there will be no change to either baseflows or streambed leakage."*	Section 5.3.1. of Dundon Consulting (2015). Section 5.4 of Section 5.1 of Dundon Consulting (2015)
Branxton Formation	*"Groundwater levels in the uppermost 100 m or so of the Branxton Formation are predicted to be unaffected by the proposed Modification."*	Section 5.3.2. of Dundon Consulting (2015)
Greta Coal Seam	*"The Greta Coal Measures, including the Greta Seam, are predicted to be dewatered within the immediate proximity of LWB1-B3, and will also be substantially depressurised for some distance away from the longwalls, in a manner consistent with the already extracted longwall panels. As described above in Section 5.2, slightly higher inflows may be experienced at the south-western ends of LWB1-B3, due to the proximity to Ellalong goaf. No beneficial users will be affected.*	Section 5.3.3. of Dundon Consulting (2015)

Environment	Predicted impact	Notes
Mine Inflows	*"It is expected that the proposed Modification will result in a small incremental increase in total water inflow to the mine, due to the extension of the mine into a new mining area. The inflow rate is likely to increase initially with the advance of the development headings for the proposed panels, but the increase is expected to be modest and short lived, as the proposed panels are along strike rather than downdip the closest previously mined LWA5 and LWA5A, which are only about 300 m to the northeast, and the Greta Seam and the immediate roof and floor sediments have already been substantially dewatered/depressurised."* *"The Modification LWB1-B3 will extend to within about 50 m laterally from the Ellalong goaf, which is flooded with a water level approximately 50 m higher than the Greta Seam floor elevation within LWB1-B3 at their closest point to the Ellalong goaf. … This may cause a slightly higher rate of groundwater inflow at the south-western ends of the new longwalls than elsewhere. However, the magnitude of seepage inflows is predicted to be within the range of inflows that have been experienced in other locations of the Austar Coal Mine."*	Section 5.2 of Dundon Consulting (2015)

3.1.4 Austar (2017a) - Site Water Management Plan

Yancoal Austar Coal Mine, 2017a. *"Site Water Management Plan. April 2017".*

The published SWMP is dated 2013; however, the 2017 version is understood to have been submitted to DPE in April 2017, and includes some updates (including for the LWB1-LWB3 Extraction Plan Water Management Plan (Austar, 2016)) and it was therefore selected for review. Of relevance to groundwater, the 2017 SWMP outlines the:

- current conceptual hydrogeological model for the site;
- SWMP objectives, including:
  - the "*structures, strategies and procedures to be implemented to ensure that the Austar Mine Complex does not result in unacceptable impacts on surface and groundwater systems, groundwater dependent ecosystems and downstream water users";*
  - the groundwater/surface water monitoring program(s); and
  - protocols for *managing and reporting any incidents, complaints, non-compliances*, including trigger levels for assessing monitoring data for potential impacts.
- predicted impacts associated with the mining at ACM; and
- a groundwater monitoring program.

3.1.5 Dundon Consulting (2017) –MOD 7

Dundon Consulting, 2017. *"Austar Coal Mine – LWB4-LWB7 Modification – Groundwater Assessment, May 2017".*

This report is the groundwater impact assessment prepared to support the DA29/95 MOD7 application and is based primarily on the Connell Wagner (2007) impact assessment. The report provides a comprehensive environmental setting and description of the conceptual hydrogeological model. The impact assessment is also based on review of updated climate and groundwater monitoring data and the proposed mine extensions.

This report predicts qualitatively as follows, *"Based on the findings of these previous groundwater investigations and ongoing groundwater monitoring at Austar Coal Mine, assessment of groundwater impacts for the proposed modification has been based on review of past and current monitoring above and surrounding current and prior underground mining areas. This review shows no adverse impacts on any high quality water resource or beneficial user. In addition, the proposed modification is encompassed within an area that has already been extensively mined. Recent approval applications at Austar Coal Mine have been based on similar empirical assessments of groundwater impacts, and this is an appropriate assessment approach for the proposed modification, as further discussed below."*

These appear to be reasonable given the history of surrounding mining impacts and monitoring. There is, however, a lack of predictive assessment, whether it is analytical or numerical. In effect, the assessment appears to be that substantial mining related groundwater impacts have already developed and minimal further impacts are expected: *"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."*. Also, "*the impacts of previous mining on other parts of both of these alluvial areas provides confidence that the proposed extraction from LWB4 to LWB7 will have no noticeable impact on the alluvial groundwater resources*."

A summary of the impact assessment findings is shown in Table 3.4.

Table 3.4 Summary of impact assessment by Dundon Consulting (2017)

Environment	Predicted impact	Notes
Subsidence	The disturbed or fractured zone) above extracted longwall panels is expected to be similar to those at panels LWA1 and LWA2, 85 m for LWA1 and 150 m for LWA2. The height of discontinuous fracturing above LWB4-B7 (i.e. the constrained or aquiclude zone) could extend to between 235 m and 355 m above the seam, well short of the ground surface (between 400 m and 505 m above the seam). Surface cracking in the soils above the proposed longwalls is not expected to be observed. Any surface cracking that might occur in the creek beds is expected to be minor and to infill naturally with subsequent streamflow events. Hence, the zone of discontinuous fracturing is not expected to reach the ground surface.	Section 5.1 of Dundon Consulting (2017)
Alluvium and Regolith	*"…no noticeable change in groundwater levels will be observed in the alluvium/colluvium/regolith aquifer after completion of the proposed Modification".* *"no change to either baseflows or streambed leakage"*	Section 5.3.1. of Dundon Consulting (2017) Section 5.4 of Dundon Consulting (2017)
Branxton Formation	*"Groundwater levels in the uppermost 100 m or so of the Branxton Formation are predicted to be unaffected by the proposed Modification."*	Section 5.3.2. of Dundon Consulting (2017)

Environment	Predicted impact	Notes
Greta Coal Seam	*"The Greta Coal Measures, including the Greta Seam, are predicted to be dewatered within the immediate proximity of LWB4-B7, and will also be substantially depressurised for some distance away from the longwalls, in a manner consistent with the already extracted longwall panels. No beneficial users will be affected."*	Section 5.3.3. of Dundon Consulting (2017)
Mine Inflows	"*The proposed Modification is expected to result in minimal increase in total water inflow to the mine, as the proposed panels are up-dip from the current LWB1 to LWB3 panels, into areas that are already substantially depressurised*." *"The water takes from the 'porous rock' water source for the currently approved mine plan are estimated by mine site Technical Services personnel to be less than 2 ML/d during the period from June 2016 to present, which equates to approximately 730 ML/y. This is based on a maximum rate of water removal from the mine of around 5 ML/d, of which approximately 3 ML/d is imported water."*	Section 5.2 of Dundon Consulting (2017) Section 7 of Dundon Consulting (2017)

3.1.6 Austar (2017b) - Annual Environmental Management Report

Yancoal Austar Coal Mine, 2017b. *"Annual Environmental Management Report, July 2016 – June 2017. September 2017".*

This report is a summary of environmental monitoring data for the period July 2016 to June 2017. The groundwater aspects of the report refer to groundwater inflow, groundwater levels and quality.

The report states that the **"***The total incidental groundwater interception of 699.7 ML for the reporting period is within the licensed groundwater interception of 770 ML in any 12 month period. The total incidental groundwater intercepted is greater than the 280 ML recorded for the 2015-2016 reporting period and similar to but greater than the predicted take of 550 ML prepared for the LWB1-B3 Environmental Assessment for DA29/95 MOD 6. A further groundwater assessment completed for the LWB4-B7 modification in May 2017 predicted groundwater take of approximately 730 ML, as estimated by mine site Technical Services personnel"* (Dundon Consulting, 2017).

The groundwater monitoring bores do not appear to show any impacts with the exception of MB01. The groundwater level in this bore (screened in the Branxton Formation) decreased during the reporting period as a likely result of mining at the site. An investigation was carried out in line with the SWMP protocol that found the change in water level coincided with an underground face "bump" and a microseismic event. Monitoring data also showed that the Branxton Formation in the area of MB02 is likely of very low hydraulic conductivity, as seen by the water level not recovering between groundwater monitoring events when the bore was heavily purged in previous years.

3.1.7 AGE (2017a) – September 2017 VWP monitoring

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2017a. *"Monitoring of Austar Colliery VWP Installation - EX01H. Project G1828C, September 2017."*

This report is a letter report prepared for internal Austar purposes on the data collected from vibrating wire piezometer (VWP) - EX01H (*located in the Stage 2 area near the intersection of Sandy Creek Road and Quorrobolong Road.)*. The report states that the VWP sensors are installed "*within the Permian geology both affected and unaffected by the zone of subsidence, and the underlying coal seam.",* namely at:

- 280 mbgl – above the predicted "height of connected subsidence" (i.e. fractured zone with changes in hydraulic parameters);
- 400 mbgl – within the predicted connected subsidence;
- 500 mbgl – within the "caved zone"; and
- 580, 607 mbgl and 618 mbgl – within in the GS roof, centre and floor, respectively.

The monitoring data showed that the coal seam body and floor have similar pressure heads indicating that the seam and floor are connected hydraulically and so will likely react to stresses in a similar manner (Figure 3.1). The coal seam roof appears to have a higher head than the seam (approx. 220 m higher). Heads of sensors more than 100 m above the coal seam, show pressure heads that do not appear to be impacted by mining.

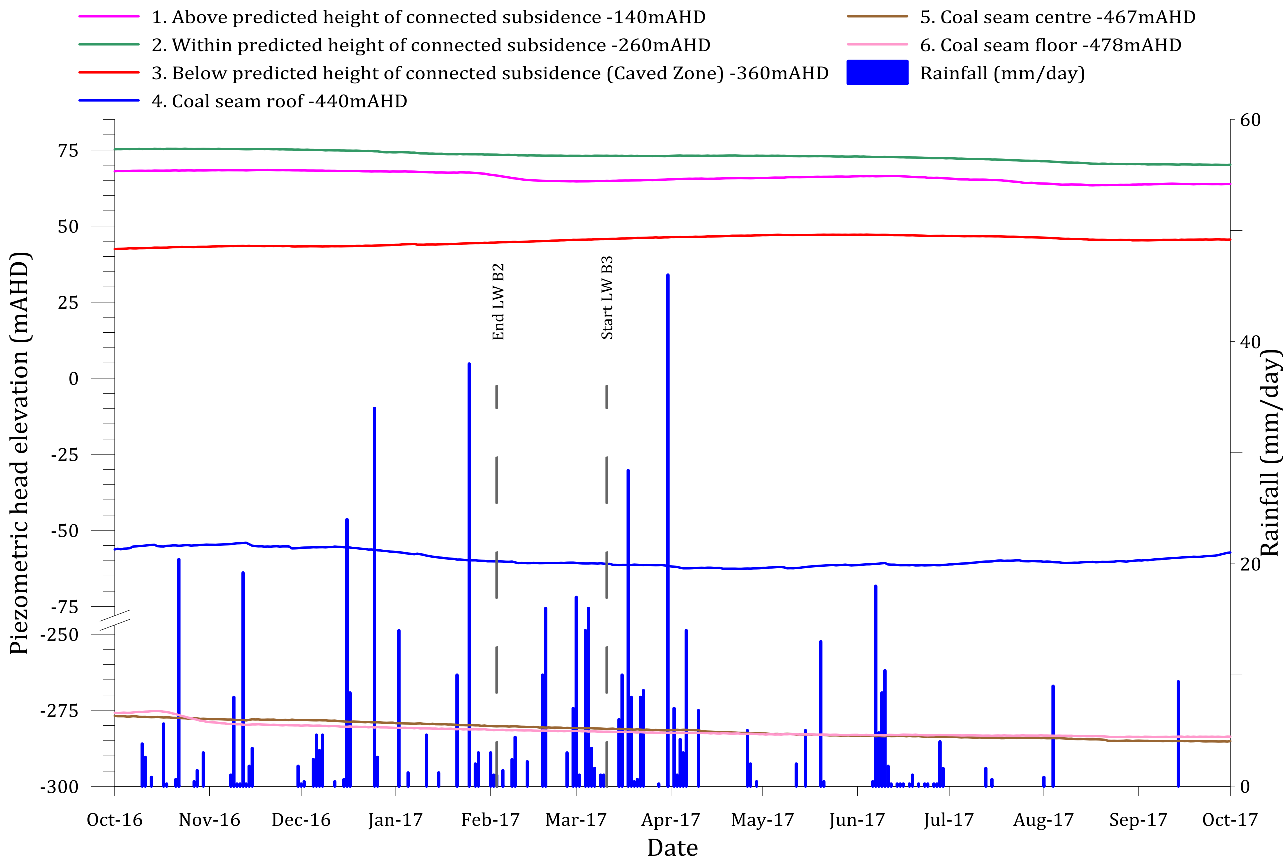


Figure 3.1 EX01H monitoring data

3.1.8 AGE (2017b) - September 2017 monitoring

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2017b. *"September 2017 Groundwater Monitoring. Project G1828C, September 2017."*

This report is an internal groundwater monitoring report reviewing the water levels and quality of seven site monitoring bores - NER1010, AQD1073a, WBH01, WBH02, WBH03, MB01 and MB02. The alluvium bore and shallow aquifer water levels are assessed against the SWMP and EPWMP triggers.

The groundwater monitoring bores do not appear to show any changes with the exception of MB01 and NER1010. MB01 was investigated previously, and the decreasing groundwater trend continued stabilise over the reporting period. NER1010 is located near the stage 2 mining area and LWB5 in the Bellbird South mining area (yet to be extracted) and presented a declining water level between August and September 2017. The pH values in this bore also increased over the same period. It is not clear whether the change in groundwater level and pH in this bore is entirely due to mining related impacts and/or to what degree climate has an influence.

3.1.9 AGE (2017c) - December 2017 monitoring

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2017c. *"December 2017 Groundwater Monitoring. Project G1828C, December 2017."*

This report is an internal groundwater monitoring report reviewing the water levels and quality of seven site monitoring bores - NER1010, AQD1073a, WBH01, WBH02, WBH03, MB01 and MB02. The alluvium bore and shallow aquifer water levels are assessed against the SWMP and EPWMP triggers.

The groundwater monitoring bores do not appear to show any changes with the exception of MB01 and NER1010. MB01 was investigated previously, and the decreasing groundwater trend continued stabilise over the reporting period. NER1010 is located near the stage 2 mining area and LWB5 in the Bellbird South mining area (yet to be extracted) and presented a declining water level between August and December 2017. The pH values in this bore also increased over the same period. It is not clear whether the change in groundwater level and pH in this bore is entirely due to mining related impacts and/or to what degree climate has an influence.

3.1.10 Austar (2017c) Extraction Plan

Yancoal Austar Coal Mine, 2017c. *"Austar Coal Mine Longwalls B4 to B7 Extraction Plan September 2017".*

The Extraction Plan for longwall panels LWB4 to LWB7 was prepared in accordance with the requirements of Schedule 3, Condition 3A of DA29/95. The objective of this Extraction Plan is to identify the management strategies for subsidence induced impacts on natural and built features from secondary extraction of longwall panels LWB4 to LWB7 within the GS at ACM using traditional longwall mining techniques.

The Extraction Plan includes a Water Management Plan for Longwall Panels LWB1-B7 (EPWMP) (Austar 2017d) which presents the predicted impacts of the extraction of LWB4 to LWB7, including potential impacts to private bores, GDEs, alluvium (against the AIP[2012]), water supply works, *highly connected surface water sources or water sources that represent a 'reliable water supply'*, and the beneficial uses of the alluvial or porous rock groundwater supply. Groundwater inflows to the mine were compared to the predicted 730 ML/year groundwater inflow.

The EPWMP Trigger Action Response Plan (TARP) includes a section relevant to groundwater (refer Figure 3.2).

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 the extent of the incident's impacts and identify contributing factors. Develop an appropriate course of action in consultation with relevant stakeholders and DPI-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.

Figure 3.2 EPWMP Trigger Action Response Plan

4 Analysis

4.1 Verification of measured groundwater impacts vs impact predictions

4.1.1 Predictions

The predictions made by the reviewed groundwater assessments use either conceptual and analytical methods (Connell Wagner, 2007) or conceptual hydrogeology only (Dundon Consulting, 2015 and 2017). This style of impact assessment is consistent with the following factors and features of the local hydrogeology:

- lack of some hydrogeological information (unconfined/confined aquifers, groundwater flow);
- complexity due to the highly modified groundwater regime;
- long-established mining impacts and only gradual incremental impacts with ongoing mining advance; and
- relatively little or no local use of groundwater.

The conceptual/analytical level of assessment also appears to be consistent with the hydrogeological setting and the fact that a lot of historical data, used by more complex predictive tools, cannot be re-created.

Although Connell Wagner (2007) used analytical tools (Darcy and Goodman equations), those are largely untraceable because the values used for various input parameters were not published. The assessments by Dundon Consulting (2015 and 2017) essentially do not predict further significant incremental impacts, based on conceptual hydrogeological considerations, and a pattern of limited incremental impacts with ongoing mining in recent years.

The predictions, against which the measurements would be compared in this report, are collated in Sections 3.1.1, 3.1.2, 3.1.3 and 3.1.5 and are subsequently summarised below in Section 4.1.6.

4.1.2 *Measurements*

The ACM shallow and alluvial aquifer groundwater monitoring network consists of eight bores (MB01, MB02, MB03, AQD1073a, NER1010, WBH1, WBH2 and WBH3; [Austar, 2017b]) which are monitored as part of the April 2017 SWMP (Austar 2017a). The 2017 SWMP, supersedes the 2013 SWMP, and was prepared to reflect progression to the LWB1-B3 Extraction Plan (Austar, 2016). The LWB1-B7 EPWMP (Austar, 2017d) includes an additional monitoring bore, installed as MB04. The SWMP and EPWMP outlines a monitoring program and key monitoring locations in areas which are potentially sensitive to mining impacts.

Although VWP installation - EX01H (formerly known as AQD1121) is not part of the SWMP, data from this monitoring point is also reviewed in Section 4. Data for DPI bores GW080974 and GW080975 were supplied by Austar. It is understood that monitoring of AQD1077, a multi-piezo installation, ceased in April 2008 due to loss of connectivity with the VWP sensors (Dundon 2017).

The monitoring locations are shown in Figure 4.1 and Table 4.1.

Table 4.1 Summary - ACM monitoring bores

ID	Monitoring target	Total depth (mbgl)	Screened zone (mbgl)	Easting	Northing	Collar (mAHD)	Status
AQD1073A	Alluvium	8.3		345700	6357254	123.40	Active
WBH1	Alluvium	15.5		346211	6357507	128.40	Active
WBH2	Alluvium	10.4		346212	6357326	123.19	Active
WBH3	Alluvium	9.2		346340	6357407	123.09	Active
MB03	Alluvium	9.7		345449	6355936	127.88	Active
MB04	Alluvium	8.4		344595	6356615	119.95	Active
NER1010	Branxton Formation	103.0	20-102	345044	6356952	124.00	Active
MB01	Branxton Formation	176.8	75-174	347207	6358279	157.87	Active
MB02	Branxton Formation	139.5	77-140	347726	6357706	133.31	Active
EX01H	Permian: Branxton Formation and Greta Coal Seam (various depths)		280, 400, 500, 580, 607 and 618 VWPs	346879	6356258	140.01	Active
AQD1077	Permian: Branxton Formation and Greta Coal Seam (various depths)*		30, 200, 310 , 360, 390, 424, 439 and 451 VWPs				No longer monitored
GW080974	DPI site, alluvium	7	3-6	345412	6356651	123.75	Monitored by DPI-Water and data provided to Austar

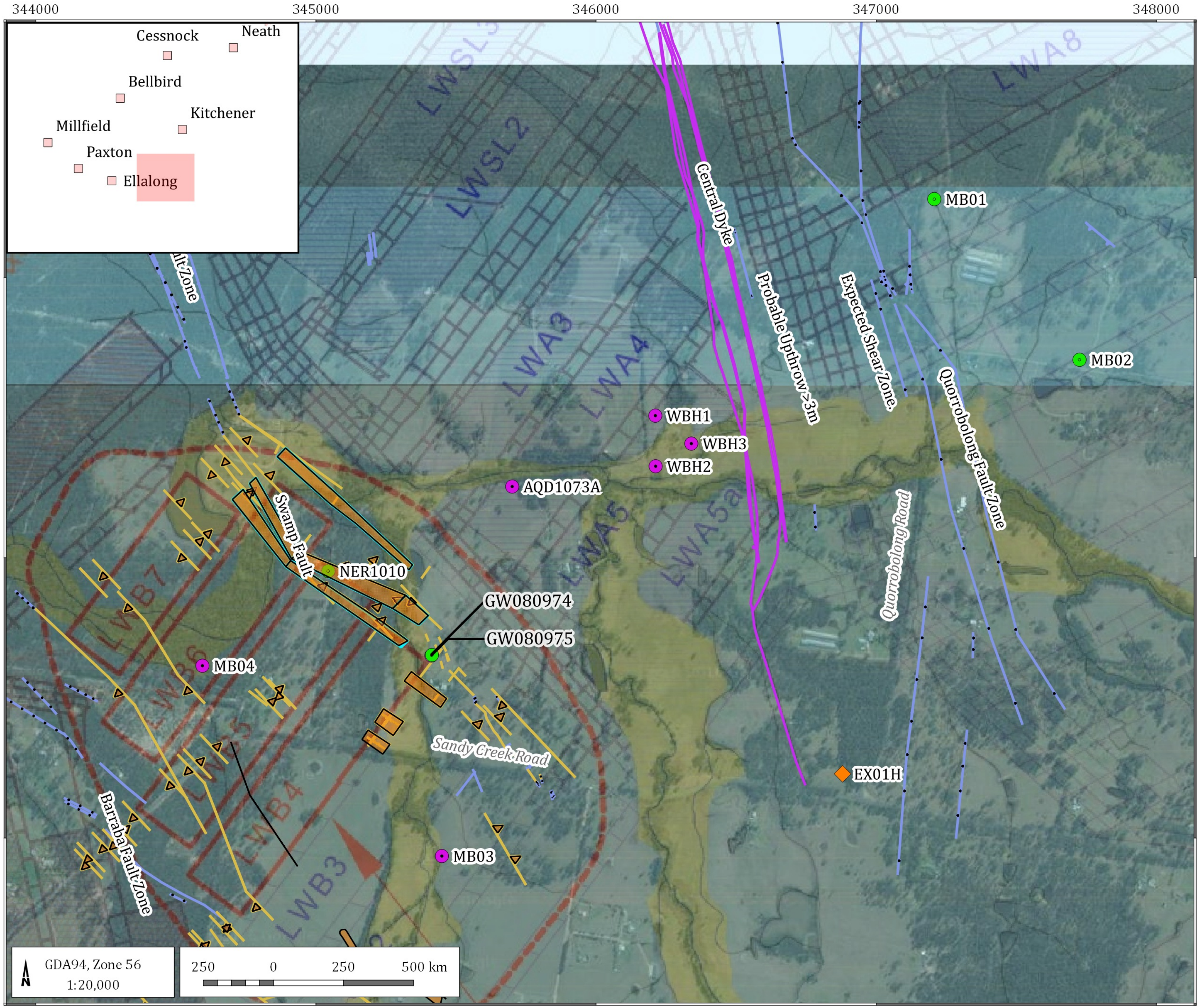
ID	Monitoring target	Total depth (mbgl)	Screened zone (mbgl)	Easting	Northing	Collar (mAHD)	Status
GW080975	DPI site, Branxton Formation	30	18-29	345414	6356653	123.85	Monitored by DPI-Water and data provided to Austar

***Note**: Coordinates are in GDA94, Zone 56*

The groundwater monitoring program includes quarterly (although pressure transducers provide high frequency data) monitoring of:

- groundwater levels (manual and automated pressure transducer measurements); and
- field water quality parameters –electrical conductivity (EC), pH and temperature.

