Australasian Groundwater and
Environmental Consultants Pty Ltd

Report on

Dartbrook Modification 7 Groundwater Assessment

Prepared for
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Groundwater Assessment
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Dartbrook Modification 7 Groundwater Assessment

1 Introduction

AQC Dartbrook Management Pty Limited (AQC) is the proprietor of the Dartbrook Mine, located in the Upper Hunter Valley of NSW. AQC is a wholly owned subsidiary of Australian Pacific Coal Limited. Dartbrook Mine is managed in accordance with Development Consent DA 231-7-2000 granted under the *Environmental Planning and Assessment Act 1979* (EP&A Act). DA 231-7-2000 allows for longwall mining operations to be carried out until 5 December 2022. However, Dartbrook Mine has been in care and maintenance since December 2006.

AQC is seeking to modify DA 231-7-2000 to facilitate limited bord and pillar mining within the already approved longwall mining area at Dartbrook Mine. This modification application has been made under Section 75W of the EP&A Act.

The Modification proposes the following:

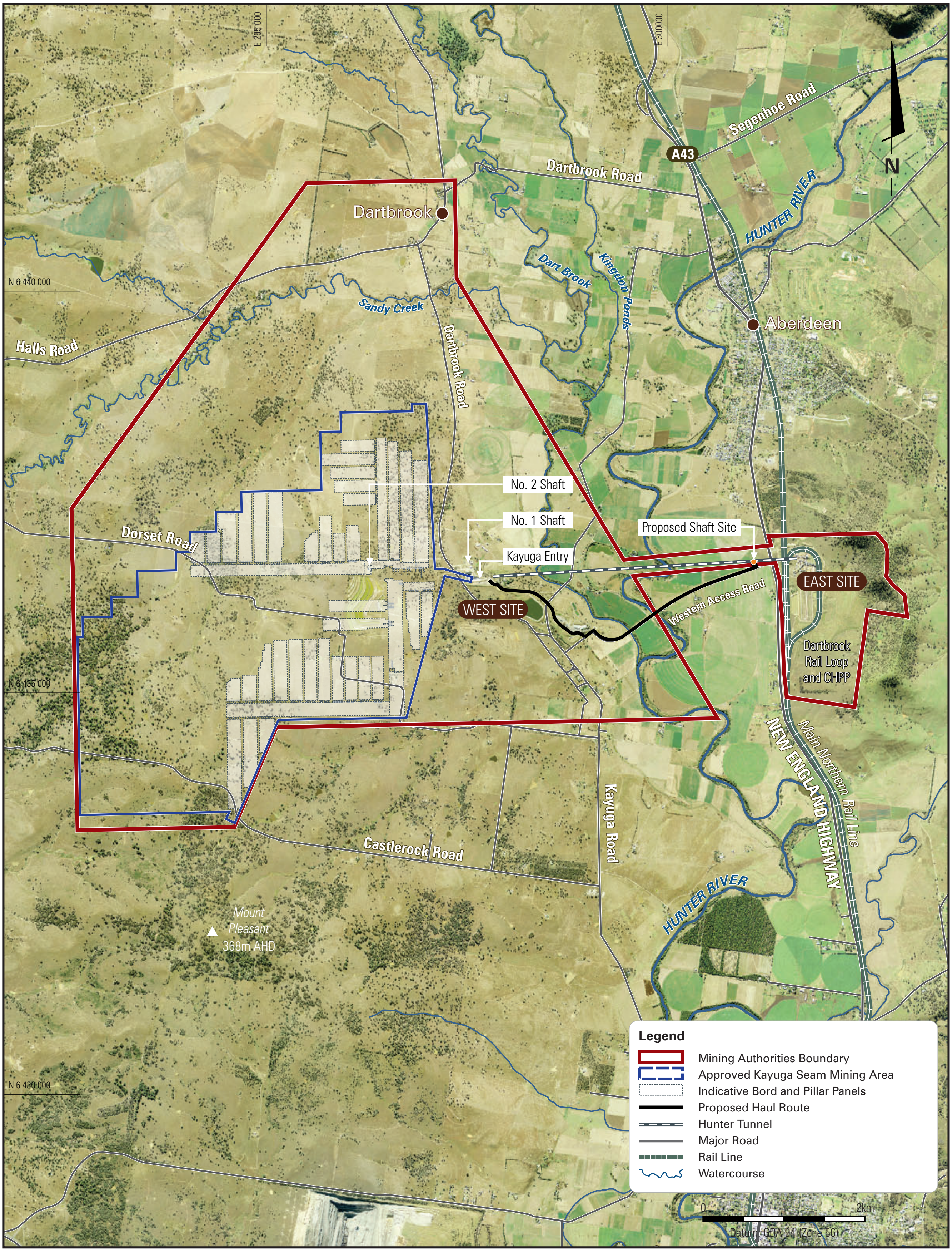
- Bord and pillar mining in part of the Kayuga coal seam as an alternative to the already approved longwall mining activities;
- An alternative method of transferring Run of Mine (ROM) coal to the coal handling infrastructure at the East Site; and
- Extending the approval period under DA 231-7-2000 by 5 years (until 5 December 2027).

DA 231-7-2000 authorises longwall mining activities in the Wynn, Kayuga, Mt Arthur and Piercefield coal seams. The Modification proposes bord and pillar mining in part of the Kayuga seam, as an alternative to the approved longwall mining activities. Bord and pillar mining will be designed and undertaken in a manner such that subsidence is imperceptible for all practical purposes.
The proposed bord and pillar workings will be located within the Approved Kayuga Seam Mining Area (see Figure 1.1). That is, the Modification will not increase the footprint of mining operations at Dartbrook Mine.

The proposed bord and pillar mining will facilitate the extraction of up to 10 Mt of ROM coal over a 10 year period. The maximum production rate that may be achieved in a single year by the proposed bord and pillar mining is 1.5 Mtpa. This is within the approved maximum production rate of 6 Mtpa.