The groundwater monitoring sites along with the longwall panels and geological structures are shown in Figure 4.1.



LEGEND

Populated place

Monitoring locations

- Alluvium
- Branxton Formation
- VWP, Branxton Formation and Greta Coal Measures

Geological structures

- Dyke
- Fault
- Fault zone
- Structures
- Geological symbol / areas

Historical Groundwater Review and Assessment, Austar Coal Mine (G1828G)

Austar monitoring bore and VWP locations

DATE
20/02/2018

FIGURE No:
4.1

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N:/Groundwater Jobs/G1828G.Austar Groundwater modelling and impacts review/G0000.Project Name_No_WHS/3_GIS/Workspaces/04_01_G1828G_Austar monitoring bore and VWP locations.qgs
Note: longwall panel background georeferenced accuracy ~10m.

4.1.2.1 Trigger values

The SWMP outlines the groundwater monitoring program, established triggers, actions and responsibilities for groundwater systems located within ACM.

The SWMP (Austar, 2017) defines impacts on groundwater (both in the alluvial aquifer and the "shallow porous rock" aquifer) when monitoring results are outside impact predictions. If the impact is sufficiently benign to cause no immediate adverse impact, the action is to increase monitoring frequency of logger download and review monthly whilst monitoring results are outside of predictions and continue to assess.

If the increased frequency of monitoring shows continual exceedance outside range of predictions (i.e. during three or more consecutive monitoring events in previous 12 months), or the monitoring results are outside impact predictions and cause immediate adverse impact, then the trigger incident reporting protocols (notify stakeholders, conduct an investigation to determine the extent of the incident's impacts and identify contributing factors) are actioned. Other triggers include developing an appropriate course of action in consultation with relevant stakeholders and DPI-Water, reviewing the monitoring program and the SWMP, and reviewing the groundwater assessment and updating monitoring and management plans.

The SWMP (Austar, 2013) established criteria to identify potential impacts to the alluvium aquifer and the shallow fractured rock aquifer; however, the criteria from the SWMP (2013) have been superseded by the criteria in the approved Water Management Plan in the Extraction Plan for LWB1-LWB3, which are incorporated into the SWMP (Austar, 2017). A further update has occurred through the approved Water Management Plan for LWB1-B7 (EPWMP) in the Extraction Plan for LWB4-LWB7. These criteria are set based on the potential impacts, as predicted by the three groundwater impact assessment that have been undertaken at site, and include:

- potential impacts to groundwater levels within the alluvial aquifer or shallow water bearing zones of porous rock aquifer;
- adverse impact on groundwater quality within alluvium or shallow water-bearing zones;
- adverse impact on groundwater quality or yield affecting other users;
- adverse impact on groundwater extraction infrastructure, including DPI Water monitoring bores within the LWB1-B7 WMP Area; and
- loss of near surface groundwater due to fracturing extending to the surface.

4.1.2.2 Groundwater levels, head and elevation

For clarity the following terms are used in this report:

- **Groundwater head** – short for groundwater potentiometric head. The potentiometric head (energy) of groundwater, at a given location (including depth of the water intake zone) and time. Normally, VWP and pressure transducer data, corrected to elevation, provide groundwater heads.
- **Groundwater elevation** is close to, but not necessarily identical to groundwater head. For the purposes of this report, and considering the depth of the bores, the salinity and the temperatures of the groundwater, the groundwater elevations and groundwater heads can be used interchangeably. Depth to groundwater measurement using a dipmeter, corrected to elevation, provides groundwater elevation.
- **Groundwater level** – normally measured by a dipmeter this is the depth to the water in a bore, normally as expressed as mbgl (metres below ground level) or mbrl (metres below reference level) or mbTOC (metres below top of casing).

Figure 4.2 shows all monitored groundwater heads (with the exception of multi-VWP installation site EX01H), monthly rainfall at the site and the cumulative rainfall departure (CRD) curve.

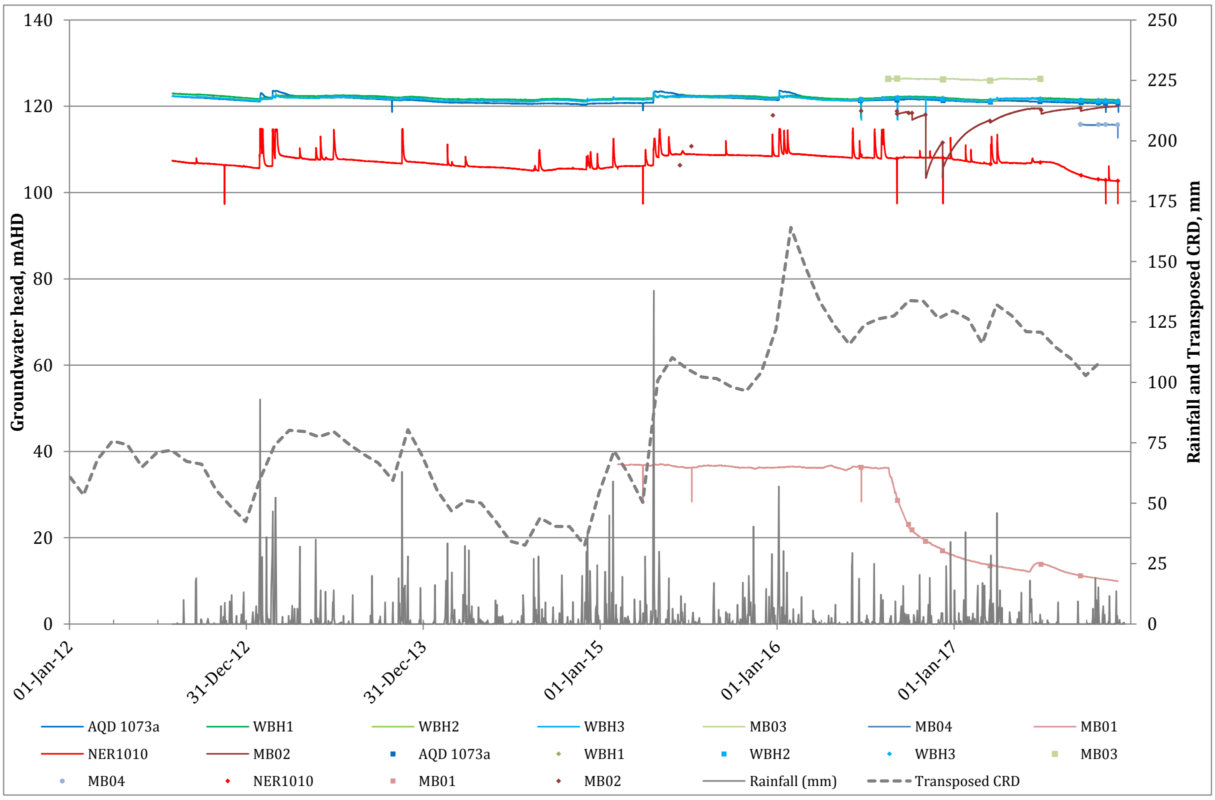

Figure 4.2 Groundwater head all sites but EX01H

The following comments/analyses are offered in relation to the data:

- The CRD is a qualitative method indicating dryer than average conditions by declining and higher than average rainfall periods by increasing trends. Accordingly, 2012-14 and 2016-17 represent dryer than average, and 2015 and early 2016 higher than average rainfall conditions. Generally, the shallower bores appear to be affected by significant rainfall events and water level trends appear to fluctuate long term with climatic condition variation.
- Heads in the alluvium are between 115 and 130 mAHD and appear to be stable with no mining induced impacts apparent.
- Heads in the Branxton Formation vary widely between 10 mAHD (MB01) and 120 mAHD (MB02 and NER1010) and show either a declining trend (MB01 and NER1010) or a trend that is suppressed by long recovery curves from the previously used purging technique for sampling at MB02. NER1010 has a lot of spikes which could be either errors or real pressure spikes such as external loading effects. The most important feature in Figure 4.2 in the Branxton Formation is the very low head in MB01. The head was approximately 36 mAHD prior to August 2016 and has declined since to about 10 mAHD by late 2017. Regardless of the decline, the head in MB01 is significantly lower than those in NER101 or MB02.
- Other important features in Figure 4.2 in the Branxton Formation are two different declines in head:
    - In MB01, the head declined from 36 m AHD to approximately 10 m AHD since August 2016. It is understood this decline may have been triggered by a vibration event related to mining and may have re-activated a preferential groundwater flow path near a fault.

- NER1010 is located approximately 500m north of the current workings and between the main headings and LWB5 (refer Figure 4.1). In NER1010, the head declined from 107 mAHD to approximately 103 mAHD since June 2017. AGE (2017b and 2017c) attributes this decline as probably to mining, noting that:
    - Longwall LWB3 was being mined in a north-easterly direction and at the end of June 2017, mining was ~630 m from NER1010 and ~ 480 m at the end of August; and
    - Austar geological structure polygons indicate the presence of a NW-SE oriented fault zone ("Swamp Fault" in Figure 2.3 and Figure 4.1) which runs very close to NER1010.

- The above indicates that NER1010 is visibly affected by major rainfall events and may also be impacted by mining via drainage of groundwater along a geological structure; however, the exact mechanism causing the water level decline is not clear.

- Figure 4.3 shows heads in the multi-VWP site EX01H, located approximately 700 m from LWB1 the current Bellbird South LWB1-B7 workings, and 775 m from nearest Bellbird South Stage 2 longwall panel – LWA5a. The initial data from February 2015 showed substantial (but not complete) depressurisation in the GS (607m VWP) and GS floor (618 m VWP), but less at the GS roof (580 m) VWP. Over the following months, the overburden strata (represented by GS roof (580 m) and caved zone (500 m) VWPs) gradually drained, and the pressures at these levels fell gradually. From June 2015, the pressures in the GS roof (580 m) and caved zone (500 m) VWPs started rising, suggesting re-saturation of the overburden strata, probably due to infilling of some of the connective cracks within the caved zone. During this time the seam and floor also started re-pressurising, probably as mining moved further away from the vicinity of the bore. During the whole period from 2015 to present, the upper strata (400 m and 280 m VWPs) remained almost unaffected by the mining. It remains unclear what is causing the large difference in heads within the GCM floor/centre and the roof. By December 2017, this difference, between the 580 m and 607 m deep VWPs, is approximately 220 m (subtracting -280 mAHD from -60 mAHD results 220 m). Further, it represents a downward vertical head difference in excess of 8 m/m. If vertical continuity within the strata between these depths, they suggest a very low hydraulic conductivity barrier between 580 m and 607 mBGL.

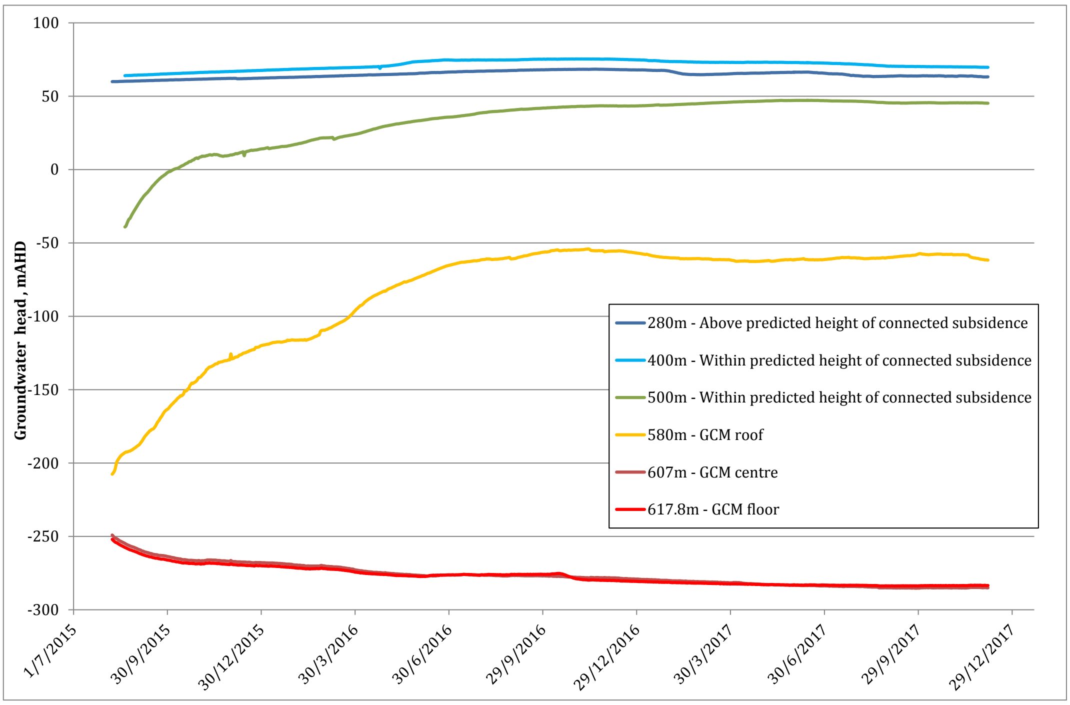

Figure 4.3 Groundwater head in EX01H

DPI monitoring bore GW080974 is located in the alluvium of an unnamed tributary overlying LWB1-B3 (Dundon Consulting, 2017). DPI monitoring bore GW080975 is located approximately 35 m north of the LWB4 take-off line, was drilled to a depth of 30 m, and intersects a low-yielding (1 L/s) water-bearing zone in the shale (Dundon Consulting, 2017) in the upper part of the Branxton Formation.

- Figure 4.4 shows heads in GW080974 and GW080975, between 120 mAHD and 124 mAHD. GW080974 is monitored with a pressure transducer; whereas, the water level in GW080975 is measured manually.
- Both GW080974 (alluvium) and GW080975 (upper Branxton Formation) appear to follow variations in rainfall and CRD. The high-frequency GW080974 datalogger shows large increases due to significant rainfall events/surface water recharge. The infrequent data for GW080975 follow in general the rainfall and CRD pattern and do not visibly respond to mining, consistent with the observations presented for NER1010.

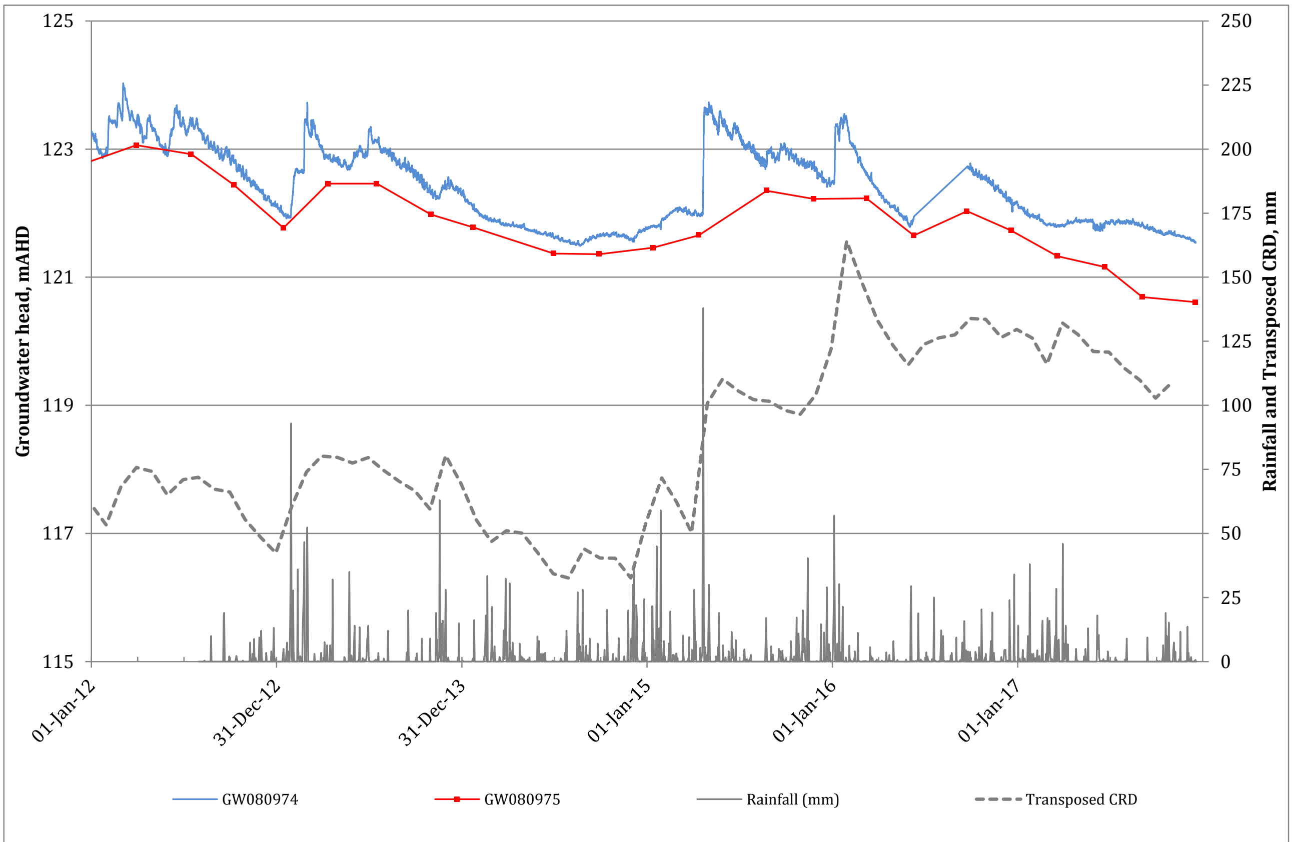

Figure 4.4 Groundwater head in GW080974 and GW080975, DPI bores

In summary, it appears that the alluvium and shallow geological units are influenced by rainfall events and hence are likely recharged by them. The alluvium has not shown mining related impacts to date, whereas the shallow Branxton Formation has shown potentially localised changes in water level that are likely to have been caused by mining related issues. The vibrating wire installation – EX01H – shows that the GS and GS floor have similar pressures and the working section is likely depressurised to some degree, although not completely depressurised. The depressurisation does not appear to extend beyond 100 m vertically from the working roof.

4.1.2.3 Groundwater quality

Field groundwater quality data are presented in Figure 4.5 (EC), Figure 4.6 (pH) and Figure 4.7 (temperature). Figure 4.5 (electrical conductivity [EC]) also includes the CRD described in Section 4.1.2.2.

The following comments/analyses are offered:

- It is understood that the sampling methodology has changed since 2016. Since 2016, the new bores MB01 and MB02 are sampled using hydrasleeve and the alluvial bores are purged. Previous purging caused large drawdowns and long and incomplete recovery in the low hydraulic conductivity materials, such as MB02 (Figure 4.2). Since 2016, alluvial ECs are between 3000 and 6000 µS/cm, prior to 2016 they were in general less than 1500 µS/cm.
- The expected inverse correlation between EC and RCD, that appeared until 2016 according to Dundon Consulting (2017) does not seem to hold after 2016. While the substantial increases in EC since early 2016 correspond to a lower than average rainfall (and decreases in groundwater head) they appear to be in excess of the increase in comparable periods, such as 2013-15.
- It is very unlikely that mining activity would cause such a sudden, simultaneous and large change in EC in all monitored bores, including those in the alluvium the groundwater head of which do not show mining impacts. This conclusion is consistent with Dundon Consulting (2017; with additional reasons provided in Comment No.7 of Section 3.1.5 of this report).
- The substantial increases in pH in MB01 and NER1010, and the approximately 2-3 °C variation in groundwater temperatures in MB01, MB02 and NER101 since 2016 are also likely due to the change in sampling methodology.
- It would be prudent in the future not to analyse the results of field groundwater quality using the pre-2016 and current sampling methodologies together. Once more data are available, only the results from 2016 onward could be analysed.

The groundwater quality is considered more representative of the natural environment as of 2016, with the improved groundwater monitoring. On this basis, the alluvium and shallow Branxton Formation groundwater quality is not considered suitable for potable purposes and only limited agricultural purposed (such as stock watering).

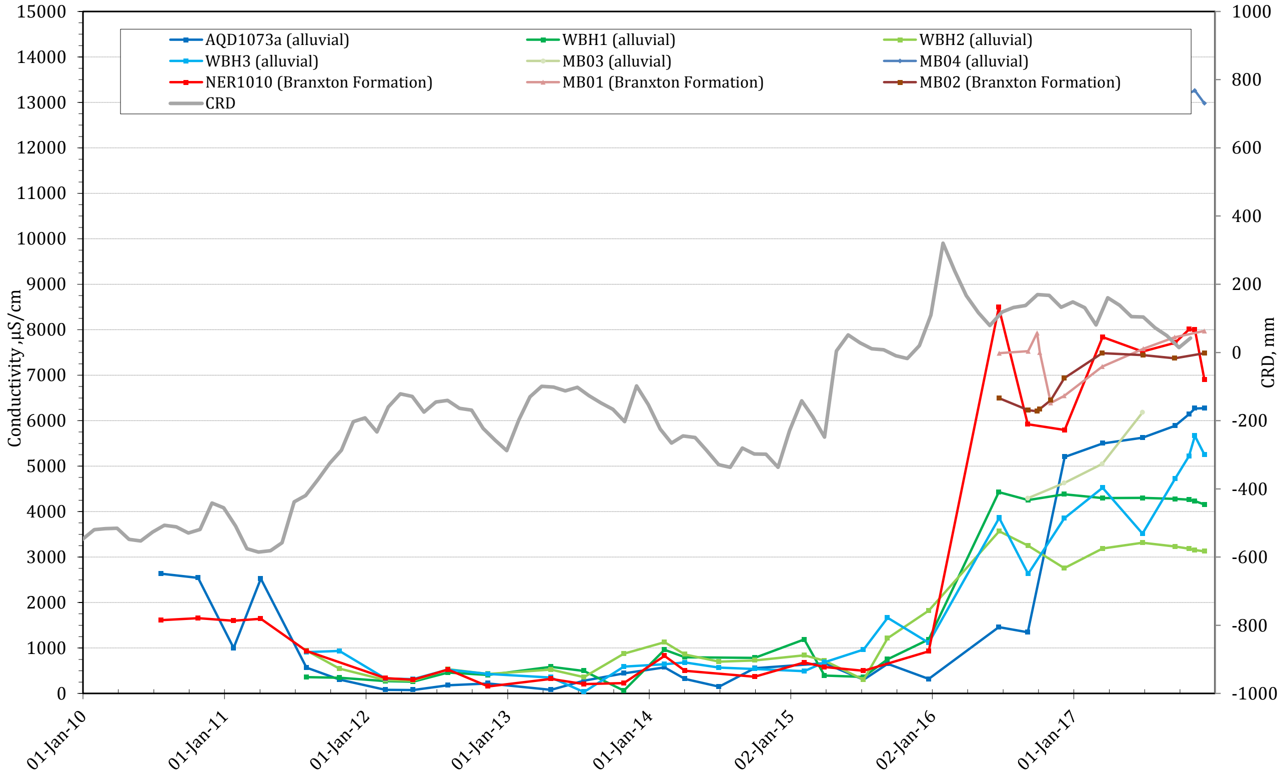

Figure 4.5 Groundwater EC

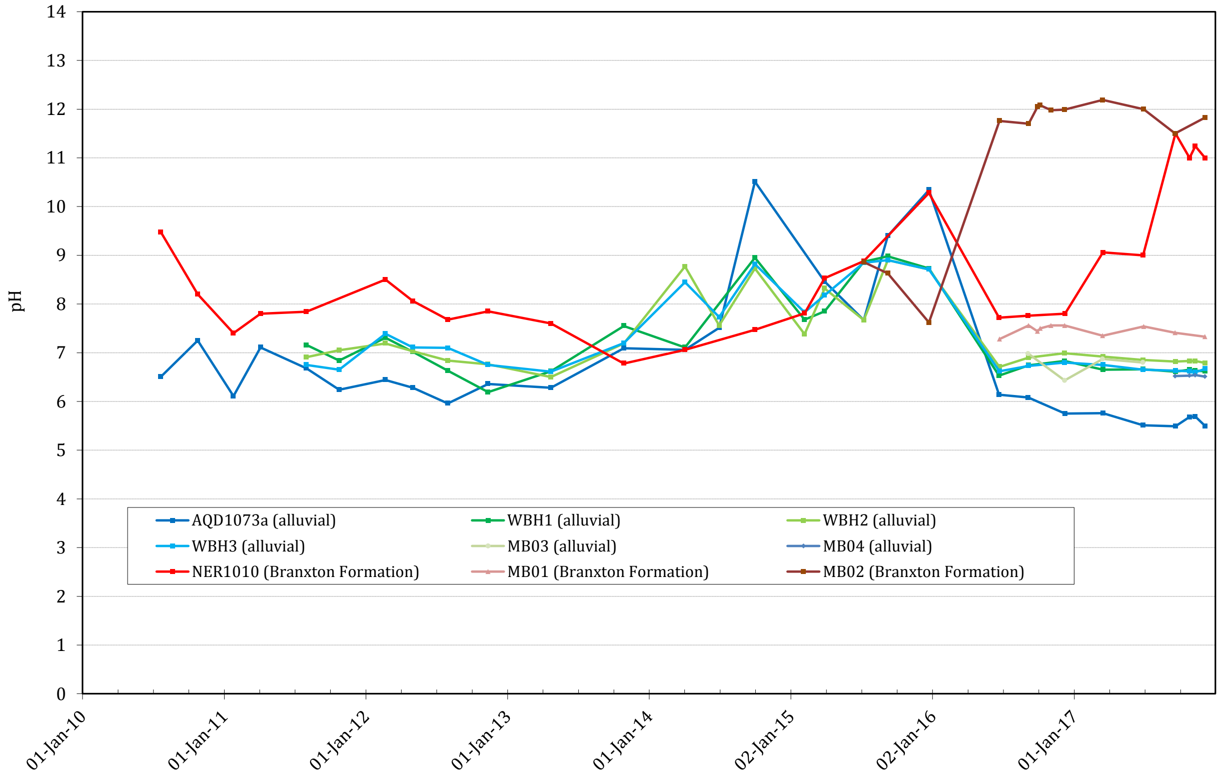

Figure 4.6 Groundwater pH

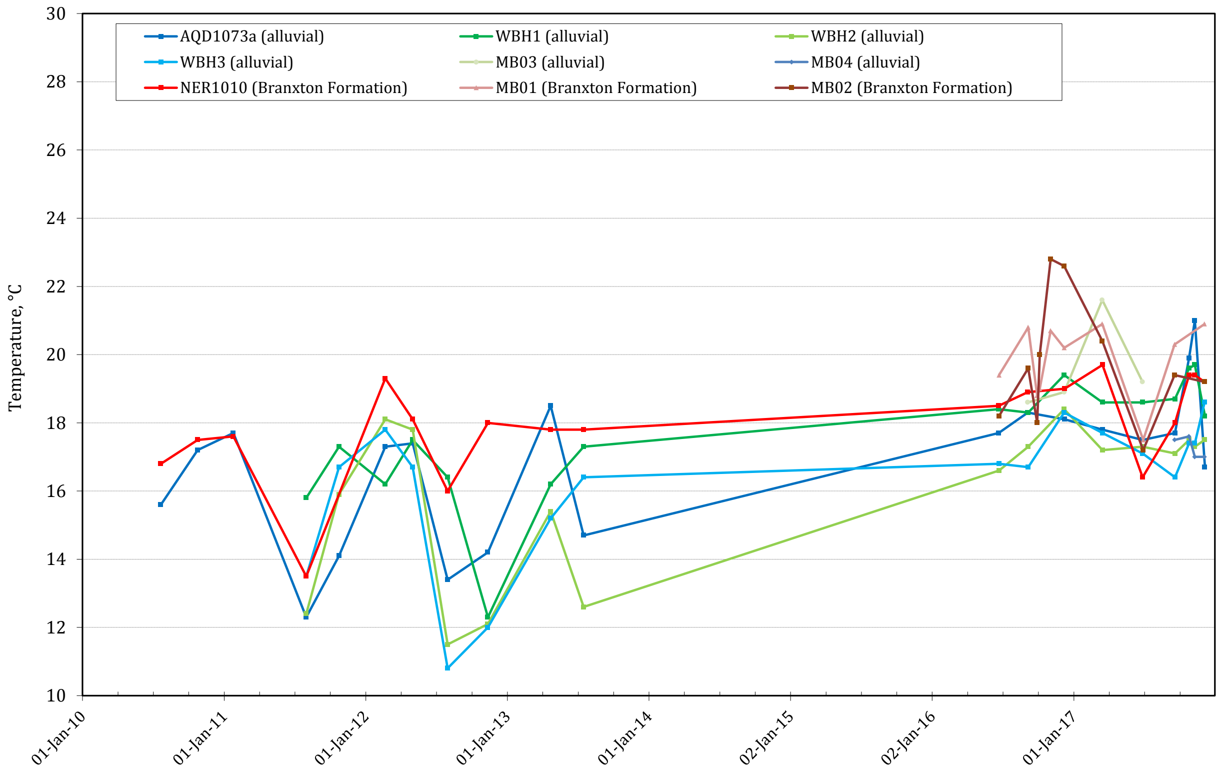

Figure 4.7 Groundwater temperature

4.1.2.4 Groundwater inflow to the mine

A detailed description of the mine water balance is presented in Austar (2017a) a summary of which is presented below. The mine has a complex groundwater management system that is heavily influenced by inflow from surrounding historic mine workings. There are many input sources, of which 'incidental groundwater interception', in Section 5.2.4 of the SWMP (Austar, 2017a) is only a part.

In essence, incidental groundwater interception is calculated from water balance as the difference between water delivered to the Bellbird South LWB1-B7 area (including recirculated water) and the water pumped out of the Bellbird South LWB1-B7 area.

The water delivered to the Bellbird South LWB1-B7 area is based on both metered and estimated flows minus the Stage 3 drilling water usage (although outside the Bellbird B1-B7 area, water is transferred from there). The amount of water pumped out is based on a mix of known pumping rates and operational duty estimates by Austar pumping personnel. The methodology for tracking abstracted volumes was updated in December 2017.

For the two year period of January 2016 to December 2017, data supplied by Austar indicate that 406 ML was delivered to the Bellbird South LWB1-B7 area and 524 ML was pumped out. The sources for the difference, 118 ML or 59 ML/year or 0.16 ML/day, includes water entering the active Bellbird South mining area from other adjacent mining areas and groundwater from storage from the seam areas extracted.

On a mine-wide scale, flowmeter measurements at the '*2ct 200 main pump*' that monitors flow to Ellalong goaf, indicate 1753 ML flow during the January 2016 to December 2017 period, an average of 2.4 ML/day.

4.1.3 Predictions vs. measurements – groundwater head

4.1.3.1 Alluvium

All reviewed assessments consider the alluvium as the most important natural groundwater resource in the vicinity of ACM and it follows that the potential or actual impacts on that resource are pivotal.

Groundwater head in the alluvium show generally stable conditions, with measured changes dominantly reflecting rainfall recharge (and possibly surface water recharge at high flows) effects. Section 4.1.2 presents the continuation of rainfall driven groundwater head trends that were identified in previous work (Connell Wagner, 2007, and Dundon Consulting, 2015 and 2017). Groundwater heads declined in 2012-14 and increased during 2015, consistent with monthly rainfall and the CRD. The recent (since January 2016) declining trend in the alluvium is dominantly due to low rainfall (lower than average rainfall and the lack of large or persistent rain and streamflow).

The large magnitude of near-instantaneous increase in head in alluvium, seemingly due to large rainfall events (for example April 2015) may suggest not just rainfall but the possibility of stream recharge, consistent with a statement made by Connell Wagner (2007). It is understood that stream flow or stage are not monitored in the vicinity of ACM, and therefore the separation to different recharge mechanism is impossible at present.

Consistent with the statements of Aurecon (2013) and Dundon Consulting (2015 and 2017) this review found that no significant effects can be attributed to mining in the alluvial hydrographs. Hence, measured groundwater heads follow the predictions made by Connell Wagner (2007) and Dundon Consulting (2015 and 2017), i.e. minimal or no impacts.

4.1.3.2 Permian strata

Groundwater head in the Branxton Formation show varying trends:

- stable conditions and no mining impact in the 280 m and 400 m deep VWP in EX01H;
- stable conditions followed by more recent declining trend in MB01 in the Stage 3 mining area and NER1010 in the Bellbird South mining area, both of which show a trend of initial decline followed by a levelling out trend which currently continues at each location;
- suppressed trend, by long recovery curves from the previously used purging technique for sampling at MB02; and
- continuing recovery trends since August 2015 in the 500 m deep VWP in EX01H.

Groundwater heads in the GCM show recovery (re-pressurisation) in the coal seam (607 m VWP), floor (618 m VWP) and overburden (580 m VWP) in EX01H since August 2015. All three piezometers had shown significant depressurisation at the start of monitoring (February 2015), and continued depressurisation.

The measured impacts therefore partially follow the predictions made by Connell Wagner (2007) and Dundon Consulting (2015 and 2017):

- *Extraction of the Greta Coal Seam will drain groundwater from the seam into the mine and lower the hydraulic head in the seam in the area to the south of the development.*
- *Any water-bearing zones which occur within the fractured zone above the Greta Coal Seam (i.e. the Lower Branxton Formation) will most likely drain into the mine opening during extraction of the longwalls.*
- *The impact of the proposed mining on the water-bearing zone at a depth of 70 to 100 metres will be negligible since it is located well above the zone of interconnected fracturing.*

Predictions 1 and 2 are confirmed by measurements, whereas measured impacts in the upper Branxton Formation, in MB01 and NER1010, can be attributed to mining. The results are, however, considered by this review to fall within the "*sufficiently benign to cause no immediate adverse impact"* classification used in Table 9.1 of the Extraction Plan Water Management Plan [EPWMP] (Austar 2017d) and SWMP (Austar, 2017a) because they are:

- localised;
- reversible (once groundwater heads recover post-mining); and
- groundwater resources in the Branxton Formation do not appear to be used locally.

4.1.3.3 Groundwater heads and subsidence in the shallow aquifers

The stable heads in the alluvium and in the 280 m and 400 m deep VWPs in EX01H, indicate no significant subsidence effect at the site. In addition, the results of micro-seismic monitoring, undertaken during mining of LWA5, have indicated that the height of fracturing likely does not extend above 220 m (SWMP, Section 8.2.4, Austar 2017a). These monitoring results support the prediction of no fracturing in the alluvial aquifer.

Of the five monitoring sites, referred to in Section 4.1.3.2, that "*intersect shallow aquifers*" (i.e. the Upper Branxton Formation), MB01, and potentially NER1010, show probable mining impact in the form of drawdown, not necessarily related to subsidence fracturing.

4.1.4 Groundwater quality

The field groundwater quality data appear to indicate large changes in EC, pH and temperature since 2016, most likely due to a change in sampling methodology. Insufficient representative data is available to correctly assess the potential impacts the groundwater quality; however, the alluvium and fractured groundwater quality is generally not suitable for any purpose other than limited agricultural purposes.

4.1.5 Mine inflow

The groundwater inflow to ACM, due to the depressurisation/dewatering of the Greta Seam and the Branxton Formation, was originally assessed by Connell Wagner (2007). As part of forward mine planning and to explore possible future changes to the water management system, Aurecon (formerly Connell Wagner) was engaged to explore potential groundwater impacts of proposed Stage 2 and Stage 3 underground mining. Predictions of future groundwater make indicated that the mine water management system had sufficient capacity to accommodate future groundwater inflows. A groundwater verification review for predicted inflows was prepared by Aurecon in 2012-2013 after completion of Longwall A5. This was intended to verify predictions from the 2007 Connell Wagner Report.

In relation to predicted future inflows, the groundwater verification by Aurecon (2013) found that:

- Mine water level data show that previously established trends in groundwater movement have generally continued without significant change.
- Mine pumping data indicate a net long term water make of approximately 3 ML/day for the whole mine (including recirculated flows). This is expected to continue at about this level, without significant increase, in the future.
- The original water make predictions were reviewed by mine staff to account for changes in mine plan. The prediction of 3.7 ML/day for whole of mine are more than, but consistent with, measured water make of 3 ML/day.

Inflows were predicted to increase from 0.7ML/day during Stage 1 to 1.2-1.3 ML/day during Stage 2 and to a maximum of 2.5 ML/day during Stage 3 mining. Reported groundwater inflow to Bellbird South LWB1-B7, 0.16 ML/day reported in Section 4.1.2.4, was below that predicted by Connell Wagner (2007). Additionally, the observed inflows in the Bellbird South area are in agreement with the prediction of Dundon Consulting (2017), *"The proposed Modification is expected to result in minimal increase in total water inflow to the mine, as the proposed panels are up-dip from the current LWB1 to LWB3 panels, into areas that are already substantially depressurised."*

4.1.6 Predictions vs. measurements – summary

The predictions made by EA (MOD 6) and EA (MOD 7) are valid against the vast majority of measured groundwater impacts. A summary of groundwater impact predictions versus measured groundwater monitoring results is shown in Table 4.2, and includes comments on the validity of the predictions.

Table 4.2 Comparison of predicted impacts vs measured impacts assessment

Environment	Predicted impacts (Connell Wagner [2007] and Dundon Consulting [2015 and 2017])	Measured impacts	Comments
Alluvium	Minimal, since the fractured zone above the mine is not expected to reach the ground surface and hence vertical drainage should not occur.	No impacts have been measured in any of the six alluvium monitoring bores in the ACM groundwater monitoring network.	The predictions made by Dundon Consulting (2015 and 2017) are all valid to the most important resource, the alluvium.
Branxton Formation	Any water-bearing zones which occur within the fractured zone above the Greta Coal Seam will most likely drain into the mine opening during extraction of the longwalls. The impact of the proposed mining on the water-bearing zone at a depth of 70 to 100 metres will be negligible since it is located well above the zone of interconnected fracturing.	One site, MB01, shows probable mining impact; however, the impact may not necessarily be related to the propagation of deeper drawdown impact from the Greta Coal Seam. NER1010 may also have been impacted by mining, but it too is not necessarily due to propagation of deeper drawdown impact from the Greta Coal Seam.	Predictions made to the Upper Branxton Formation are still considered valid as the impacts measured in MB01 and NER1010 are considered localised and not connected to each other. This impact, however, is sufficiently benign to cause no immediate adverse impacts because it is localised, reversible (once groundwater heads recover post-mining) and groundwater resources in the Branxton Formation do not appear to be used locally.
Greta Coal Seam	Extraction of the Greta Coal Seam will drain groundwater from the seam into the mine and lower the hydraulic head in the seam in the area to the south of the development. Since the incremental drawdown will be minimal, the groundwater quality is poor, the seam is very deep, and there are no known users of the resource, the impact is judged to be negligible.	VWP sensors in monitoring location - EX01H - in the Greta Seam and Greta Seam floor are very similar, and both indicate partial depressurisation due to mining. The VWP sensors in the overburden also show drawdown from mining, and subsequent recovery with mining occurring further from EX01H. No impact is apparent in the geology above 200m above the seam.	The predictions made to the Greta Seam are valid.
Mine Inflows	• 1.2 to 1.3 ML/d for Stage 2 (A3-A5) • 0.54 ML/d for A6 • 1.74 to 2.47 ML/d for Stage 3 (A7-A17) • Small incremental increase in inflows for Bellbird South MOD6 (see page 10 of Dundon 2015) or MOD7 (LWB1-B7) (Dundon 2017)	Average of 0.16 ML/day for 2016-17 (B2-B4). Only A7 and A8 mined, further Stage 3 mining has been suspended between June 2015 to date.	Reported groundwater inflows to Bellbird South LWB1-B7were below those predicted by Connell Wagner (2007), and in line with predictions from Dundon Consulting (2015, and 2017).

4.2 Assessment of the effectiveness of the existing groundwater model for current and future mining

AGE reviewed the groundwater impact assessments undertaken by Connell Wagner (2007) for the initial approval and by Dundon Consulting (2015 and 2017) for the MOD6 and MOD7 applications, respectively. The groundwater review by Aurecon (2013) was also reviewed.

The predictions made in the reviewed groundwater assessments use either conceptual and analytical methods (Connell Wagner, 2007) or conceptual hydrogeology only (Dundon Consulting, 2015 and 2017). This style of impact assessment is consistent with a system with a lack of historical hydrogeological information.

Based on the review undertaken by AGE, the predictions made in the initial assessment and the MOD6 and MOD7 impact assessments are appropriate and provide effective tools for current and future predictions.

4.3 Assessment of the effectiveness of the Extraction Plan and Water Management Plan for the development

AGE reviewed the SWMP and Longwall Extraction Plan prepared by Austar (2017a and 2017c, respectively). In relation to groundwater, the April 2017 SWMP (Austar 2017a) was prepared to reflect progression to the LWB1-B3 Extraction Plan Water Management Plan (Austar, 2016).