DA 231-7-2000 allows for ROM coal to be transferred from the mine workings to the East Site via the Hunter Tunnel. The Hunter Tunnel is an underground roadway that passes beneath the Hunter River and New England Highway. The conveyors in the Hunter Tunnel were removed by the previous owners of Dartbrook Mine during the care and maintenance phase. As such, AQC has developed an alternative coal clearance system for the Modification. ROM coal will be brought to the surface at the Kayuga Entry. Haul trucks will then transport ROM coal from the Kayuga Entry to a new shaft site to be located directly above the Hunter Tunnel (Figure 1.1). The new shaft site will include a materials delivery shaft for transferring ROM coal into the Hunter Tunnel. The coal will then be conveyed beneath the New England Highway to the East Site.

DA 231-7-2000 allows for mining activities to be undertaken until 5 December 2022. To enable the proposed bord and pillar mining activities to be conducted, the Modification seeks to extend the period of approval by 5 years (until 5 December 2027).



HB DARTBROOK Underground MOD7 1774 F1 Conceptual Modification Layout 01 06 2018

DARTBROOK MINE

Hansen Bailey ENVIRONMENTAL CONSULTANTS

Australian Pacific Coal

Conceptual Modification Layout

FIGURE 1.1

1.1 Project location

Dartbrook Mine is located about 10 km north-west of Muswellbrook in the Upper Hunter Valley. The current mine infrastructure is located on both the western and the eastern side of the Hunter River on relatively low-lying, undulating hills, that grade onto the flat alluvial lands adjacent to the Hunter River. The location of Dartbrook Mine is shown on Figure 1.2.

1.2 Climate

The climate is temperate and influenced by coastal weather patterns. Rainfall is summer dominated (October to March) and averages 640 mm per annum (Bureau of Meteorology weather station 061089).

1.3 Terrain and drainage

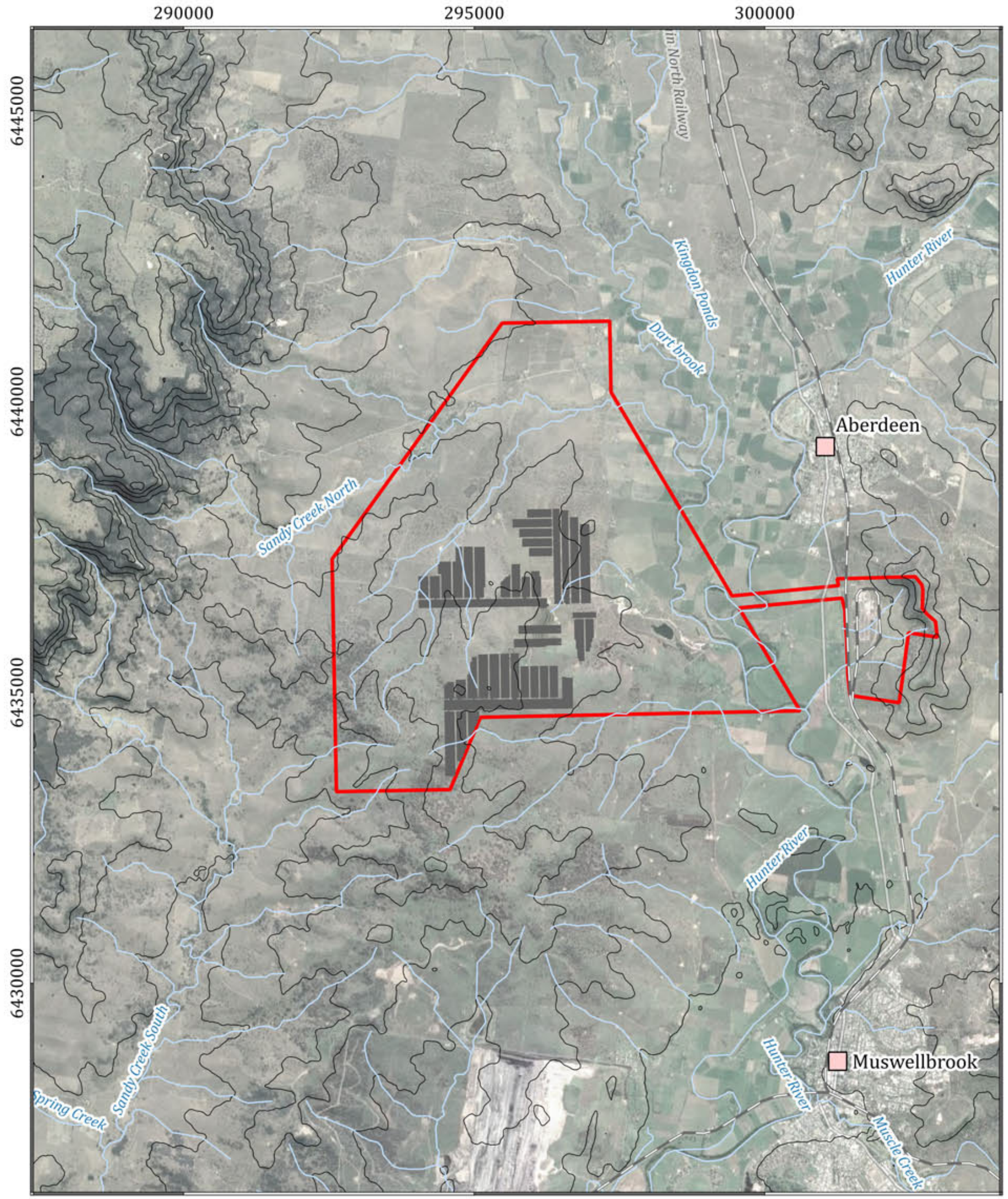
The topography in the existing and proposed mining areas drains via a series of gullies towards the Hunter River, Dart Brook and Sandy Creek (Figure 1.2).

The CHPP and associated infrastructure (the East Site) is situated adjacent to the western slope of Browns Mountain and is drained by a series of ephemeral channels into the Hunter River flood plain (Figure 1.2).

1.4 Land use

Agricultural pursuits in the vicinity of Dartbrook Mine consist of irrigation of lucerne and dairy farming along the alluvial flats with grazing of livestock on the more elevated land. Coal mining has a long history in the area, and is prevalent in the area (Figure 1.2).

The underground mine at Dartbrook was operated between 1996 and 2006. Longwall mining occurred within the Wynn Seam and the Kayuga Seam from the panels shown in KAI01-KAI03. Mining of the Kayuga Seam occurred from a series of east-west orientated longwall panels commenced in June 2004 and ceased in September 2006. The Kayuga Seam is stratigraphically located 160 m to 170 m above the Wynn Seam. Longwall panels KA101, KA102 and approximately 75% of KA103 were mined. Underground mining ceased in December2006, and the mine has been on care and maintenance since 1st January 2007.



LEGEND

- Populated place
- Mining Authorisation
- Proposed Bord and Pillar Mining Panels
- Rail
- Drainage/Creek
- Elevation contour (100 m interval)

Dartbrook Bord & Pillar MOD (G1730H)

AGE

Site location

DATE
08/06/2018

FIGURE No:
1.2

N:/Groundwater Jobs/G1730H.Dartbrook_Bord_&_Pillar_MOD/3_GIS/Workspaces/001_Deliverable1/01.02_G1730H Site location.qgs

1.5 Geology

The stratigraphic sequence at Dartbrook Mine comprises two distinct units, namely Permian coal measures, overlain by Quaternary to recent alluvial sediments occurring in eroded valley environments along the main drainages of the Hunter River and its tributaries. Figure 1.3 shows the main geological units occurring at surface.

1.5.1 Quaternary

The Hunter Coalfield Regional Geology 1:100,000 scale (Map sheet 9033), shows the Permian coal measures are overlain by thin Quaternary unconsolidated deposits associated with the Hunter River, Sandy Creek and Dart Brook. The Quaternary deposits consist of shallow unconsolidated sands overlying silty and clayey sands with occasional cleaner sands. The distribution of the Quaternary alluvium (Qa) across the region is shown on Figure 1.3.

A previous investigation undertaken by AGE (2007) defined the western margin of the alluvial floodplain associated with Dart Brook. The alluvial limit was determined by excavating 38 test pits to a depth of up to 4.1 m along 14 traverses. The limit of alluvium defined on the 1:100,000 scale geological map was refined to reflect the extent of the alluvium determined from the field investigations as shown on Figure 1.3.

Review of logs for boreholes drilled within the flood plain to the east of the Mining Authorisation Boundary indicates the alluvial sediments are typically in the order of 4 m to 15 m in thickness. The available data suggests the alluvial sediment immediately east of the western margin of the flood plain adjacent to the Mining Authorisation Boundary is relatively thin, and is potentially a palaeo embayment between the elevated land to the west and a slightly elevated ridge to the immediate west of Dart Brook. The embayment would be a low energy environment and contain shallow deposits of essentially clay and silt materials. There are few registered bores in this area, which suggests that the alluvial sediments do not form a productive aquifer in this area due to permeability and/or limited thickness.

1.5.2 Permian

The Permian stratigraphy comprises north-west dipping coal measures of the Jerrys Plains Subgroup and the Vane Subgroup separated by the Archerfield Sandstone. The surface geology including the Vane Subgroup and Jerrys Plains Subgroup is shown on Figure 1.3.