The Longwall LWB4-B7 Extraction Plan (Austar 2017c) is well suited to reviewing the potential impacts associated with longwall extraction and informing site in regards to potential monitoring required, and includes the LWB1-B7 Water Management Plan (Austar, 2017d) with an additional monitoring bore (which has been installed MB04) and a Trigger Action Response Plan to manage any identified impacts. The SWMP also outlines targeted strategies for monitoring of potential groundwater impacts, using specific monitoring bores to monitor key hydrogeological units. The criteria in the TARP from the SWMP (2013) have been superseded by the criteria in the TARP of the approved Water Management Plan in the Extraction Plan for LWB1-LWB3, which are incorporated into the SWMP (Austar, 2017), and these have been slightly updated by the criteria in the TARP in the EPWMP associated with the Extraction Plan for LWB4-B7.

The current monitoring program of the most recently approved EPWMP and the SWMP are assessed as appropriate to monitor impacts predicted by the Environmental Assessments of DA29/95 MOD6 and DA29/95 MOD7 to groundwater. The TARPs in the relevant management plans are assessed as appropriate to identify and manage impacts to groundwater that may be identified for development, currently and in the future.

For consistency, it is recommended that the SWMP (Austar 2017a) be updated to include the approved EPWMP monitoring and management protocols.

5 Conclusions

AGE was commissioned by Austar Coal Mine to assess observed groundwater conditions in comparison to predicted potential impacts at ACM. The review is required by Condition 12A (Schedule 3) of the MOD7 development consent for DA29/95. The findings of this review are summarised in Table 5.1 and details of the findings are outlined in the following sections under headings that address Condition 12A.

Table 5.1 Consent conditions vs findings

Condition	Conclusion	Finding
Impact predictions in EA (MOD 6) and EA (MOD 7) vs measured groundwater impacts	The predicted impacts by the groundwater impact assessments from the DA29/95 MOD6 EA, and the DA29/95 MOD7 EA have, in general, been validated by measurements.	The predictions when compared to current groundwater monitoring data (groundwater levels, quality and mine inflow) are **valid**.
Effectiveness of the existing groundwater model for use in current and future mining operations	There has been no material departure identified from the groundwater predictions in the DA29/95 MOD6 EA, and the DA29/95 MOD7 EA.	The groundwater assessments are **appropriate** and provide **effective** tools for current and future predictions.
Continued effectiveness of any approved Extraction Plan or Water Management Plan	The most recently approved EPWMP and the SWMP outline targeted strategies and TARPs for monitoring of potential impacts as predicted by the environmental assessments of DA29/95 MOD6 EA, and the DA29/95 MOD7 EA.	The most recently approved EPWMP and the SWMP are assessed as **appropriate** and **effective** tools to monitor for potential mining induced impacts.

Condition 12A (a) – Validate the impact predictions in EA (MOD 6) and EA (MOD 7) against measured groundwater impacts;

Following an overview of mining and hydrogeology, a detailed review of ten publications dated between 2007 and 2017, was completed. Monitoring data were presented, analysed and evaluated against predictions.

Analysis of the data, in combination with the reviews presented in Section 3, revealed a general agreement between predicted and measured impacts, in particular for the most important alluvial groundwater resource that does not show any impacts related to mining, i.e. *any impact that may have been caused by mining is insignificant in magnitude, compared to those caused by rainfall and streamflow recharge.*

There are two sites, NER1010 and MB01 (refer Sections 3.1.8 and 3.1.9), in the Upper Branxton Formation, that show unpredicted changes. In the case of NER1010, these are dominantly linked to changes in rainfall/stream recharge and were traced back to the long screen interval, from 20 mbgl to 102 mbgl. That is, NER1010 is likely to show a composite groundwater head, a hydraulic conductivity weighted average of all groundwater heads within the screened zone. It is therefore possible that NER1010 reacts to both rainfall recharge from above (either via leakage from the alluvium or recharge from nearby Branxton Formation outcrop) and mining induced drawdown from a confined aquifer intersected by the bore. The groundwater impact assessment for the MOD7 modification concluded that *"… based on worst case predictions of subsidence fracturing impacts, groundwater in fracture zones in the uppermost 100 m or so of the Branxton Formation could theoretically experience temporary impacts …"* (ie to within the depth intersected by NER1010) although this would be unlikely to occur until mining of LWB5.

The low groundwater head in MB01, the head difference between MB02 and MB01, and the proximity of MB01 to an already mined longwall panel, LWA8, however, suggest a mining related impact. It is possible that the head in MB01 was lowered by mining induced drawdown in the underlying GS and drawdowns in the overburden due to subsidence effects. However, the mechanism causing these impacts are likely localised and would be difficult to replicate in a conceptual, analytical or numerical model. The impact measured in the Branxton Formation, however, is sufficiently benign to cause no immediate adverse impacts as it is:

- localised;
- reversible (once groundwater heads recover post-mining); and
- groundwater resources in the Branxton Formation do not appear to be used locally.

Impacts on groundwater quality, although unlikely in the alluvium, cannot be established with certainty because of the large variations caused by changes in sampling methodology, and the natural variability associated with seasonal effects of natural recharge and discharge.

In summary, the predicted impacts by the groundwater impact assessments from the DA29/95 MOD6 EA, and the DA29/95 MOD7 EA have, in general, been validated by measurements.

Condition 12A (b) – Evaluate the effectiveness of the existing groundwater model for use in current and future mining operations.

As discussed in Section 4.2, the predictions made in three groundwater assessments (Connell Wagner, 2007, Dundon Consulting 2015 and Dundon Consulting 2017) for the site were undertaken to investigate potential impacts to the groundwater system. The conceptual models utilised in these assessments were based on site specific data and area specific understanding of the geology and hydrogeology. The authors' knowledge and understanding of groundwater systems and impacts from underground mining at site, in the area and elsewhere, were used to further refine the models and apply them to the site.

Groundwater monitoring data to date, discussed above, correctly reflect the modelled potential impacts, with the exceptions of two minor localised impacts. Reported groundwater inflows to Bellbird South LWB1-B7 were below those predicted by Connell Wagner (2007) and in line with predictions from the DA29/95 MOD6 and MOD7 Groundwater Impacts Assessments by Dundon Consulting (2015, and 2017).

Based on the review undertaken by AGE, the predictions made in the initial assessment and the MOD6 and MOD7 impact assessments are appropriate and provide effective tools for current and future predictions.

Condition 12A (c) – Evaluate the continued effectiveness of any approved Extraction Plan or Water Management Plan for the development:

The site groundwater issues are currently managed under two main documents – the SWMP and Longwall B1-B7 Extraction Plan Water Management Plan (EPWMP) prepared by Austar (2017a and 2017d, respectively). The current monitoring program of the most recently approved EPWMP and the SWMP are assessed as appropriate to monitor impacts predicted by the Environmental Assessments of DA29/95 MOD6 and DA29/95 MOD7 to groundwater. The TARPs in the relevant management plans are assessed as appropriate to identify and manage impacts to groundwater that may be identified for development, currently and in the future. For consistency, it is recommended that the SWMP (Austar 2017a) be updated to include the approved EPWMP monitoring and management protocols.

In summary, the groundwater impact assessments undertaken to date for the development, and SWMP and Longwall Extraction Plan and associated Water Management Plan as approved for the development, are generally fit for purpose to manage groundwater issues for the development described by DA29/95 MOD6 and MOD7 for current and future mining. Further, there has been no material departure identified from the groundwater predictions in the DA29/95 MOD6 EA or the MOD7 EA.

6 References

Aurecon, 2013. "*Groundwater review after LWA5, Austar groundwater project, Austar Mine*". Draft, Revision No.1, March 2013.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2017a. *"Monitoring of Austar Colliery VWP Installation - EX01H. Project G1828C, September 2017." Draft report.*

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2017b. *"September 2017 Groundwater Monitoring. Project G1828C, September 2017." Draft report.*

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2017c. *"December 2017 Groundwater Monitoring. Project G1828C, December 2017." Draft report.*

Connell Wagner, 2007. *"Appendix 14. Future Mine Development Groundwater Impact Assessment Austar Coal Mine. October 2007."*

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

Dundon Consulting, 2017. *"Austar Coal Mine – LWB4-LWB7 Modification – Groundwater Assessment, May 2017"*

Yancoal Austar Coal Mine, 2016. *"Austar Coal Mine Longwalls B1 to B3 Extraction Plan Water Management Plan, July 2016."*

Yancoal Austar Coal Mine, 2017a. *"Site Water Management Plan. April 2017".*

Yancoal Austar Coal Mine, 2017b. *"Annual Environmental Management Report, July 2016 – June 2017. September 2017".*

Yancoal Austar Coal Mine, 2017c. *"Austar Coal Mine Longwalls B4 to B7 Extraction Plan September 2017."*

Yancoal Austar Coal Mine, 2017d. *"Austar Coal Mine Longwalls B1 to B7 Extraction Plan Water Management Plan September 2017."*

Attachment A

Submission

YANCOAL
兖煤澳大利亚有限公司

AUSTAR COAL MINE
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02 July 2018

Howard Reed
Director – Resource Assessments
Department of Planning and Environment
GPO Box 39
SYDNEY NSW 2001

Dear Howard,

SUBMISSION OF *REPORT ON HISTORICAL GROUNDWATER REVIEW AND ASSESSMENT AUSTAR COAL MINE* REQUIRED BY DEVELOPMENT CONSENT DA29/95 MOD7 SCHEDULE 3 CONDITION 12A

Austar Coal Mine Pty Ltd (Austar) is required to review the groundwater impacts of the development as required by Schedule 3 Condition 12A of Development Consent DA29/95 MOD 7.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) were engaged to undertake the groundwater review and prepared the **attached** *Report on Historical Groundwater Review and Assessment Austar Coal Mine* (01 March 2018 v01.07). The groundwater review was undertaken in consultation with DoI-Water (response **attached**). Austar also engaged Dundon Consulting Pty Limited to review the AGE Report and DoI-Water's response, and advise on and respond to the DoI-Water comments and recommendations. Dundon Consulting's response is **attached**.

The AGE Report assessed observed groundwater conditions in comparison to predicted potential impacts at Austar Coal Mine. It was found that: the predictions when compared to current groundwater monitoring data are valid; the groundwater assessments are appropriate and provide effective tools for current and future predictions; and the most recent approved Extraction Plan Water Management Plan LWB1-B7 and the Site Water Management Plan are assessed as appropriate and effective tools to monitor for potential mining induced impacts.

The AGE Report, DoI-Water comments and recommendations, and Dundon Consulting's response are submitted. Austar kindly request the Department review the enclosed documents and seek the Secretary of the Department's satisfaction of this condition.

If you have any queries in relation to this matter, please do not hesitate to contact me on (02) 4993 7334.

Yours faithfully,

Carly McCormack
Environment & Community Superintendent
Austar Coal Mine
Ph: 02 4993 7334
Email: Carly.McCormack@yancoal.com.au

Enclosed:

- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), *Report on Historical Groundwater Review and Assessment Austar Coal Mine* (01 March 2018 v01.07)
- DoI-Water, Letter re: *Austar Coal Mine Groundwater Verification Review - DA29/95 MOD7* (03 April 2018)
- Dundon Consulting Pty Limited, Letter re: *Austar – DoI-Water Response to Groundwater Verification Review – DA29/95 (MOD7) – Condition 12A, Schedule 3* (28 June 2018)

Our ref V13/3707#7 & OUT18/5597

Gary Mulhearn
Environment and Community Manager
Austar Coal Mine
Locked Bag 806
Cessnock NSW 2325

via email: Gary.Mulhearn@yancoal.com.au

Dear Mr Mulhearn,

Re: Austar Coal Mine Groundwater Verification Review - DA29/95 MOD7

I am writing in reference to your correspondence sent to DoI Water on 1 March 2018, requesting a review of the Groundwater Review and Assessment report prepared by Australian Groundwater and Environmental Consultants Pty Ltd and dated 1 March 2018.

DoI Water notes that the report has been submitted in accordance with condition 12A, Schedule 3 of consent DA29/95 MOD7 and provides the following comment and recommendations.

- The proponent should develop a numerical groundwater model consistent with previous recommendation by DoI Water for the Modification (MOD7) development consent.
- The proponent should prepare a report to investigate and identify the driver for the change in beneficial use of groundwater resources. This report will need to:
    - confirm how each monitoring bore is currently sampled;
    - verify correct low-flow sampling and sample-handling protocols, and adequate equipment cleaning between sampling sites;
    - verify the salinity field and lab measurements: meter calibration, sensor, calibration fluid maintenance etc; comparing field-measured parameters with equivalent lab results;
    - review the duplicate samples against primary samples results;
    - advise on significant equipment, sampling, handling, storage or analytical issues;
    - confirm from observed time-series data how responsive each aquifer is, that is, pressure-response lag time with respect to climatic and mining stress "events", to inform aquifer connectivity and whether an increase in salinity could be realistically expected and, if so, when and where;
    - if data is available, compare ion ratios with respect to conservative ions (especially Cl and Br) for samples collected prior to and after the salinity increase. These ratios should not significantly change in every individual aquifer if the response is climatically driven. This is because some of these aquifers must be a contributing source of water to other aquifers and thus would remain

stable in chemistry. Use these ionic ratios to quantify any connectivity (mixing) between aquifers, again to identify processes;

  - complete charge balance error to ensure collection of representative data;
  - if data is available, review the concentrations of minor and trace elements, isotopes (especially of Sr), dating, etc; if so, other ratios and water signatures; and
  - make recommendations to improve the veracity of the water quality monitoring program and develop appropriate interim performance measures as part of the Trigger and Action and Response Plan. These performance measures will need to be included into the updated Site Water Management Plan.

- The proponent should have an independent expert review the above report and submit to DoI Water.

A DoI Water hydrogeologist can be made available should you wish to discuss any points raised in this letter.

Please contact Ryan Shepherd, Water Regulation Officer (Newcastle) on (02) 4904 2650 or ryan.shepherd@dpi.nsw.gov.au if you have further enquiries regarding this matter.

Yours sincerely

Irene Zinger
Manager Regulatory Operations – Metro

03 April 2018

Dundon Consulting Pty Limited
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28 June 2018

Austar Coal Mine Pty Ltd
Locked Bag 806
CESSNOCK, NSW 2325

Attention: Ms Carly McCormack

Dear Carly,

Austar – DoI-Water Response to Groundwater Verification Review – DA29/95 (MOD7) – Condition 12A, Schedule 3

Condition 12A, Schedule 3 of DA29/95 requires Austar to review the groundwater impacts associated with the approved MOD 6 and MOD 7 (i.e. Longwalls B1-B7) developments. This review (among other things) must be undertaken in consultation with the Department of Industry - Water (DoI Water).

Austar engaged AGE (Australasian Groundwater and Environmental Consultants) to conduct the required groundwater review and on 1 March 2018 Austar provided the AGE review report to DoI Water for its review and comment. On 3 April 2018 DoI Water provided its comments on the AGE review report.

I have reviewed DoI Water's comments and discussed these with Mr John Williams (DoI Water Hydrogeologist), the primary author of DoI Water's comments.

The following response is provided based on my review of DoI Water's comments and following discussion with John Williams.

DoI Water Comment (Letter dated 3 April 2018)	**Response**
The proponent should develop a numerical groundwater model consistent with previous recommendation by DoI Water for the Modification (MOD7) development consent.	DoI-Water acknowledges the AGE report has been prepared in fulfilment of Condition 12A, Schedule 3 to DA29/95, but has simply restated its position expressed in its submission on the DA29/95 MOD7 application. Condition 12A, Schedule 3 to DA29/95 includes a trigger for developing a "*revised groundwater assessment*"… including … "*quantitative surface and groundwater modelling*" **but only if** there is a material departure of observed impacts versus predicted impacts (as assessed in the MOD6 and MOD7 applications). The AGE verification report does not identify any such material departure from predicted groundwater impacts, therefore the requirement to

DoI Water Comment (Letter dated 3 April 2018)	Response
	update predictions using quantitative modelling has not been triggered and is not required (at this stage) under this consent condition.
The proponent should prepare a report to investigate and identify the driver for the change in beneficial use of groundwater resources. This report will need to:	DoI Water has expressed the view that the reported increase in EC in the alluvium monitoring bores in 2016 represents a change in beneficial use of the alluvial groundwater, based on a similar increase being observed in two DoI Water monitoring bores – GW080974 and GW080975 in the vicinity. Firstly, the EC rise in Austar's bores was first noted in samples collected on 22-23 June 2016, coinciding with the change of monitoring contractor (from Aurecon to AGE). However, the EC rise in DoI Water bore GW080975 did not occur until 18 December 2017 and at 22 May 2018 in GW080974. Note that the EC at GW080975 was also very high prior to October 2012, at a time when the Austar alluvium bores had ECs below 1,000 µS/cm. So there is not a coincidence of timing of EC increases at all bores. See attached **Table 1** and **Figure 1**. Consequently, Secondly, DoI Water has not understood the change of sampling technique as reported by AGE in the verification report. There have in fact been two changes of sampling method – the first change took place from June 2016, and was a change to more thorough purging prior to sampling; the second change occurred sometime in 2017, and involved the use of hydrasleeve in the two deep Permian bores MB01 and MB02, as these bores were not recovering from purging between sampling events. This second change of sampling method only applied to the two deep bores, and the alluvium bores continue to be purged prior to sampling. The AGE verification report only referred to the second sampling method change (at page 33); the first method change was reported previously in [1]AGE (2016). Note that nothing is known about the sampling method employed at the two DoI Water bores.
confirm how each monitoring bore is currently sampled;	In response to this comment, I recommend a brief description of the current groundwater monitoring bore sampling method be included in the Site Water Management Plan (SWMP) when next it is revised. I suggest this include reference to applicable sampling and testing guidelines and standards as appropriate.
verify correct low-flow sampling and sample-handling protocols, and adequate equipment cleaning between sampling sites;	See above.

[1] *"Yancoal-Austar June 2016 Groundwater Monitoring Report",* dated 30 September 2016

DoI Water Comment (Letter dated 3 April 2018)	Response
verify the salinity field and lab measurements: meter calibration, sensor, calibration fluid maintenance etc; comparing field-measured parameters with equivalent lab results;	See above.
review the duplicate samples against primary samples results;	Duplicate sampling is not considered necessary at Austar, since the monitoring consists only of EC, temperature and pH, all of which can be determined by field measurement, such that any anomalies can be verified immediately. Further, the SWMP requires that any (water) parameter that exceeds a trigger value be checked by follow-up sampling, and investigation if necessary.
advise on significant equipment, sampling, handling, storage or analytical issues;	See above.
confirm from observed time-series data how responsive each aquifer is, that is, pressure-response lag time with respect to climatic and mining stress "events", to inform aquifer connectivity and whether an increase in salinity could be realistically expected and, if so, when and where;	I understand this is addressed in the Annual Review process which examines trends or anomalies in the monitoring data and compares these against the assessment predictions, including holistic consideration of water levels/pressures, water quality, rainfall and mining activity, including any observed subsidence.
if data is available, compare ion ratios with respect to conservative ions (especially Cl and Br) for samples collected prior to and after the salinity increase. These ratios should not significantly change in every individual aquifer if the response is climatically driven. This is because some of these aquifers must be a contributing source of water to other aquifers and thus would remain stable in chemistry. Use these ionic ratios to quantify any connectivity (mixing) between aquifers, again to identify processes;	There is no specific ionic data available either from Austar's bores or from the DoI Water bores. The monitoring at Austar which comprises only EC, temperature and pH is considered sufficient to be able to detect changes in beneficial use as the beneficial use categories are based only on EC/TDS and pH. Testing for major ions is often done at the initial investigation stage as part of the groundwater characterisation process. At this stage testing of major ions would serve no useful purpose in the absence of any pre-project ionic data. It may form part of a response should monitoring indicate that a primary trigger has been exceeded.
complete charge balance error to ensure collection of representative data;	This is not relevant as specific ions are not measured (see above).
if data is available, review the concentrations of minor and trace elements, isotopes (especially of Sr), dating, etc; if so, other ratios and water signatures; and	Data is not available (see above).
make recommendations to improve the veracity of the water quality monitoring program and develop appropriate interim performance measures as part of the Trigger and Action and Response Plan. These performance measures will need to be included into the updated Site Water Management Plan.	A TARP is already included in the Extraction Plan Water Management Plan for LWB4-B7 which was prepared in consultation with DoI Water.
The proponent should have an independent expert review the above report and submit to DoI Water.	In my opinion the observed increase in EC in the Austar alluvium monitoring bores is reflective of sampling methodology and not any mining induced impact. See attached **Table 1**, **Figure 1** and supporting analysis. As such, a further report on this is unwarranted.