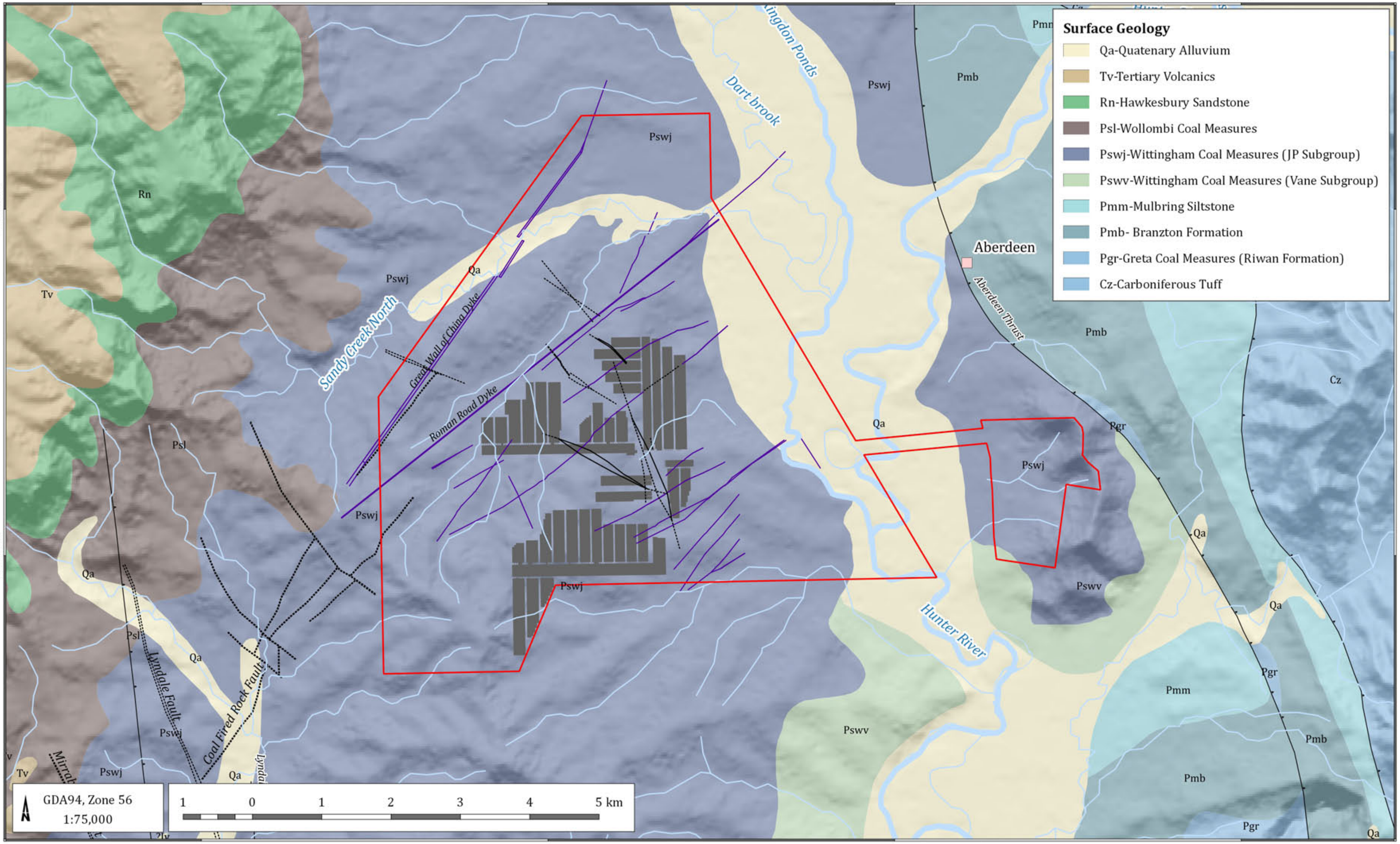
The coal measures dip at 3 to 6 degrees to the north-west forming the western limb of the Muswellbrook anticline. Coal seams occurring within the Mining Authorisation Boundary include (from shallow to deep), the Woodlands Hill, Arrowfield, Bowfield, Warkworth, Mt. Arthur, Kayuga, Piercefield, Vaux, Broonie, Bayswater, Wynn and Edderton Seams and seam splits. The entire sequence was deposited during the Permian period (+250 million years ago).

The Kayuga coal seam is around 3.2 m thick and strikes north-east to the east of the Mining Authorisation Boundary, sub-cropping about 500 m east into Permian bedrock. About one kilometre to the north-east the Kayuga coal seam sub-crops beneath the Quaternary alluvium associated with Dart Brook and the Hunter River as shown in Figure 1.4.

1.5.3 Structure

Weak regional east-west compression of the coal measures has resulted in the development of a number of structural features shown on Figure 1.3. Significant thrust fault systems include the Aberdeen Thrust located to the east of Dartbrook Mine and the Lyndale, Mirrabooka and Mt. Ogilvie Faults located to the south-west. A number of north-west trending faults have also been surficially mapped although the dip and throw of the faults, along with whether or not the faults are acting as impermeable barriers, is unknown.

There are two major dykes located to the north-west of the proposed mine known as the 'Roman Road' and 'Great Wall of China' dykes. These dykes strike in a north-easterly direction with near vertical dips and a thickness of 15 m to 25 m. Exploration programs have identified a number of other smaller igneous intrusions with similar orientations within the proposed mining areas. Regional joint sets tend to be vertical to sub-vertical in an east-south-easterly direction. Joint frequency is highly variable and inferred to be low but increasing southwards.



LEGEND

Populated place
Mining Authorisation
Proposed Bord and Pillar Mining Panels
Drainage/creek
Major fault
Fault
Dykes

Dartbrook Bord & Pillar MOD (G1730H)

AGE

Surface Geology

DATE 08/06/2018

FIGURE No: **1.3**

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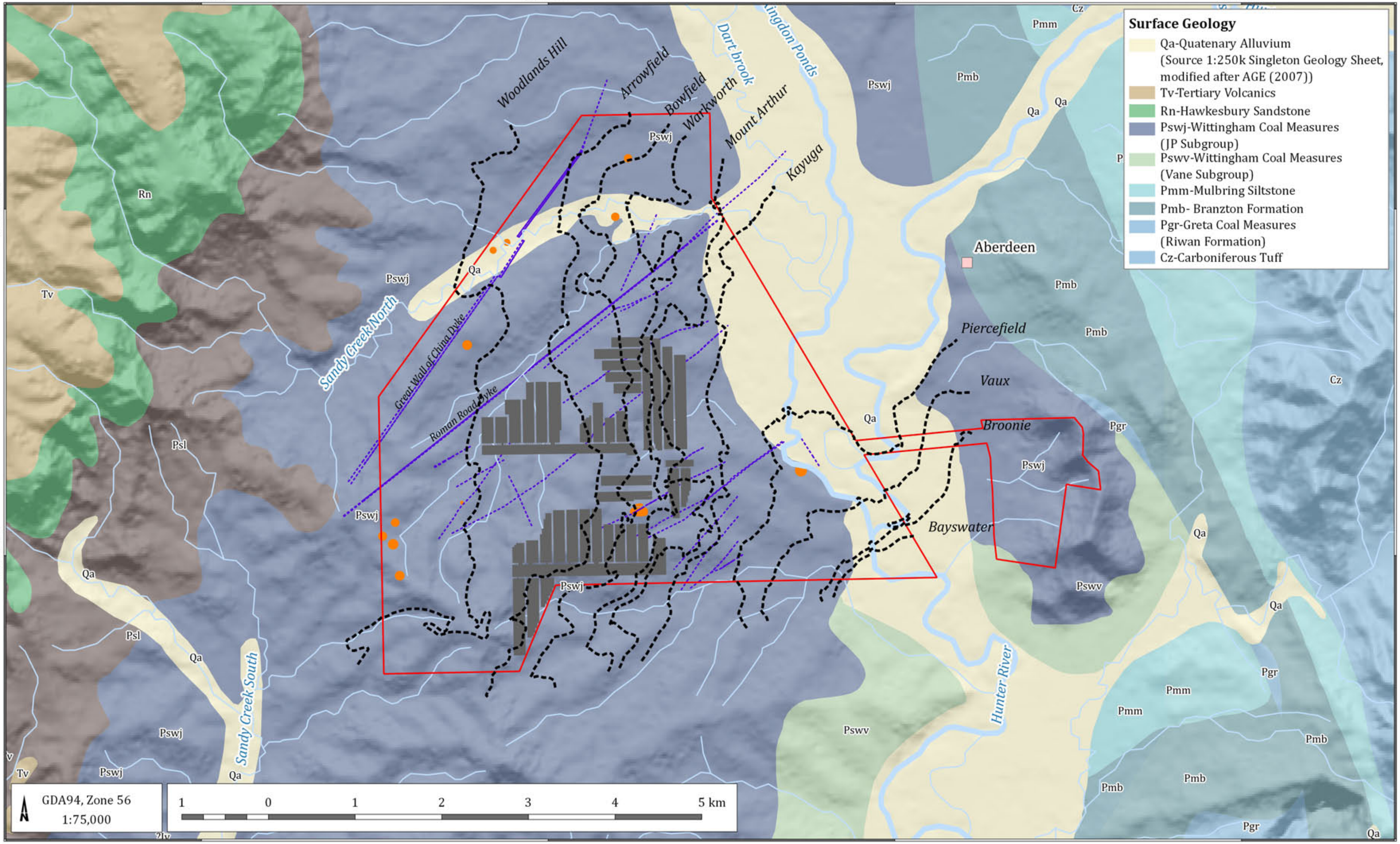