Table 1: Alluvium/regolith monitoring bore records – electrical conductivity EC (µS/cm)

Date	AQD1073A	WBH1	WBH2	WBH3	MB03	GW080974	GW080975
Screen interval (mbgl)	**4.7 - 7.7**	**1.5 - 15.1**	**1.5 - 10**	**1.5 - 10**	**7.5 - 9**	**3 - 6**	**18 - 29 (Permian)**
11-10-07	[a b] *676 / 1,760*						
15-Jul-10							9,312
22-Jul-10	2,632						
25-Oct-10	2,543						
10-Jan-11							9,427
25-Jan-11	1,001						
5-Apr-11	2,525						
12-Apr-11							12,000
28-Jul-11							10,900
1-Aug-11	571	361	944	909			
25-Oct-11	305	346	548	909			
7-Nov-11							9,447
21-Feb-12	79	274	292	328			
30-Mar-12							10,200
2-May-12	76	257	283	317			
16-Jul-12							9,860
31-Jul-12	180	461	533	525			
8-Oct-12							1,709
12-Nov-12	222	406	430	428			
14-Jan-13							1,976
12-Apr-13							1,892
23-Apr-13	78	586	526	352			
17-Jul-13	279	496	360	33			1,494
28-Oct-13	443	63	876	591			
1-Nov-13							1,782
23-Jan-14							1,753
10-Feb-14	575	960	1128	642			
4-Apr-14	497	796	859	681			
1-Jul-14			700	569			1,666
29-Sep-14							1,723
1-Oct-14	366	785	727	539			
13-Jan-15							1,773
6-Feb-15	681	1188	839	492			
30-Mar-15	580	396	720	685			
13-Apr-15						721	2,034
09-Jul-15	497	363	302	965			
25-Aug-15						682	1,842
09-Sep-15		751	1,214	1,666			
26-Nov-15						1,870	1,870
24-Dec-15	926	1,187	1,822	1,116			
9-Mar-16						479	1,727
10-Jun-16						555	1,701

Date	AQD1073A	WBH1	WBH2	WBH3	MB03	GW080974	GW080975
22/23-Jun-16	8,491	4,430	3,567	3,862			
5/6-Sep-16	5,924	4,253	3,249	2,630	4,293		
23-Sep-16							1,740
8/9-Dec-16	5,795	4,380	2,755	3,854	4,629		
19-Dec-16						549	1,691
20-Mar-17						564	1,674
7-Apr-17	5,600	4,300	3,200	4,600			
22-Jun-17						443	1,262
20-Jul-17	5,700	4,200	3,300	3,500			
4-Sep-17							[c] 5,552
18-Dec-17						901	[c] 8,663
22-May-18						8,150	

Notes:

a. Shaded cells possibly contaminated by surface water ingress / insufficient purging before sampling.

b. Drillers log for AQD1073A reports piezometer installed 6 July 2006. Measurements of EC on 11 October 2007 – 676 µS/cm at 3m; 1760 µS/cm at 4.5m.

c. September 2017 and December 2017 EC readings from 28m depth in GW080975, previous measurements recorded from 5m depth.

The low EC data in **Table 1** above are believed to be anomalous, due to likely 'contamination' of the water in the bore by an unnatural ingress of low salinity surface runoff or sheet-wash during or following rain events, causing a bailed sample to report a lower salinity than the natural groundwater.

The earliest available EC data from AQD1073A (from 11 October 2007 in **Table 1** above) revealed significant stratification in the bore, with low salinity near the surface and higher salinity at depth. This is consistent with the suggestion of 'contamination' by low salinity water ingress at the bore collar.

If the groundwater is naturally saline (ie high EC), then any ingress of lower salinity rainfall or runoff/sheetwash, would cause the salinity in bailed samples to be lower than normal. If the low salinity water were a natural recharge process, in which the incident rainfall and/or runoff/sheetwash infiltrates the ground surface and percolates downwards to the water table, it could lead to a general lowering of salinity in the groundwater in the alluvium, however there could be stratification with the fresher recharge water on top of the more saline groundwater beneath. A sample bailed at or just below the water table could have a lower salinity than a sample from deeper below the water table, or bailed after full purging of the bore.

Alternatively, if there has been incomplete sealing of the space around the top of the casing at ground level, this could allow runoff or sheetwash to enter the annulus around the outside of the bore casing and make its way down the bore annulus to the water table. This could result in an unnatural lowering of salinity in the water inside and immediately adjacent to the bore.

In either case, more thorough purging of the bore prior to sampling would remove most of the lower salinity water from the bore and the region close to the bore, so that the sample subsequently taken would be a more accurate reflection of the true aquifer water quality. Based on the information available, namely:

- It is known that water samples collected from the Austar alluvium bores since June 2016 have been sampled after appropriate purging, hence those salinity values are considered to be reliable. The thoroughness of purging of Austar's bores prior to June 2016 is not known. Likewise, it is not known how or whether the DoI Water monitoring bores are purged prior to sampling.

- The reporting of higher salinity from deeper in bore AQD1073A in October 2007 (see footnote to **Table 1** above) strongly suggests salinity stratification in the water column within the bore.

- The latest two EC measurements from DoI-Water's bore GW090875 (ie 4 September 2-17 and 18 December 2017) were recorded as having been taken at 28m depth, whereas previous sampling of this bore was reportedly taken at 5m or 6m depth. Notwithstanding that this is a Permian bore not alluvium, this also is consistent with salinity stratification in the bore. The DoI-Water data report also includes a note for 4 September 2017 "WQ meter not working this day".

- The changes in salinity (from high EC to low EC and then to high EC over time) occur at very different times at Austar's monitoring bores and the DoI-Water's monitoring bores. If the occurrences of low EC were coincident in both Austar's bores and the DoI Water bores, then it would be more likely that the lower salinities were reflecting a recharge event, which would be expected to influence the entire alluvium aquifer system at approximately the same time. Since they are not, it is more likely that the cause of the low salinity is a feature of specific bores (ie some bores may be less well sealed at the collar than others) or the thoroughness of the purging prior to sampling (ie some bores may have been more effectively purged than others).

In conclusion, it is considered that the EC values measured in Austar's monitoring bores since June 2016 are the most reliable data available concerning the salinity of the alluvium groundwater. All other EC measurements (ie in Austar's bores pre-June 2016, and all measurements from DoI Water's bores) are less reliable. Apart from the timing of salinity increases at the Austar bores all at the identical time (ie between the June 2016 and December 2016 samplings), all other changes in EC from high to low to high were inconsistent, it is concluded that (other than the Austar bores since June 2016) the changes in EC values are very bore specific, and most likely are a feature of insufficient purging or leakage around the bore collar.

It is my opinion that there is no convincing evidence that there has been a change in beneficial use value of the alluvial groundwater. Accordingly, there is no justification for much of the additional work proposed by DoI Water in their letter of 3 April 2018.

I would be happy to discuss any of the above if necessary.

Yours faithfully,

Peter Dundon

Director

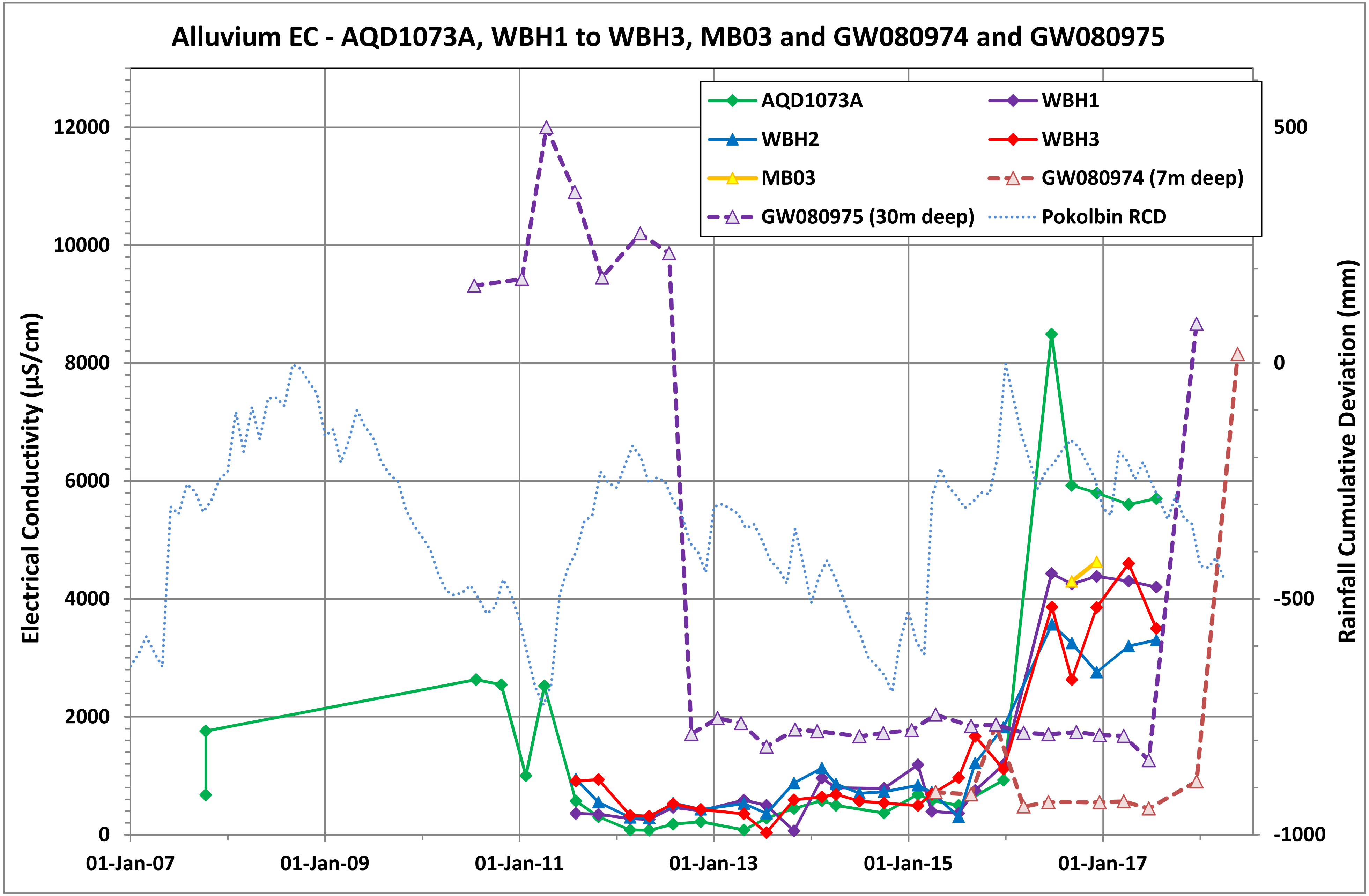

Figure 1: E C - Austar's Alluvium Monitoring Bores and DoI-Water's Monitoring Bores

Attachment B

Response to Submission

Planning Services
Resource Assessments
Contact: Jack Murphy
Phone: 8217 2016
Email: jack.murphy@planning.nsw.gov.au

Ms Carly McCormack
Environment and Community Superintendent
Austar Coal Mine Pty Ltd
Locked Bag 806
Cessnock NSW 2325

Email: Carly.McCormack@yancoal.com.au

Dear Ms McCormack,

Austar Coal Mine (DA29/95 MOD 7)
Historical Groundwater Review and Assessment

The Department has reviewed the Historical Groundwater Review and Assessment for Austar Coal Mine provided on Monday 2 July 2018, which has been prepared in accordance with condition 12A of Schedule 3 of DA29/95 MOD 7.

The Department has reviewed the document and conducted further consultation with the Department of Industry Lands and Water (DoI), and considers it has not adequately addressed the requirements of the relevant condition. To address these requirements, the Department recommends the document is updated in accordance with comments made in DoI's letter dated 15 October 2018.

The Department requests that this document is re-submitted once DoI's comments have been addressed, and no later than **20 November 2018**.

Should you have any enquiries in relation to this matter, please contact Jack Murphy.

Yours sincerely,

J. Evans 26/10/18

Jessie Evans
A/Director
Resource Assessments
As nominee of the Secretary

Jack Murphy
Environmental Assessment Officer
Resource Assessments
Department of Planning and Environment
320 Pitt Street
SYDNEY NSW 2000

OUT18/15874

via email: jack.murphy@planning.nsw.gov.au

Dear Mr Murphy,

RE: Review of Groundwater Management Plan

Thank you for providing the Department of Industry – Lands and Water (DoI Water) the opportunity to provide comments on the Austar Groundwater Management Plan. DoI Water has reviewed the latest response from Austar Coal Mine and provides the following comment and recommendations.

Increase in Groundwater Salinity

In an earlier review, DoI Water noted a rise in salinity across Austar Coal Mines' (ACM) alluvial monitoring network and also within the closest DoI Water observation bores (see Figure 1 in Attachment A). DoI Water advised that given the indicative change in alluvial aquifer beneficial use, an investigation into the drivers for change be undertaken.

DoI Water notes that Mr Peter Dundon from Dundon Consulting has completed the investigation on behalf of ACM. Mr Dundon attributes the change in salinity at ACM bores being due predominantly to changes with contractor inferring that a more thorough purging of the alluvial bores is now undertaken.

Secondary influences described in the response from ACM include:

(i) Unnatural ingress of low salinity surface run-off or sheet wash following rain events to enter the annulus around the outside of the bore
(ii) Stratification low salinity near the surface
(iii) Temporal differences between bores for the rise in salinity.

Mr Dundon concludes:

> *"It is my opinion that there is no convincing evidence that there has been a change in beneficial use value of the alluvial groundwater. Accordingly, there is no justification for much of the additional work proposed by DoI Water in their letter of 3 April 2018."*

In reply to Mr Dundon's assessment it is noted from Figure 1, Attachment A, that visually the low salinity observations do not correlate with the rising trends of Pokolbin RCD (Rainfall Cumulative Deviation) trend line, that is, periods of wet climate when sheet runoff is likely to occur. The data could be explored statistically to draw out any significance between climate and salinity but at this point it would appear visually the salinity increase commenced in mid-2015 during a rising RCD trend.

DoI Water acknowledges the potential for stratification within monitoring bores and this is evident in DoI Water deeper bore GW080975 where downhole profiling shows the potential for more dense saline water at depth. Hence, why the depth of measurement is reported in DoI Water bore and these bores are not purged. The concern of note is that salinity in the DoI Water shallow observation bore (GW080974) screened in the alluvial aquifer has also risen sharply where there has been no history of stratification.

The ACM and Department alluvial bores are at shallow depths with only small casing storage volumes (i.e. 10-20 litres). Hence, purging of these bores would be a relatively quick event and thus if there were particular issues with the previous contractor purging duration being inefficient, then greater variability would be anticipated, particularly if there was any stratification. In effect, Figure 1 in Attachment A presents the opposite with more stable conditions under the previous contractor and more erratic nature in the later sampling events.

In addition, the argument on temporal differences for the rise in salinity not occurring at the same time across the network, then logically a more thorough purging technique introduced by the new contractor should have derived this universal rise across the network at the contract changeover if the bores were in fact always saline as implied. Hence, DoI Water interprets the ACM information differently to Mr Dundon's conclusion.

DoI Water previously recommended assessing major ions, trace metals and charge ion balance data. It is understood that ACM does not undertake any additional sampling beyond field sampling of EC, pH and temperature, unlike other mine sites where annual comprehensive analyte suite measured at all observation bores is standard.

Trigger Action Response Plan

Mr Dundon reports the Trigger Action and Response Plan (TARP) was prepared in consultation with DoI Water. DoI Water recommended in July 2017 that triggers for the groundwater impact assessment were required to meet the conditions of consent. A letter sent by DoI Water (our ref: OUT 17/28114) to ACM confirmed this requirement. No subsequent advice relating to adequacy of the WMP is noted on file to indicate DoI Water acceptance that the issues had been satisfactorily addressed.

Mr Dundon draws attention of the need for a response should monitoring indicate that a primary trigger has been exceeded. However, in this instance, whilst only three water quality parameters are being measured, the TARP did not lead to any agency notification with the rapid change in observed E.C. The known points are that there has been a significant change in measured E.C and DoI Water should err on the precautionary side until the issue can be supported scientifically.

The ACM response assessment describing the drivers resulting for this change is questionable. Whilst Mr Dundon asserts that no further work is required, DoI Water finds there is sufficient justification to further explore the reasons for increasing groundwater salinity and there is a need to revise the TARP to ensure such events do not go unrecognised and there is complimentary monitoring procedures in place to provide further detailed work if required. At the earliest opportunity DoI Water should seek significant amendments to the WMP to ensure a more robust and comprehensive sampling and performance evaluation is encapsulated within the WMP in line with previous recommendations made by DoI Water.

Recommendation

Based on the above information, DoI Water recommends that the WMP should be updated to ensure the document incorporates a more comprehensive sampling program with demonstrated quality assurance protocols and linked to prescriptive performance evaluation.

A DoI Water hydrogeologist can be made available to discuss the above information if required.

Please contact Ryan Shepherd, Water Regulation Officer (Newcastle) on (02) 4904 2650 or ryan.shepherd@nrar.nsw.gov.au if you have further enquiries regarding this matter.

Yours sincerely,

Irene Zinger
Manager, Regional Water Regulation Branch (East)
Natural Resources Access Regulator
Department of Industry, Lands and Water

15 October 2018

Attachment A

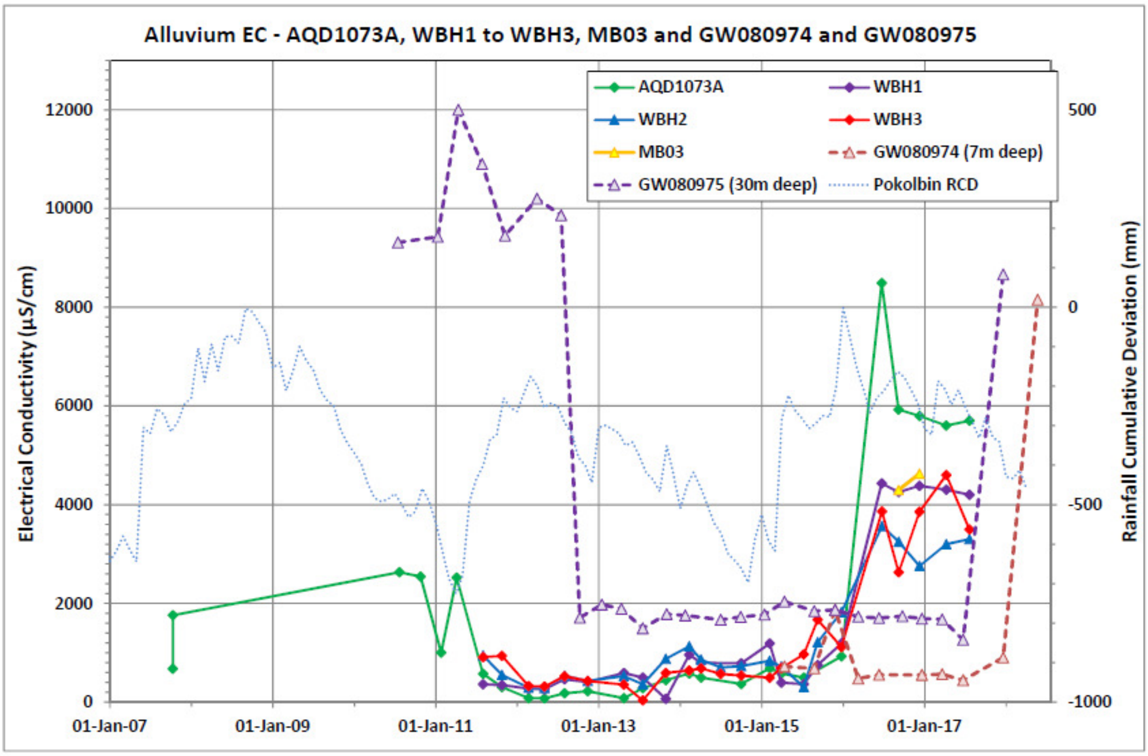

Figure 1: E C - Austar's Alluvium Monitoring Bores and DoI-Water's Monitoring Bores

Figure 1. Water quality results for Austar Mine monitoring bores and DoI Water bores.

Attachment C

Additional Information

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PHONE: +61 2 4993 7200
FAX: +61 2 4993 7326
WEBSITE: www.austarcoalmine.com.au
ABN 67 111 910 822

23 November 2018

Howard Reed
Director – Resource Assessments
Department of Planning and Environment
GPO Box 39
SYDNEY NSW 2001

Attention Jack Murphy

Dear Howard,

Austar Coal Mine, Historical Groundwater Review and Assessment (DA 29/95, Mod 7)

This letter and the enclosed attachments address the comments made in relation to Austar Coal Mine's *Historical Groundwater Review and Assessment* (Groundwater Review) by the Department of Industry, Lands and Water (DoI) in their letter dated 15 October 2018.

The Groundwater Review was prepared in accordance with condition 12A of Schedule 3 of DA 29/95 Mod 7 and lodged on 2 July 2018.

Dundon Consulting has assisted in the review of DoI's comments in the **attached** Letter Report. In his report, Peter Dundon further investigates the change in electrical conductivity in the groundwater bores of the Quorrobolong Valley, and maintains that there are 'no convincing evidence for a change in beneficial use and the changes in EC observed at the bores were predominantly due to a change in sampling methodology accompanying a change in monitoring contractor'.

While the DoI suggest that 'the data could be explored statistically to draw out any significance between climate and salinity', Dundon has recommended additional sampling and lab analysis be undertaken for the next 12 months to better understand the groundwater chemistry in the Quorrobolong Valley. The findings of the additional monitoring will be reported back to DPE and DoI by the end of 2019 and used to guide any required changes to the ongoing monitoring program and Trigger Action Response Plan (TARP).

The proposed changes to the monitoring program include:

- Taking samples before and after purging (to support the conclusion that stratification may have been skewing monitoring results and allow for better comparison between Austar and DoI monitoring bores). This addresses comments made in DoI's letter, Page 2, paragraphs 1, 2 and 3.
- Commence laboratory testing of basic parameters EC, pH, TDS, along with major ions. This will address comments made in DoI's letter Page 2, paragraph 4.

In relation to DoI comments on the TARP (Page 2), it is our opinion that the current approved TARP functions effectively, and the changes in measured water quality were examined and did not trigger stakeholder notifications.

The proposed changes to monitoring over the next 12 months will be reported to DoI quarterly. The 12 months of monitoring will inform the need for any changes to the existing approved TARP and this will be documented in the final report.

Conclusion

Austar, with the support of Dundon Consulting has addressed the concerns of DoI and committed to the recommendations outlined in their letter dated 15 October 2018. A 'more comprehensive sampling program' (sampling before and after purging) with 'demonstrated quality assurance protocols' (NATA certified lab analysis of pH, EC, TDS and major ions along with a documented groundwater sampling procedure will be undertaken quarterly over the next 12 months, with results compared to background data used to further inform the improvement of the TARP ('prescriptive performance evaluation') if required.

Austar kindly request the Department review the enclosed response and seek the Secretary of the Department's satisfaction of this condition.

If you have any queries in relation to this matter, please do not hesitate to contact me on (02) 4993 7334.

Yours faithfully,

Carly McCormack
Environment & Community Superintendent
Austar Coal Mine
Ph: 02 4993 7334
Email: Carly.McCormack@yancoal.com.au

Enclosed:

- DoI-Water, Letter re: *Review of Groundwater Management Plan* (15 October 2018)
- Dundon Consulting Pty Limited, Letter re: *Austar – DoI-Water Response to Groundwater Verification Review – DA29/95 (MOD7) – Condition 12A, Schedule 3* (22 November 2018)

Jack Murphy
Environmental Assessment Officer
Resource Assessments
Department of Planning and Environment
320 Pitt Street
SYDNEY NSW 2000

OUT18/15874

via email: jack.murphy@planning.nsw.gov.au

Dear Mr Murphy,

RE: Review of Groundwater Management Plan

Thank you for providing the Department of Industry – Lands and Water (DoI Water) the opportunity to provide comments on the Austar Groundwater Management Plan. DoI Water has reviewed the latest response from Austar Coal Mine and provides the following comment and recommendations.

Increase in Groundwater Salinity

In an earlier review, DoI Water noted a rise in salinity across Austar Coal Mines' (ACM) alluvial monitoring network and also within the closest DoI Water observation bores (see Figure 1 in Attachment A). DoI Water advised that given the indicative change in alluvial aquifer beneficial use, an investigation into the drivers for change be undertaken.

DoI Water notes that Mr Peter Dundon from Dundon Consulting has completed the investigation on behalf of ACM. Mr Dundon attributes the change in salinity at ACM bores being due predominantly to changes with contractor inferring that a more thorough purging of the alluvial bores is now undertaken.

Secondary influences described in the response from ACM include:
- (i) Unnatural ingress of low salinity surface run-off or sheet wash following rain events to enter the annulus around the outside of the bore
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Mr Dundon concludes:

> *"It is my opinion that there is no convincing evidence that there has been a change in beneficial use value of the alluvial groundwater. Accordingly, there is no justification for much of the additional work proposed by DoI Water in their letter of 3 April 2018."*

In reply to Mr Dundon's assessment it is noted from Figure 1, Attachment A, that visually the low salinity observations do not correlate with the rising trends of Pokolbin RCD (Rainfall Cumulative Deviation) trend line, that is, periods of wet climate when sheet runoff is likely to occur. The data could be explored statistically to draw out any significance between climate and salinity but at this point it would appear visually the salinity increase commenced in mid-2015 during a rising RCD trend.

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The ACM and Department alluvial bores are at shallow depths with only small casing storage volumes (i.e. 10-20 litres). Hence, purging of these bores would be a relatively quick event and thus if there were particular issues with the previous contractor purging duration being inefficient, then greater variability would be anticipated, particularly if there was any stratification. In effect, Figure 1 in Attachment A presents the opposite with more stable conditions under the previous contractor and more erratic nature in the later sampling events.

In addition, the argument on temporal differences for the rise in salinity not occurring at the same time across the network, then logically a more thorough purging technique introduced by the new contractor should have derived this universal rise across the network at the contract changeover if the bores were in fact always saline as implied. Hence, DoI Water interprets the ACM information differently to Mr Dundon's conclusion.

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Mr Dundon draws attention of the need for a response should monitoring indicate that a primary trigger has been exceeded. However, in this instance, whilst only three water quality parameters are being measured, the TARP did not lead to any agency notification with the rapid change in observed E.C. The known points are that there has been a significant change in measured E.C and DoI Water should err on the precautionary side until the issue can be supported scientifically.

The ACM response assessment describing the drivers resulting for this change is questionable. Whilst Mr Dundon asserts that no further work is required, DoI Water finds there is sufficient justification to further explore the reasons for increasing groundwater salinity and there is a need to revise the TARP to ensure such events do not go unrecognised and there is complimentary monitoring procedures in place to provide further detailed work if required. At the earliest opportunity DoI Water should seek significant amendments to the WMP to ensure a more robust and comprehensive sampling and performance evaluation is encapsulated within the WMP in line with previous recommendations made by DoI Water.

Recommendation

Based on the above information, DoI Water recommends that the WMP should be updated to ensure the document incorporates a more comprehensive sampling program with demonstrated quality assurance protocols and linked to prescriptive performance evaluation.

A DoI Water hydrogeologist can be made available to discuss the above information if required.

Please contact Ryan Shepherd, Water Regulation Officer (Newcastle) on (02) 4904 2650 or ryan.shepherd@nrar.nsw.gov.au if you have further enquiries regarding this matter.

Yours sincerely,

Irene Zinger
Manager, Regional Water Regulation Branch (East)
Natural Resources Access Regulator
Department of Industry, Lands and Water

15 October 2018

Attachment A

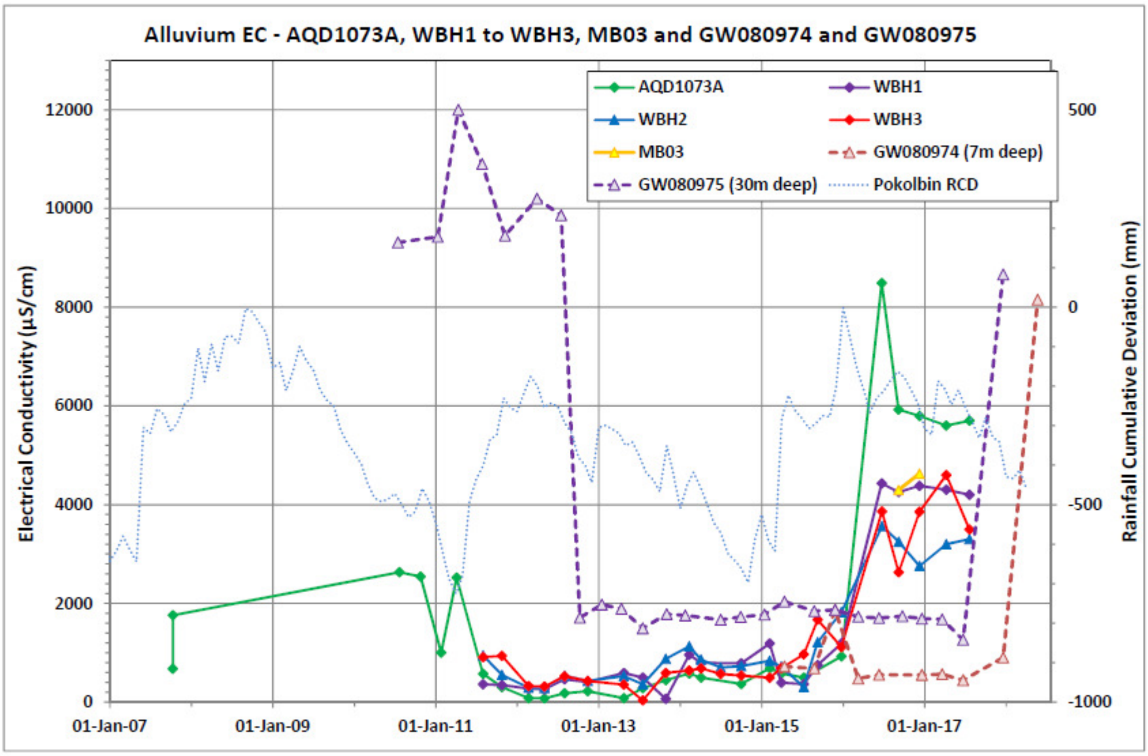


Figure 1: E C - Austar's Alluvium Monitoring Bores and DoI-Water's Monitoring Bores

Figure 1. Water quality results for Austar Mine monitoring bores and DoI Water bores.

Dundon Consulting Pty Limited
ACN 083 246 459
ABN 27 083 246 459

PO Box 6219, PYMBLE NSW 2073
telephone: 02-9988 4449
facsimile: none
mobile: 0418 476 799
email: pjdundon@ozemail.com.au

22 November 2018

Austar Coal Mine Pty Ltd
Locked Bag 806
CESSNOCK, NSW 2325

Attention: Ms Carly McCormack

Dear Carly,

Austar – DoI-Water Response to Groundwater Verification Review – DA29/95 (MOD7) – Condition 12A, Schedule 3

This letter is prepared in response to DoI-Water letter to Department of Planning and Environment (DPI) dated 15 October 2018 (Ref OUT18/15874).

DoI-Water raised concerns in an earlier letter dated 3 April 2018 (Ref V13/3707#7 & OUT18/5597). In that letter, DoI-Water recommended (inter alia) a program of investigation *"… to investigate and identify the driver for the change in beneficial use of groundwater resources."* The basis for this DoI-Water view was a significant change in groundwater quality in the Austar bores located within the Quorrobolong Valley, which quarterly sampling of these bores showed had occurred between successive samplings in December 2015 and June 2016 (there was no sampling in March 2016).

Our letter of 28 June 2018 responded to the DoI-Water letter of 3 April 2018. In summary, we contended that there was no convincing evidence for a change in beneficial use, and that the changes in EC observed at the bores were predominantly due to a change in sampling methodology accompanying a change in sampling/monitoring contractor. We continue to hold that view, as discussed below.

The recent DoI-Water letter of 15 October 2018, sent in response to our 28 June 2018 letter, restates its recommendation for the water quality issue to be further investigated, and also that changes be made to the TARP and WMP, as follows:

> *"… DoI Water finds there is sufficient justification to further explore the reasons for increasing groundwater salinity and there is a need to revise the TARP to ensure such events do not go unrecognised and there is complimentary monitoring procedures in place to provide further detailed work if required. At the earliest opportunity DoI Water should seek significant amendments to the WMP to ensure a more robust and comprehensive sampling and performance evaluation is encapsulated within the WMP in line with previous recommendations made by DoI Water."*

The principal reasons for our continued assertion that the change in reported groundwater quality was primarily due to the change in sampling procedure are outlined in Attachment A.

Notwithstanding, I recommend that some additional sampling and lab analysis be undertaken for the next 12 months to better understand the groundwater chemistry in the Quorrobolong Valley area, as follows:

- Continue quarterly sampling of all bores currently being monitored.

- Prior to purging, collect an initial sample each bore from just below the water level. Then undertake purging as currently being performed, before collecting a second sample from near the base of the screened interval as is being done at the present time.

- Submit both samples for laboratory testing of basic parameters (EC, pH, TDS) and for major ions (Ca, Mg, Na, K; Cl, SO_4 and CO_3/HCO_3 alkalinity).

- Compare the water quality and major ion chemistry of the two sets of water samples. Provide a brief quarterly letter report on the results and any significant findings.

- Request additional water quality data (including major ions) from DPI-Water for samples from the department's bores GW080974 and GW080975.

- Review the results of the 12 month sampling program as outlined above, detailing any conclusions about the overall groundwater quality and any stratification present within each of the three main aquifers being monitored (alluvium, weathered Permian and Permian), and responses to rainfall pattern (comparison of water level and water quality data with the RCD curve). Provide a recommendation for ongoing groundwater quality monitoring, which might include:

  - Continued quarterly sampling and field analysis for basic quality parameters (EC, pH and TDS).

  - Annual sampling for lab analysis for basic parameters (EC, pH and TDS) and major ions (Ca, Mg, Na, K; Cl, SO_4 and CO_3/HCO_3 alkalinity).

Following this 12 month review and assessment, any appropriate changes to the TARP and/or the SWMP and extraction plan WMP would be proposed.

I would be happy to discuss any of the above if necessary.

Yours faithfully,

Peter Dundon

Director

1. Quorrobolong Valley Groundwater Monitoring Network

The monitoring network includes bores in each of the three major aquifer systems within the shallow subsurface beneath the Quorrobolong Valley floodplain, viz

- Alluvium,
- Weathered Permian, and
- Permian.

Nine Austar bores are currently monitored, as detailed in **Table 1**. This table also includes two DoI-Water bores monitored by the department.

Table 1: Groundwater Monitoring Bores – Quorrobolong Valley Area

Bore	Depth (mbgl)	Screened Interval (mbgl)	Aquifer/lithology screened	EC (µS/cm)**	
				24 Dec 2015	22-23 Jun 2016
NER1010	102.0		Permian	926	8,491
AQD1073A	7.7		Alluvium	320	1,459
WBH1	15.0	1.5-15	Weathered Permian	1,187	4,430
WBH2	10.0	1.5-10	Alluvium / Weathered Permian	1,822	3,567
WBH3	10.0	1.5-10	Alluvium / Weathered Permian	1,116	3,862
MB01	176.1	75-174	Permian	-	7,485
MB02	139.4	80-140	Permian	-	6,496
MB03	9.1	7.5-9	Alluvium / Weathered Permian	-	4,293 (5/9/16)
MB03A*	6.1	2.5-6.1	Alluvium	-	13,200 (16/10/18)
MB04	7.5	1.5-7.5	Alluvium / Weathered Permian	-	13,050 (17/9/17)
GW080974	7	3-6	Alluvium	1,870 (26/11/16)	555 (10/6/16) 8,150 (22/5/18)
GW080975	30	18-29	Weathered Permian	1,870 (26/11/16)	1,701 (10/6/16) 5,552 (4/9/17)

* MB03A was installed as a replacement for MB03, which was not able to be sampled after 28 June 2017, as the landowner withdrew access approval. Has not yet been sampled by AGE. EC reading on 16 October 2018 was field measurement at time of bore construction.

**- data for Austar bores is the last reading before salinity increase in column 5 and first reading after in column 6; data for Water NSW GW bores in column 5 is last date of low salinity data in Water NSW GW bores, whereas data in column 6 is last data before date of salinity change in Austar bores, then first data after salinity increase in Water NSW GW bores.

2. Sampling Methodology

Groundwater monitoring and sampling of the Austar bores was performed by Aurecon up to and including 24 December 2015. Thereafter (starting at 22-23 June 2016) monitoring and sampling has been performed by AGE.

The sampling method used up to and including 24 December 2015 was bailing from close to the top of the water column in the bore. No purging was carried out prior to sampling. There are no records of instrument calibration to confirm the accuracy of the water quality parameters reported.

From 22-23 June 2016, water samples were collected by two different methods, depending on the bore depth and yield potential.

Initially, it was attempted to purge the shallow bores (AQD1073A, WBH1 to WBH3 and MB03) using a Mega Monsoon low-flow submersible pump, with the aim to remove at least 3 bore volumes of water from the bore prior to sampling. The pump was set close to but a metre or so above the base of the bore. Water samples were collected from the Mega Monsoon discharge. Water quality parameters (EC, pH and temperature) were monitored at intervals to ensure that the water quality was stable prior to sampling. The field quality monitoring equipment was calibrated in the field during the sampling. This method of purging proved to be generally satisfactory for bores WBH1 to WBH3 and MB03. However, the yield potential of AQD1073A was insufficient to permit 3 bore volumes to be pumped, and the bore pumped dry during purging, with the bore then allowed to recover before additional purging. In any case, samples were only collected after water quality parameters had stabilised.

At later sampling dates, purging was conducted until water quality parameters had stabilised.

The deeper bores NER1010, MB01 and MB03 were initially purged (until quality stabilisation) using a discrete depth stainless steel bailer, bailing from close to the base of the screened interval, to ensure that the water sampled was from the inflow zone. From October 2016, sampling from the base of the screened interval in the deep bores was done with the aid of a Hydrasleeve, to eliminate the need for purging from the deeper bores. All three of the deep bores were insufficiently permeable to allow removal of the desired 3 bore volumes under conventional purging.

The water quality monitoring methodology for the DoI-Water bores is not known, but is believed to be by means of a down-hole sensor rather than collection of a sample by pumped or bailed means. It is understood that no purging has been carried out prior to recording of quality parameters. Water quality measurements are generally taken at shallow depth, but on occasions from near the base of the screened interval.

3. Change in Water Quality in June 2016 (Austar bores) and 2017-2018 (DoI-Water Bores)

Large increases in salinity occurred in all Austar bores within the Quorrobolong Valley on the same date (22-23 June 2016), which was the first date of sampling by the new monitoring/sampling contractor AGE. Large increases in salinity were noted in DoI-Water bores on 18 December 2017 (GQ090875) and 22 May 2018 (GW090874). The salinity changes are shown on the attached plot of EC vs time for all bores (**Figures 1 to 5**).

I believe that the salinity increases noted in Austar's bores and the increases noted later in the DoI-Water bores are the result of unrelated causes. The reasons for this view are as follows:

- The salinity change in Austar's bores coincided with a change in sampling methodology, following a change in monitoring contractor. The large increases in salinity occurred in all Austar bores within the Quorrobolong Valley on the same date (22-23 June 2016), which was the first date of sampling by the new monitoring/sampling contractor AGE. Previously sampling and monitoring had been undertaken by Aurecon, with the last samples collected by them on 24 December 2015.

- Up to 24 December 2015, sampling was undertaken by bailing from the top of the water column in each bore. No purging was undertaken prior to sampling.

- From 22-23 June 2016, the shallow bores AQD1073A, WBH1 to WBH3 and MB03 were purged and sampled using a Mega Monsoon low-flow submersible pump, with the pump set at the base of the screen. Initially 3 or 4 bore volumes were purged prior to sampling. Purging using a stainless steel bailer was attempted on the deeper bores NER1010, MB01 and MB02, but the very low inflow rates prevented 3 bore volumes from being purged. In those bores, samples were collected by a discrete bailer set near the base of the screen, and after October 2016 with the aid of a Hydrasleeve set at the base of the screen interval.

- The dramatic salinity increases between 24 December 2015 (Aurecon) and 23 June 2016 (AGE) occurred in all Austar bores at the same time. These included bores completed in alluvium, weathered Permian and deeper fresh Permian, so the increase in salinity was not limited to a particular aquifer. Although Austar's bores in the Quorrobolong Valley are loosely referred to as the "alluvial" monitoring network, in fact they include bores completed into all three aquifers, and to varying depths, as detailed in **Table 1** above.

- The five bores installed after 23 June 2016 (MB01, MB02, MB03, MB03A (replacement for MB03) and MB04 all reported very high salinities, consistent with the post-December 2015 salinities in the five bores that had been available both before and after the change of sampling procedure.

- Thus, all water samples collected from the Austar bores after December 2015 had salinities greater than 2,000 µS/cm EC (mostly well above 2,000), and all samples collected during the previous five years had salinities well below 2,000 µS/cm EC[1].

- The two DOI-Water bores GW080974 (alluvium) and GW080975 (weathered Permian) both showed an increase in salinity, but not until 18 months and 23 months respectively after the Austar bores. Thus there is no timing coincidence between the Austar bores and the DOI-Water bores with respect to the rise in salinity.

- AGE's field notes of water quality monitoring during purging show that from the start of sampling, ECs were consistently much higher than had previously been reported by Aurecon. This is interpreted as indicating a difference in water quality between the top and bottom of the water column within the bores, even the shallow alluvium bores.

- Salinity stratification had previously been documented in the driller's log for AQD1073A – *"Drillers log for AQD1073A reports piezometer installed 6 July 2006. Measurements of EC on 11 October 2007 – 676 µS/cm at 3m; 1760 µS/cm at 4.5m".*

- The DoI-Water records likewise suggest salinity stratification – reported ECs in GW090875 on 22 June 2017 were 1262 µS/cm at 5m depth and 5552 µS/cm at 28m depth.

It is our conclusion that the reported water quality is highly sensitive to the sampling methodology employed, and in particular the depth from which the water samples are collected in the bores.

The most reliable water quality data relating to groundwater exposed to the bore through the screened interval is that derived from Austar's bores from June 2016, as this sampling has been conducted in accordance with the Australian standard for bore sampling. The accuracy and reliability of water samples collected from Austar's bores up to December 2015 is considered low, as it is known that there was no purging carried out prior to sampling, and samples were collected from close to the top of the water column in each bore, and the reliability of the water quality meter

[1] The higher salinities reported for AQD1073A in 2007 to 2011 may be the result of either deeper bailing or more effective purging, as little is known of the sampling method from that time.

cannot be verified. The water quality data from the DoI-Water bores cannot be verified without more detail on the sampling methodology and sample collection depths.

4. Relationship Between Groundwater Salinity and Rainfall (RCD Trend)

The monitoring data also show that in addition to the abrupt increase in salinity, three of the Austar bores are currently displaying a rising trend in EC – ADQ1073A, WBH3 and MB03 (until monitoring ceased). This may be related to the declining trend in rainfall as displayed by the RCD trend over the period 2016 to 2018 (see **Figures 1 to 5**).

All other bores are showing a consistent higher salinity since the change of sampling procedure.