LEGEND

- Populated place
- Mining Authorisation
- Proposed Bord and Pillar Mining Panels
- Drainage/creek
- Seam subcrop
- Dykes
- Plug

Dartbrook Bord & Pillar MOD (G1730H)

Seam subcrop

DATE
08/06/2018

FIGURE No:
1.4

1.6 Groundwater monitoring network

Groundwater is currently managed at Dartbrook Mine according to the procedures outlined in the Site Water Management Plan (WMP) (Anglo American, 2015). A network of 38 monitoring bores has been used to monitor groundwater levels and quality during the care and maintenance period. An additional 13 bores (labelled "MB series") were installed at Dartbrook Mine in 2012. These bores have continued to be monitored annually but do not form part of the 38 monitoring sites currently presented within the WMP.

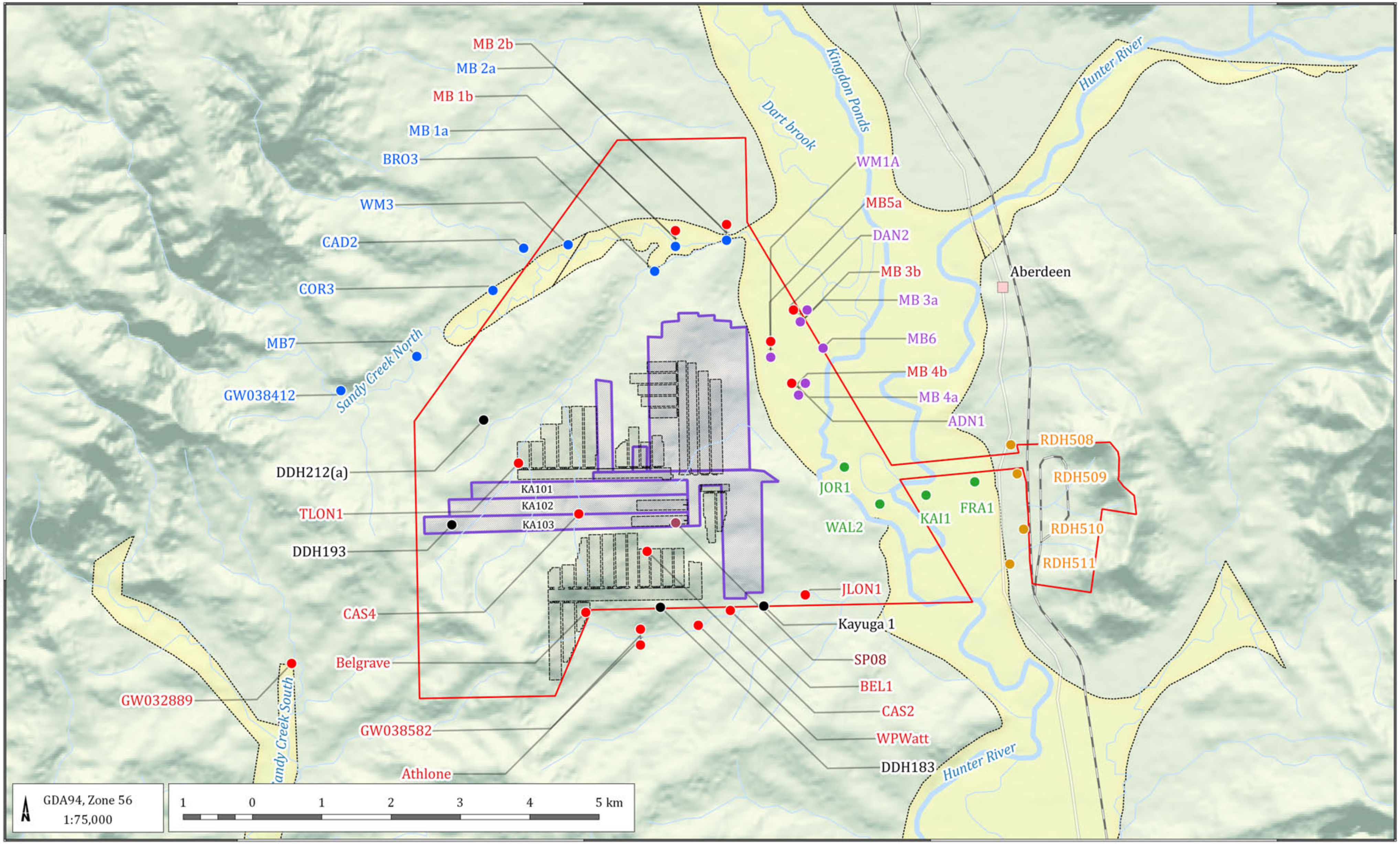
The groundwater monitoring program was developed with the objective of satisfying the following approvals:

- Development Consent DA 231-7-2000, where the conditions require surface and groundwater quality and quantity monitoring as outlined in the WMP; and
- monitoring of selected landowner bores in accordance with the approved Property Subsidence Management Plan (PSMP).

The groundwater monitoring bore network was designed to assess deep and shallow depressurisation of the coal measures strata created by mine dewatering during longwall operation, and any adverse impact dewatering may have. The WMP indicates the monitoring bore network was designed to monitor all potential impacts including:

- "*impacts on alluvial aquifers including the Hunter river alluvium, Dart Brook alluvium, and Sandy Creek alluvium;*
- *impacts from the storage of tailings and mine water in the Wynn seam goaf;*
- *leakage from the staged discharge dam;*
- *seepage from the Rejects Emplacement Area (REA); and*
- *groundwater levels in the coal seams and privately owned stock watering bores*".

A summary of the bores included within the WMP, including the "MB series" bores, is provided in Appendix A with the locations of the monitoring bores shown on Figure 1.5.



LEGEND

- Populated place
- Mining Authorisation
- Alluvium (Source: 1:250k Singleton Geology Sheet modified after AGE (2007))
- Mined Out Panels
- Proposed Bord and Pillar Mining Panels
- Drainage/creek
- Roman road dyke and SP08
- Hunter River Alluvial Bores
- Regolith Shallow Bedrock Bores
- Sandy Creek Alluvial Bores
- CHPP/REA Monitoring Bores
- Coal Seam Bores
- Dartbrook Alluvial Bores

Dartbrook Bord & Pillar MOD (G1730H)

AGE

Groundwater monitoring network

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08/06/2018

FIGURE No:
1.5

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2 Groundwater regime and conceptual groundwater model

The groundwater regime at Dartbrook Mine consists of three aquifer systems, namely the:

- alluvium along the Hunter River, Sandy Creek and Dart Brook;
- weathered bedrock (regolith); and
- the coal seams of the Permian Wittingham Coal Measures.

Alluvial deposits are present along the Hunter River and also along Sandy Creek and Dart Brook, especially near their confluence with the Hunter River. The main groundwater bearing units occur in the Hunter River and Dart Brook flood plains due to greater saturated thickness.

The regolith (weathered bedrock) directly below the ground surface may have a higher hydraulic conductivity, compared to the deeper interburden, owing to weathering effects. The regolith aquifer represents a less significant water source than the alluvial aquifers in terms of both water volume and quality but is the most readily accessible unit for landholders outside the flood plain.

The Permian Wittingham Coal Measures are not considered to be a significant aquifer. While some coal seams may show an elevated hydraulic conductivity, the dominant interburden sections are of very low hydraulic conductivity due to the low porosity and limited jointing noted previously. Occurrence and flow of groundwater is governed by the presence of micro faults, joints, fractures, and bedding planes which are often locally discontinuous.

Groundwater quality across the hydro stratigraphic units is highly variable, ranging from fresh to saline. Groundwater quality is best within the alluvial aquifers, but still variable based on location. Groundwater within the regolith and coal seams is generally brackish to saline, but can be suitable for stock and domestic purposes, where salt contents are lowest.

The generally lower salinity occurring within the Quaternary alluvium indicates more significant recharge rates occurring via:

- diffuse rainfall and deep drainage through the flood plain soils;
- seepage of river and creek flows through the stream bed; and
- runoff from the topographically higher bedrock hills and subsequent deep drainage through the soil profile at the fringes of the alluvium.

Recharge to the regolith is via direct infiltration of rainfall. The regolith in turn provides recharge to the Permian coal measures through areas of either coal seam or interburden sub crop.

The potentiometric surface and flow directions in both the regolith and the Permian coal measures are a subdued reflection of topography, with flow to the east towards the low lying alluvial flood plain. The flow within the alluvium is aligned with the direction of flow within the streams to the south and south-east.

In addition to natural groundwater systems, anthropogenic activities also influence groundwater flow over the Dartbrook Mine area. The current approved underground workings receive water inflows due to seepage from overlying strata and water pumped in from the Hunter Tunnel. A description of the water management system is provided in Section 5.

Landholders preferentially extract groundwater from the alluvial aquifers compared to the adjacent elevated Permian hills. Within the hills, most bores/wells are situated near drainages where recharge to regolith and shallow Permian is expected to be enhanced.

Measurements of groundwater levels in monitoring bores indicate underground mining has reduced groundwater levels and pressures within the regolith and Permian coal measures in a zone above the mined longwall panels. The mined panels (KAI01-KAI03) are approximately 200 m wide by 3000 m long, 3.2 m thick and have a cover depth ranging from 120 mbgl to 260 mbgl. The mined seams cover a sub-surface area of about 215 ha. The Wynn seam has been partially drained by pumping during the care and maintenance period (more information is provided within Section 5.2). Some monitoring bores have recorded recovery during the care and maintenance period, whilst others continue to show a long-term declining trend, indicating very slow drainage due to fracturing and connective cracking from longwall mining.

Regional groundwater levels within the alluvium appear unaffected by mining. Detailed description of groundwater trends is provided in the Dartbrook Annual Environmental Reports.