5. Recommended Further Investigation

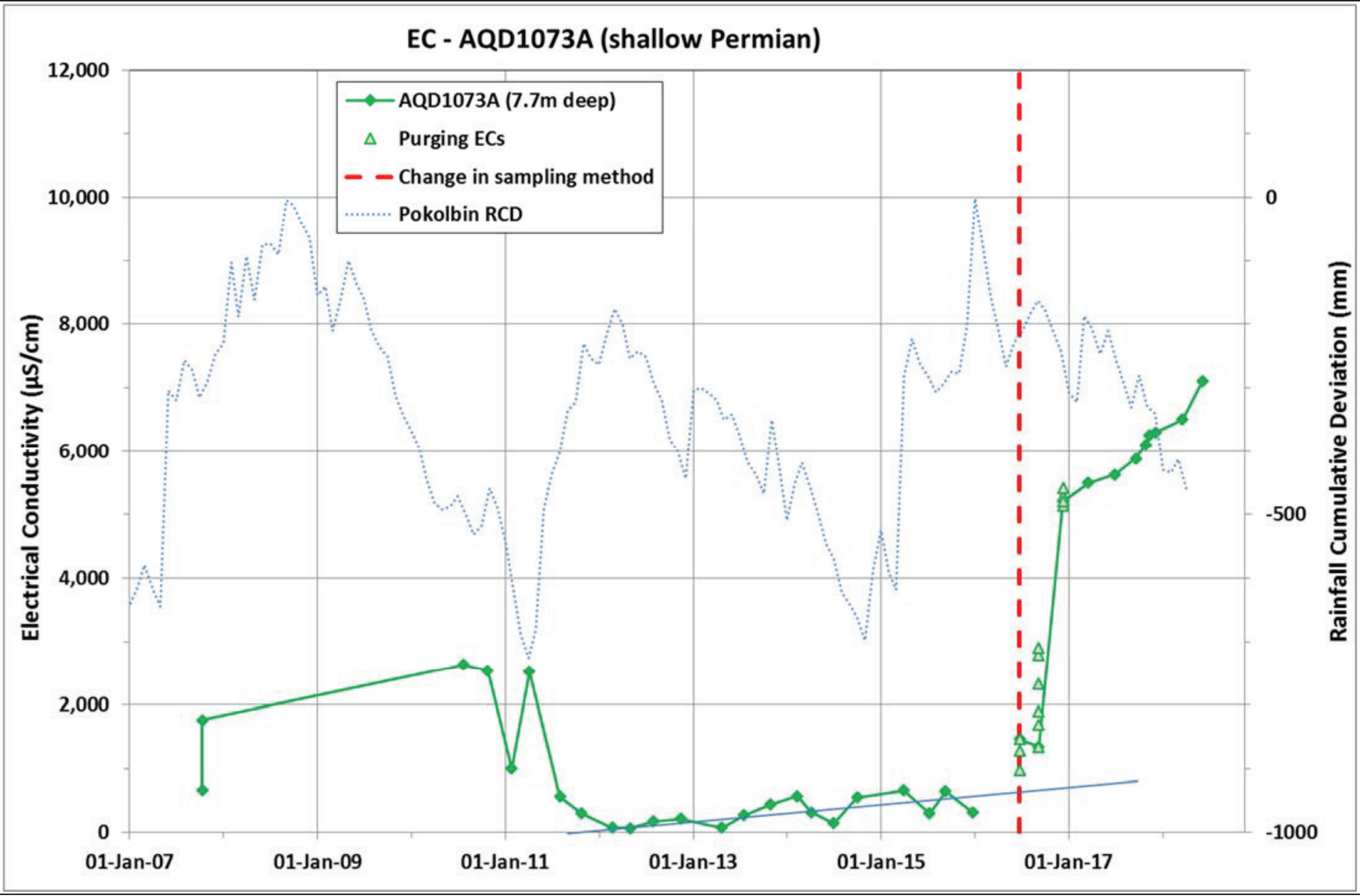
Although we are satisfied that there has not been a change in groundwater beneficial use, I recommend that some additional sampling and lab analysis be undertaken for the next 12 months to better understand the groundwater chemistry in the Quorrobolong Valley area, as follows:

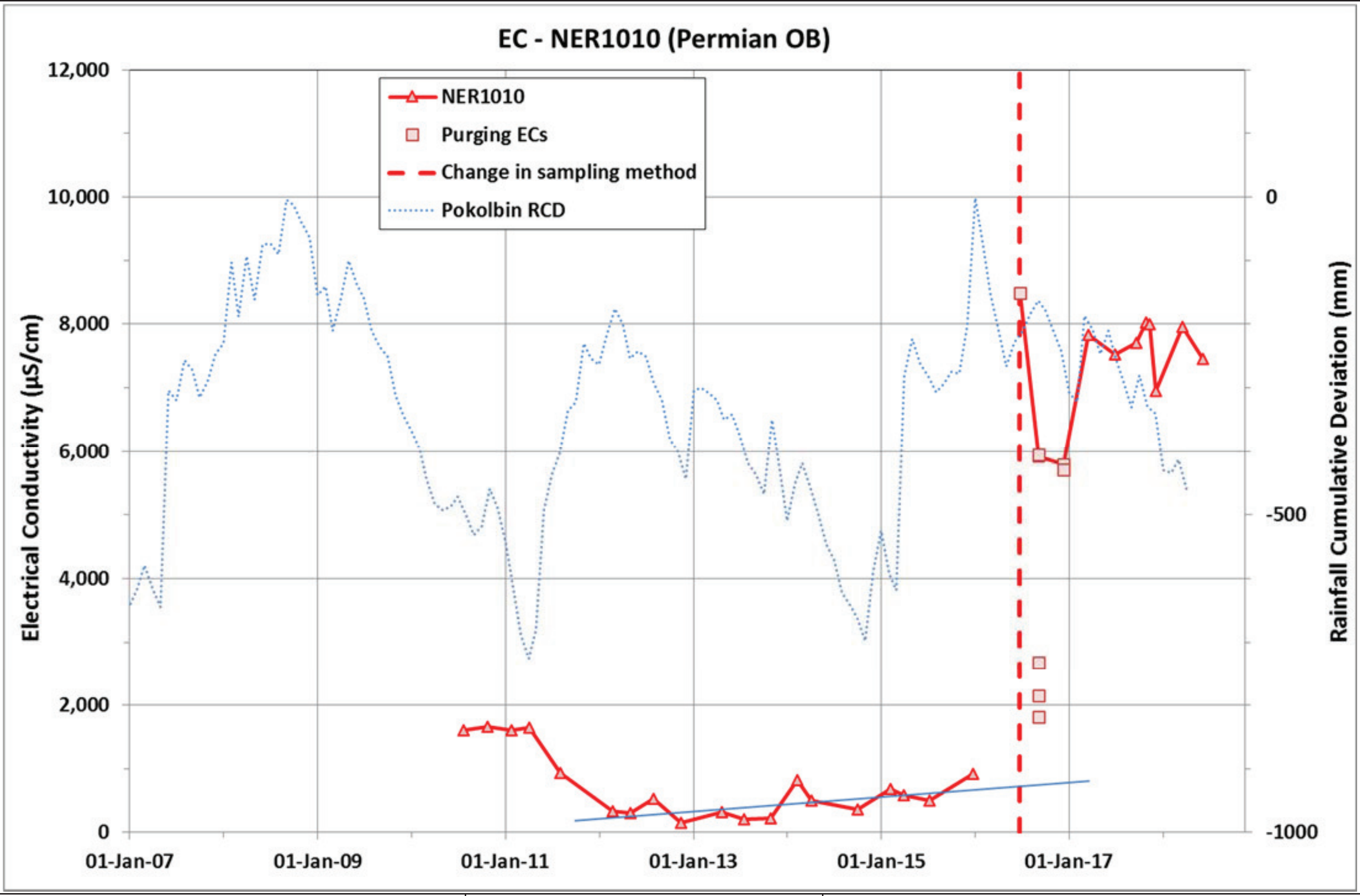
- Continue quarterly sampling of all bores currently being monitored.
- Prior to purging, collect an initial sample each bore from just below the water level. Then undertake purging as currently being performed, before collecting a second sample from near the base of the screened interval as is being done at the present time.
- Submit both samples for laboratory testing of basic parameters (EC, pH, TDS) and for major ions (Ca, Mg, Na, K; Cl, SO_4 and CO_3/HCO_3 alkalinity).
- Compare the water quality and major ion chemistry of the two sets of water samples. Provide a brief quarterly letter report on the results and any significant findings.
- Request additional water quality data (including major ions) from DPI-Water for samples from the department's bores GW080974 and GW080975.
- Review the results of the 12 month sampling program as outlined above, detailing any conclusions about the overall groundwater quality and any stratification present within each of the three main aquifers being monitored (alluvium, weathered Permian and Permian), and responses to rainfall pattern (comparison of water level and water quality data with the RCD curve). Provide a recommendation for ongoing groundwater quality monitoring, which might include:
    - Continued quarterly sampling and field analysis for basic quality parameters (EC, pH and TDS).
    - Annual sampling for lab analysis for basic parameters (EC, pH and TDS) and major ions (Ca, Mg, Na, K; Cl, SO_4 and CO_3/HCO_3 alkalinity).

Following this 12 month review and assessment, any appropriate changes to the TARP and/or the SWMP and extraction plan WMP would be proposed.

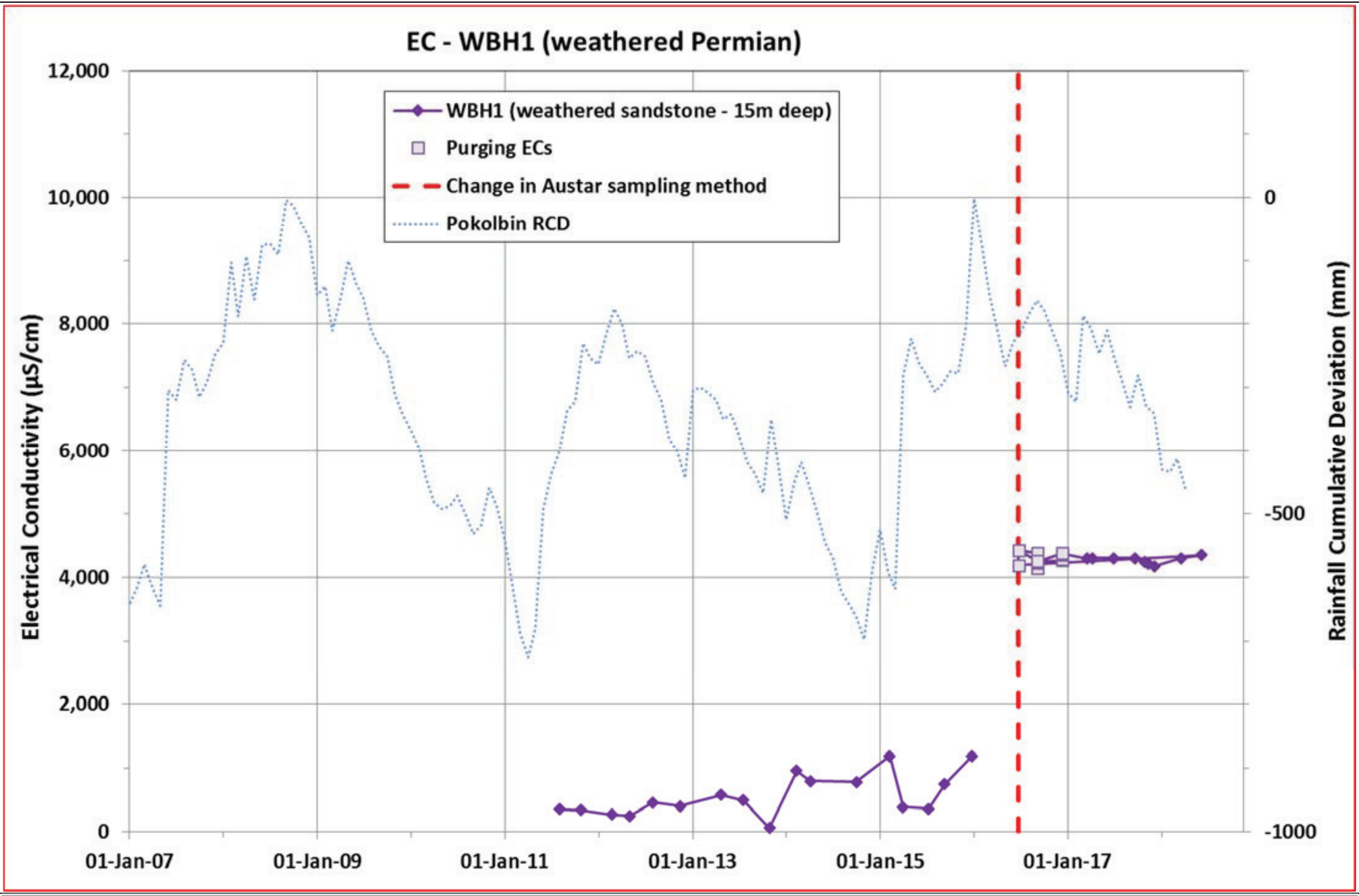
The collection of pre-purging top samples and post-purging bottom samples may or may not resolve any uncertainty around the groundwater quality. If the dual sampling produces different pre-purging and post-purging water qualities, it would be a demonstration of stratification or at least a variety of sources for groundwater inflow to the bores. However, if the dual sampling produces consistent water qualities between pre-and post-purging, it may merely be because of the residual effects of the past purging event. The deeper bores in particular are very slow to recover after purging. In the case of MB01, water levels do not fully recover between sampling events even when there has been no purging. The sample collection itself is sufficient to cause a protracted lowering of the water level.

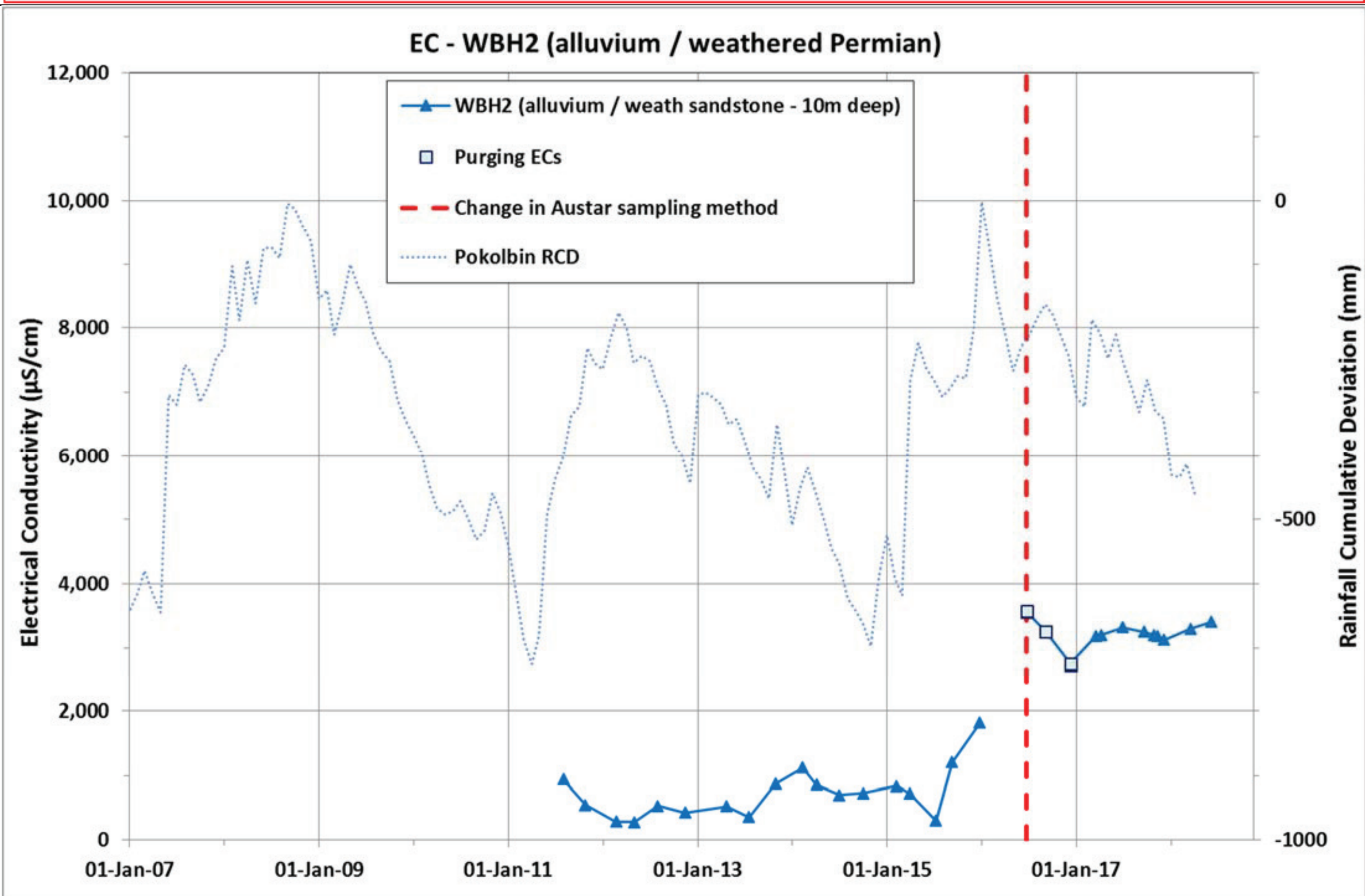
The above investigation program may also assist in clarifying any relationship between water EC and rainfall trends.



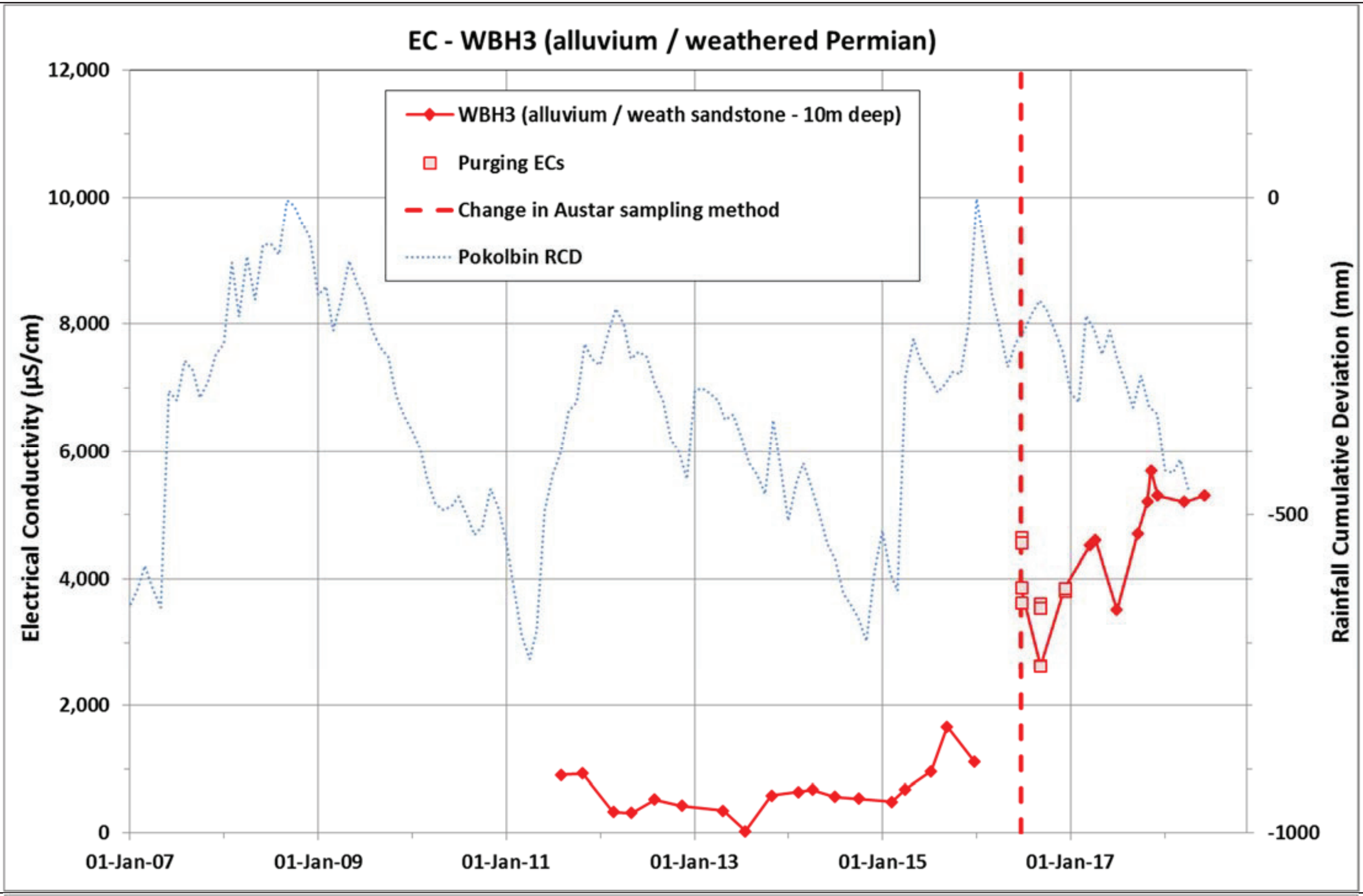


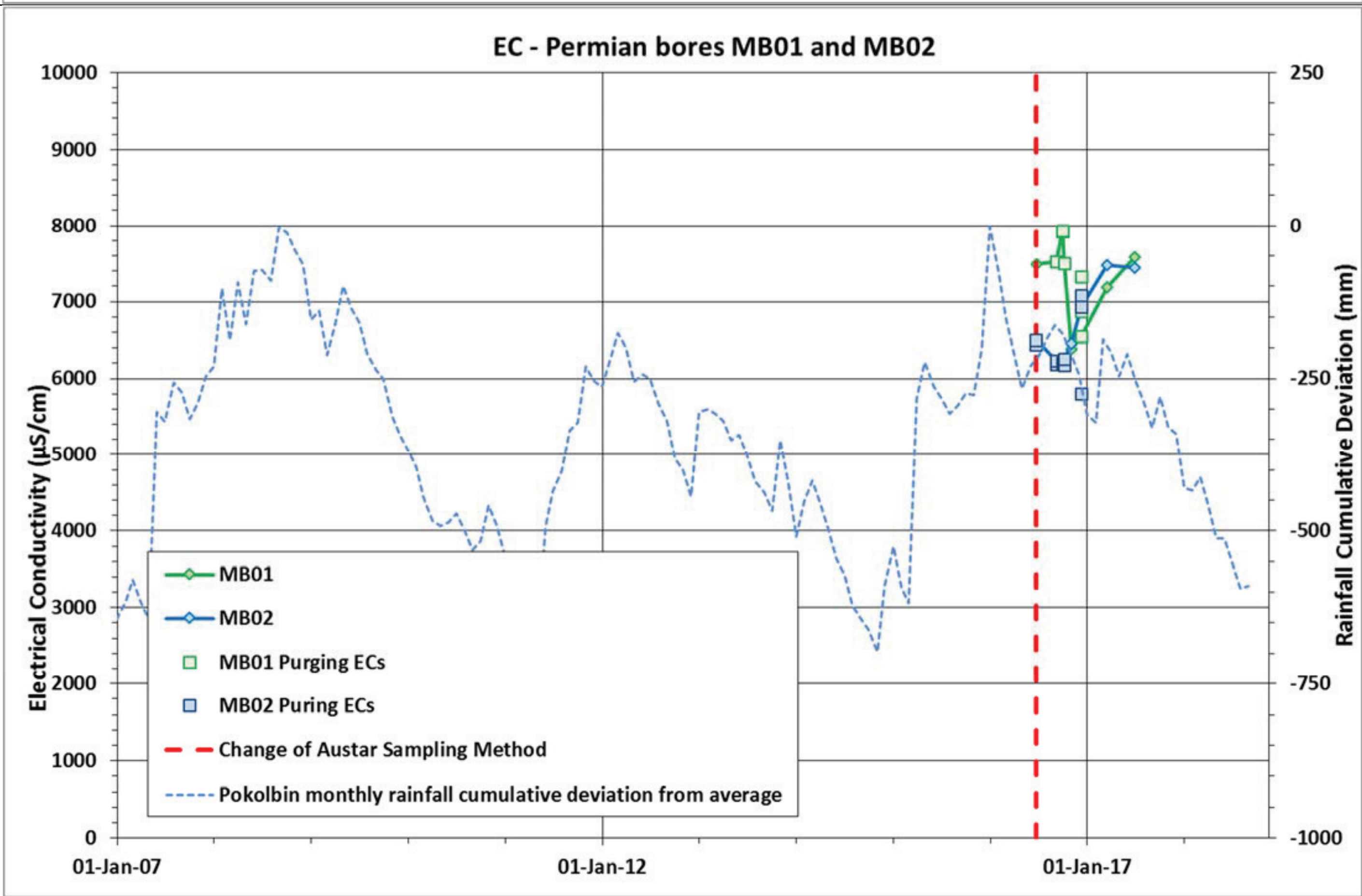
Date: 23 November 2018		Scale: as shown	**Austar Coal Mine Pty Ltd**
Author: PD	Checked: PD	Project No: 18-0349	**Quorrobolong Valley Groundwater Water Quality – EC AQD1073A and NER1010**
Dwg No: 0349-001		Revision: 0	
Dundon Consulting Pty Ltd			**Figure 1**