Two large, steeply dipping dykes of Tertiary age exist in the north-west of the proposed bord and pillar mining area. No groundwater data exists in relation to these structures, but it is expected the dykes would compartmentalise the local scale groundwater flow regime.

3 Previous modelling

Mackie Environmental Research (MER, 2000) developed a computer based numerical groundwater flow model of the region using the MODFLOW code. The model was developed to assess the potential impacts arising from the approved longwall mining. The model results were documented in Appendix L of the Dartbrook extension EIS, dated June 2000 (HLA Envirosciences, 2000).

The groundwater model was used to simulate depressurisation of the coal measures since commencement of mining in 1996, and to predict the impact of longwall mining of the Kayuga Seam, which was proposed for mining at the time of model development.

The numerical modelling of the Kayuga Seam underground mine assessed the impact on surrounding registered bores and predicted a net change in the alluvium leakage balance. Potential drawdown impacts to local bores were dependent on recharge rates and MER (2000) concluded a *"loss of aquifer pressure water levels within the coal measures may have impact on existing bores and wells in the hardrock coal measures depending upon location and local recharge mechanisms".*

The modelling predicted a net change in the alluvium leakage balance of about 0.1 ML/day with the maximum change potentially inducing downward leakage at a rate less than 0.01 L/m^2/day at the completion of underground mining of the Kayuga Seam. The leakage rate from the alluvium was shown to be less than that of rainfall recharge which was calculated to be at least 90 mm/year or approximately 0.25 L/m^2/day. That is, more than two orders of magnitude higher than the predicted loss. Therefore, it was concluded that bores and wells potentially impacted were primarily limited to the lower recharge Permian units, rather than the bores in the alluvium.

The model results predicted a steady rise in mine water seepage from the Kayuga coal seam from 0.2 ML/day to 1.2 ML/day in year 18. The peak inflow occurs near the completion of mining of the 20Kayuga coal seam panels. The 20 Kayuga seam longwall panels cover an area of around 16.2 km^2,compared to the proposed bord and pillar area is about 5.7 km^2.

4 NSW water regulatory framework

4.1 Water sharing plans

NSW Water Sharing Plans (WSPs) establish rules for sharing water between the environmental needs of the river or aquifer and water users, and between different types of water use such as town supply, rural domestic supply, stock watering, industry, and irrigation.

The NSW Department of Industry (DoI) Water is progressively developing WSPs for rivers and groundwater systems across NSW following the introduction of the *Water Management Act 2000*. The purposes of these plans are to protect the health of rivers and groundwater, while also providing water users with perpetual access licences, equitable conditions, and increased opportunities to trade water through separation of land and water.

Three WSPs apply to the aquifers and surface waters affected by the Modification, namely the:

- *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016 (North Coast Fractured and Porous Rock WSP);*
- *Water Sharing Plan for the Hunter Regulated River Water Source 2016 (Hunter Regulated WSP); and*
- *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 (Hunter Unregulated WSP).*

AQC currently holds Water Access Licences (WALs) to account for water take. A summary of WALs held by AQC is presented in Table 4.1.

Table 4.1 Summary of WALs currently held by AQC

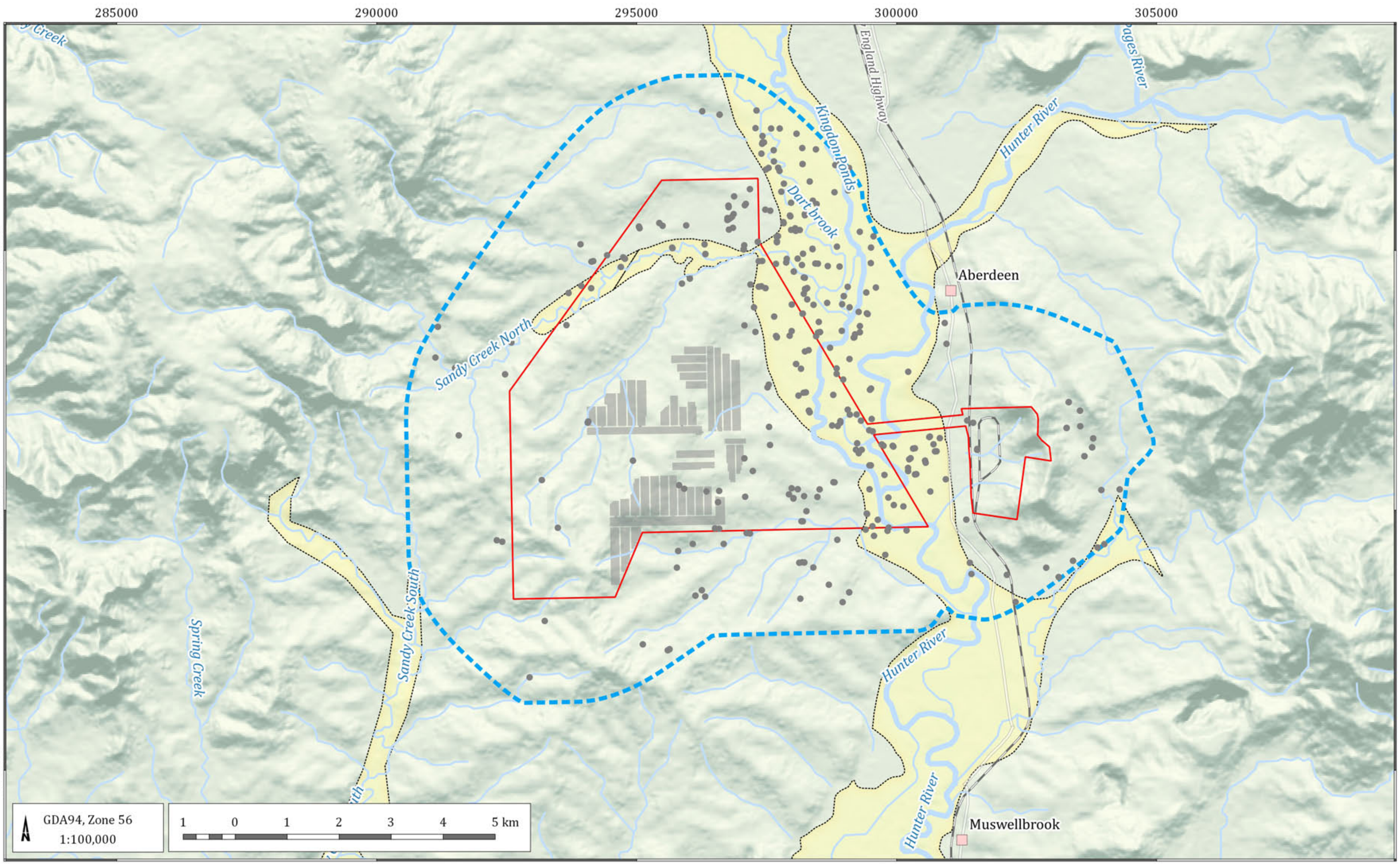
<table>
<tr><th>Water sharing plan</th><th>Water source</th><th>Licence category</th><th>Total share component</th></tr>
<tr><td>North Coast Fractured and Porous Rock WSP</td><td>Sydney Basin – North Coast Groundwater Source</td><td>aquifer</td><td>180*</td></tr>
<tr><td>Hunter Regulated WSP</td><td>Hunter Regulated River Water Source (Zone 1a)</td><td>regulated river</td><td>3,071.8</td></tr>
<tr><td rowspan="4">Hunter Unregulated WSP</td><td>Muswellbrook</td><td>aquifer</td><td>Basic rights</td></tr>
<tr><td rowspan="2">Dart Brook</td><td>unregulated river</td><td>85</td></tr>
<tr><td>aquifer</td><td>950</td></tr>
<tr><td>Hunter Regulated River Alluvial</td><td>aquifer</td><td>1,249</td></tr>
</table>