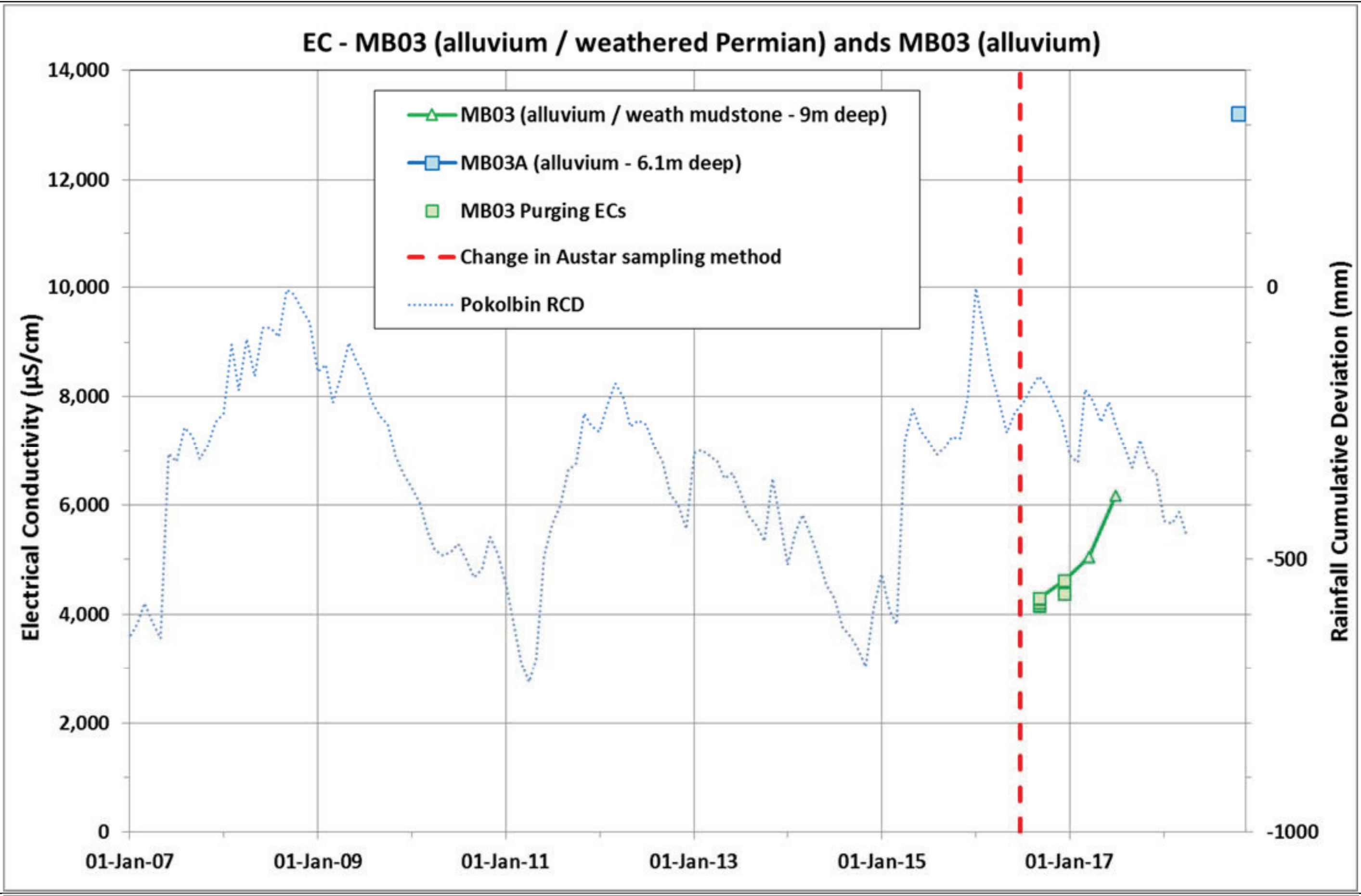


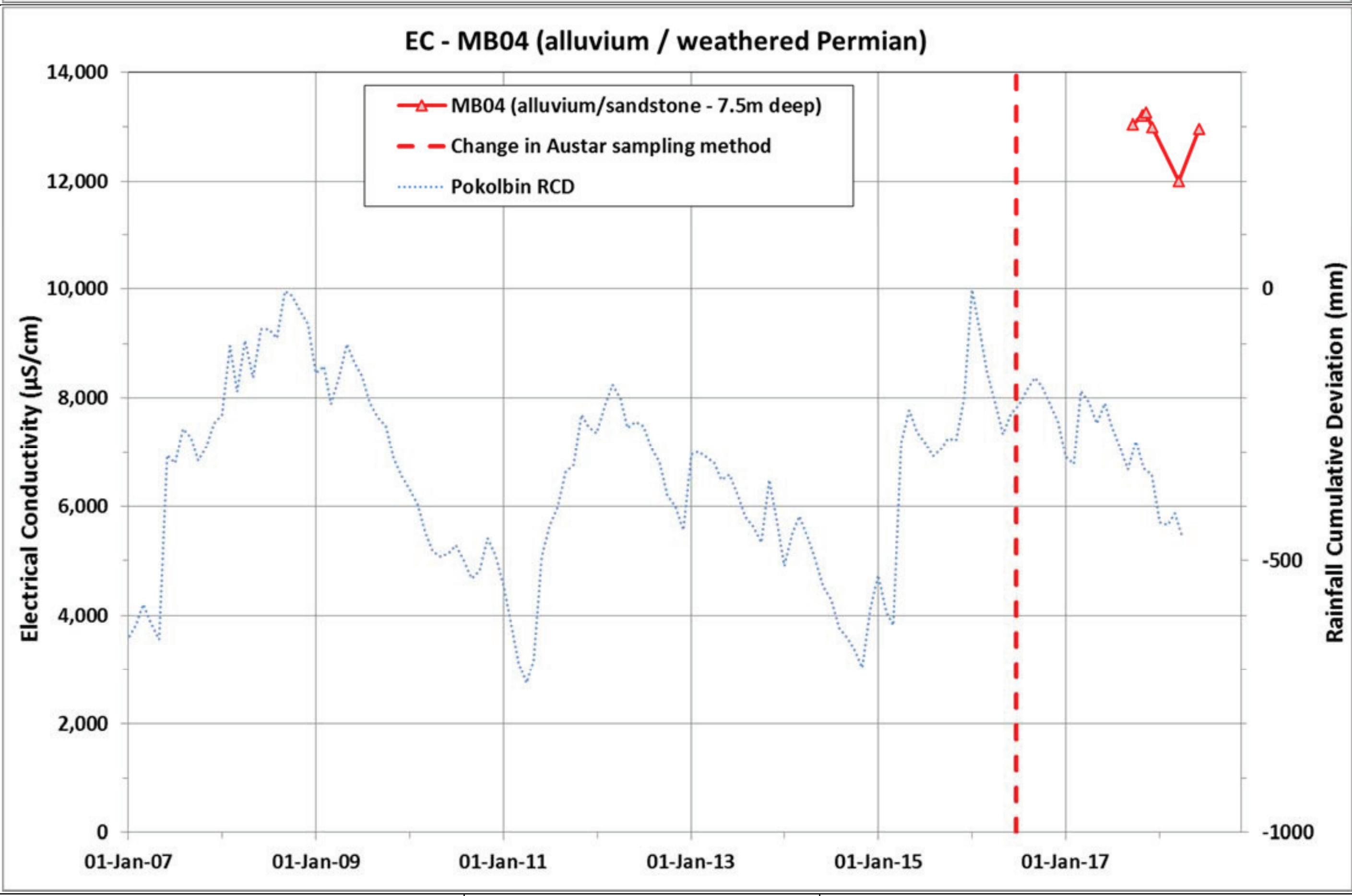
Date: 23 November 2018		Scale: as shown	**Austar Coal Mine Pty Ltd**
Author: PD	Checked: PD	Project No: 18-0349	**Quorrobolong Valley Groundwater Water Quality – EC WBH1 and WBH2**
Dwg No: 0349-002		Revision: 0	
Dundon Consulting Pty Ltd			**Figure 2**



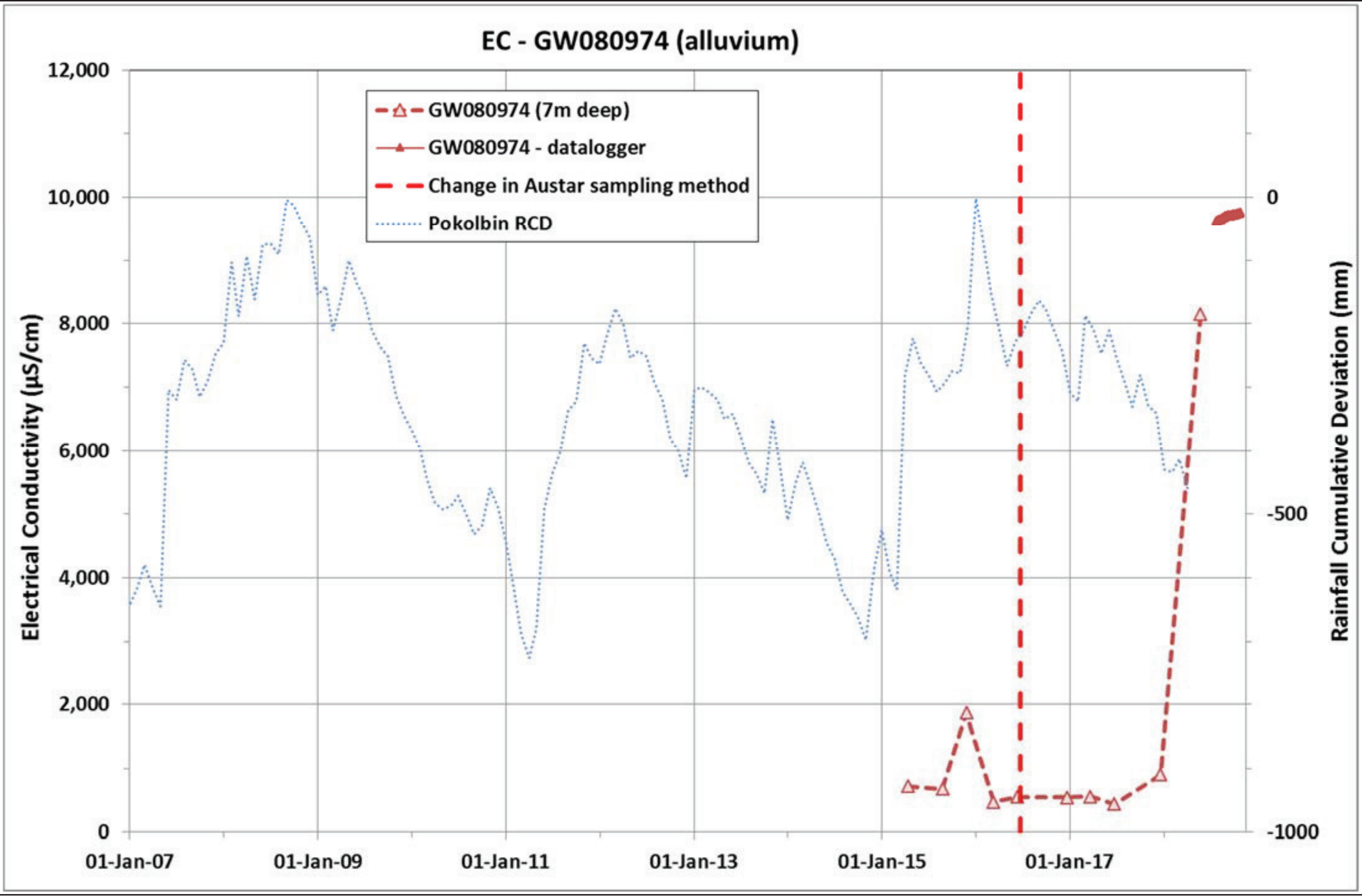


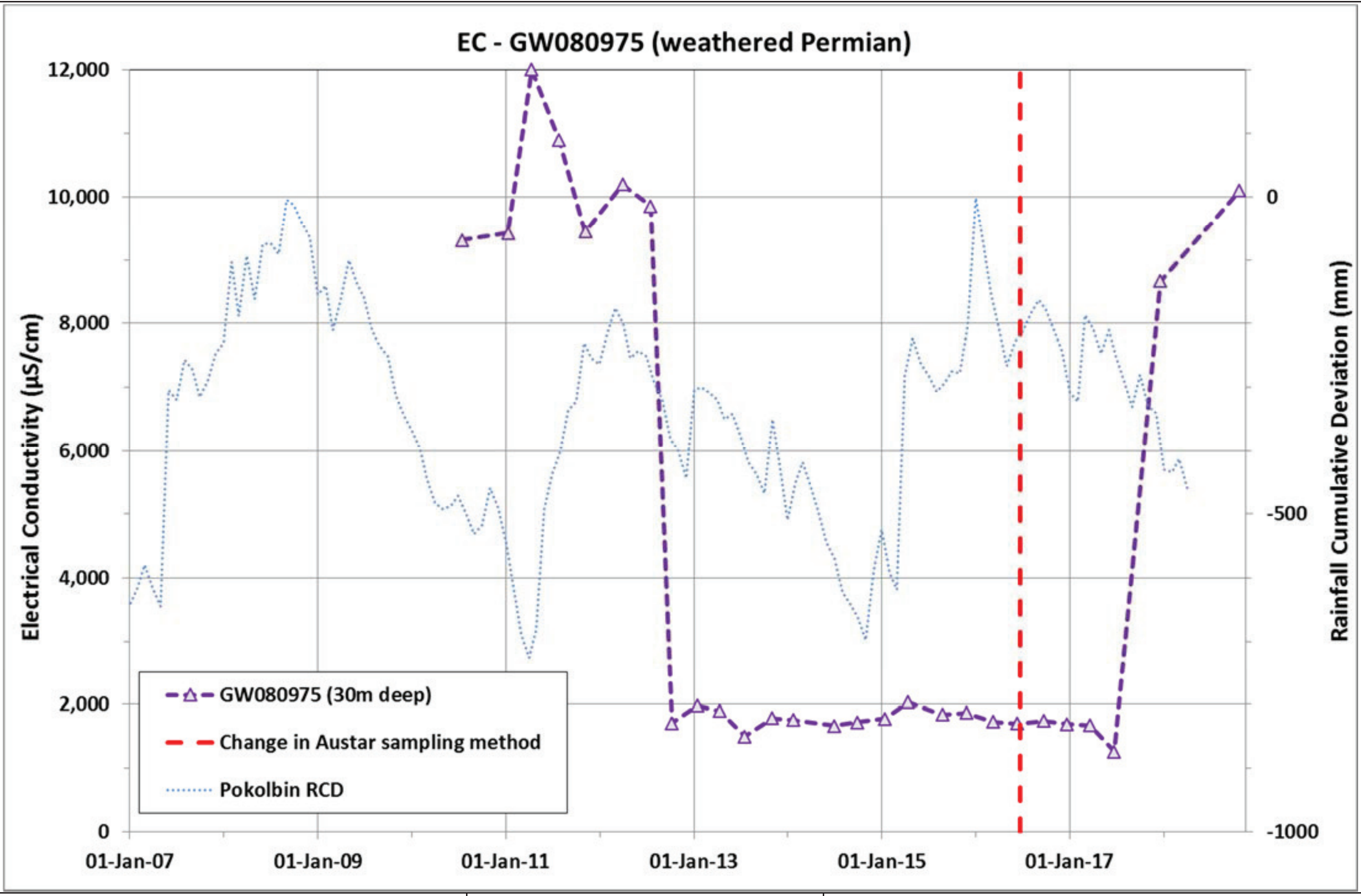
Date: 23 November 2018		Scale: as shown	**Austar Coal Mine Pty Ltd**
Author: PD	Checked: PD	Project No: 18-0349	**Quorrobolong Valley Groundwater Water Quality – EC WBH3, MB01 and MB02**
Dwg No: 0349-003		Revision: 0	
Dundon Consulting Pty Ltd			**Figure 3**





Date: 23 November 2018		Scale: as shown	**Austar Coal Mine Pty Ltd**
Author: PD	Checked: PD	Project No: 18-0349	**Quorrobolong Valley Groundwater Water Quality – EC MB03, MB03A and MB04**
Dwg No: 0349-004		Revision: 0	
Dundon Consulting Pty Ltd			**Figure 4**





Date: 23 November 2018		Scale: as shown	**Austar Coal Mine Pty Ltd**
Author: PD	Checked: PD	Project No: 18-0349	**Quorrobolong Valley Groundwater Water Quality – EC GW090874 and GW090875**
Dwg No: 0349-005		Revision: 0	
Dundon Consulting Pty Ltd			**Figure 5**

Attachment D

Response to Additional Information

Carly McCormack

From: Ryan Shepherd <ryan.shepherd@nrar.nsw.gov.au>
Sent: Wednesday, 23 January 2019 10:08 AM
To: Jack Murphy
Cc: Carly McCormack; Landuse Enquiries; Water Referrals
Subject: Re: V13/3707#7 DA29/95 MOD7 Schedule 3 Condition 12A - Groundwater Review

Hi Jack,

NRAR /DoI Water has reviewed the proposed sampling methodology put forward by Dundon Consulting Pty Ltd in their letter dated 22 November 2018, and is satisfied that this is an appropriate method to inform any changes to the TARP and/or Management Plans, if necessary.

Regards,

Ryan Shepherd | Water Regulation Officer (East)
Natural Resources Access Regulator
Department of Industry | Lands & Water
Level 3 | 26 Honeysuckle Drive | Newcastle NSW 2300 | PO Box 2213, Dangar NSW 2309
T: 02 4904 2650 | F: 02 4904 2501 | E: ryan.shepherd@nrar.nsw.gov.au
W: www.industry.nsw.gov.au

On Tue, Jan 22, 2019 at 2:05 PM Jack Murphy <Jack.Murphy@planning.nsw.gov.au> wrote:

> Good Afternoon
>
> Just following up the below.
>
> Kind Regards
>
> Jack
>
> **Jack Murphy**
>
> Environmental Assessment Officer
>
> Resource Assessments | Planning Services
>
> 320 Pitt Street | GPO Box 39 | Sydney NSW 2001
> T 02 8217 2016 E jack.murphy@planning.nsw.gov.au

Planning Services
Resource Assessments
Contact: Jack Murphy
Phone: 8217 2016
Email: jack.murphy@planning.nsw.gov.au

Ms Carly McCormack
Environment and Community Superintendent
Austar Coal Mine Pty Ltd
Locked Bag 806
Cessnock NSW 2325

Email: Carly.McCormack@yancoal.com.au

Dear Ms McCormack,

Austar Coal Mine (DA29/95 MOD 7)
Historical Groundwater Review and Assessment

I refer to your email dated 1 February 2019, submitting the revised Historical Groundwater Review and Assessment for approval.

The Department has reviewed this document and considers that it meets condition 12A of Schedule 3 of DA29/95 MOD 7. Consequently, the Secretary has approved this document.

Please ensure a finalised copy of this document is made available on the company's website.

Should you have any enquiries in relation to this matter, please contact Jack Murphy.

Yours sincerely,

Howard Reed

Howard Reed 4.2.19
Director
Resource Assessments
As nominee of the Secretary