Note: ** WALs are currently attached to the Alstonville Basalt Plateau Groundwater Source. Applications to DoI Water have sought to correctly attach these WALs to the Sydney Basin – North Coast Groundwater Source.*

4.2 Groundwater use

A search of the DoI Water registered bore database indicates that there are over 344 bores and wells located within two kilometres of the Mining Authorisation Boundary. The greatest density of bores occurs in the vicinity of the confluence of Dart Brook and the Hunter River.

Very few bores were shown to be located in elevated hardrock areas (i.e. Permian coal measure outcrop) owing to poor water quality and low yield characteristics. Of those that are located in the elevated hardrock areas, most are situated near drainages where some recharge to shallow unconsolidated deposits occurs. Figure 4.1 shows the locations of registered bores in the area within 2 km of the Mining Authorisation Boundary.



LEGEND

- Populated place
- Mining Authorisation
- Mining Authorisation buffer (2 km)
- Proposed Bord and Pillar Mining Panels
- Alluvium (Source: 1:250k Singleton Geology Sheet,modified after AGE (2007))
- Rail
- Drainage/creek
- Approved drawdown (m)
- Pineena registered bores

Dartbrook Bord & Pillar MOD (G1730H)

AGE

Groundwater uses within 2 km

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FIGURE No:

4.1

N:/Groundwater Jobs/G1730H.Dartbrook_Bord_&_Pillar_MOD/3_GIS/Workspaces/001_Deliverable1/04.01_G1730H Groundwater Uses within 2 km.qgs

5 Impact assessment

5.1 Methodology

The key potential impacts due to the Modification are interception of groundwater, drawdown within the aquifer systems and potential for impacts upon groundwater users and ecosystems. The methodology adopted, relied upon analytical methods and analysis of data collected during mining/care and maintenance, rather than numerical modelling. To increase the confidence in the conclusions drawn, multiple lines of evidence were used to confirm the expected impact of the Modification on the groundwater regime. Groundwater seepage rates into the bord and pillar workings and the associated drawdown were estimated using:

- water balance records collected for the existing underground mine during care and maintenance;
- analytical methods informed by hydraulic conductivity and hydraulic gradients at the site;
- previous numerical modelling predictions for the approved longwall mining; and
- water level records within bores surrounding the existing longwall mining areas and within the alluvial aquifer.

This section summarises the assessment of the potential impacts and is structured as follows:

- Section 5.1 provides an overview of the proposed underground mining activities, and includes a general explanation of the way in which groundwater may be impacted;
- Section 5.2 outlines the water management within the underground workings and information from the water balance that was used to infer groundwater seepage rates to the existing longwall mining areas;
- Section 5.3 describes the analytical methods used to estimate groundwater seepage rates into the proposed bord and pillar workings; and
- Section 5.4 discusses the potential for drawdown within the coal seams and the alluvial aquifers based on existing observations within the monitoring bore network.

This modification will involve establishing a bord and pillar operation within the footprint where longwall mining was previously approved but not commenced. The layout of the mine is shown on Figure 1.2.

In bord and pillar mining the coal seam is divided into a regular block-like array by driving through it primary headings, which are intersected at regular intervals by connecting cut-throughs. The headings and cut-throughs are the 'bords', and the blocks of coal bounded by them are the 'pillars'. Unlike the approved longwall mining, negligible subsidence of the overlying strata or deformation of the overburden will occur due to the pillars of coal remaining in-situ that support the overlying strata. Therefore, unlike longwall mining the strata overlying the mining area will not be fractured which reduces the potential to depressurise and drain the groundwater from the overlying rock mass. Any groundwater that enters the bord and pillar mining operation will be directed through drains to sumps where it will be pumped to the surface.

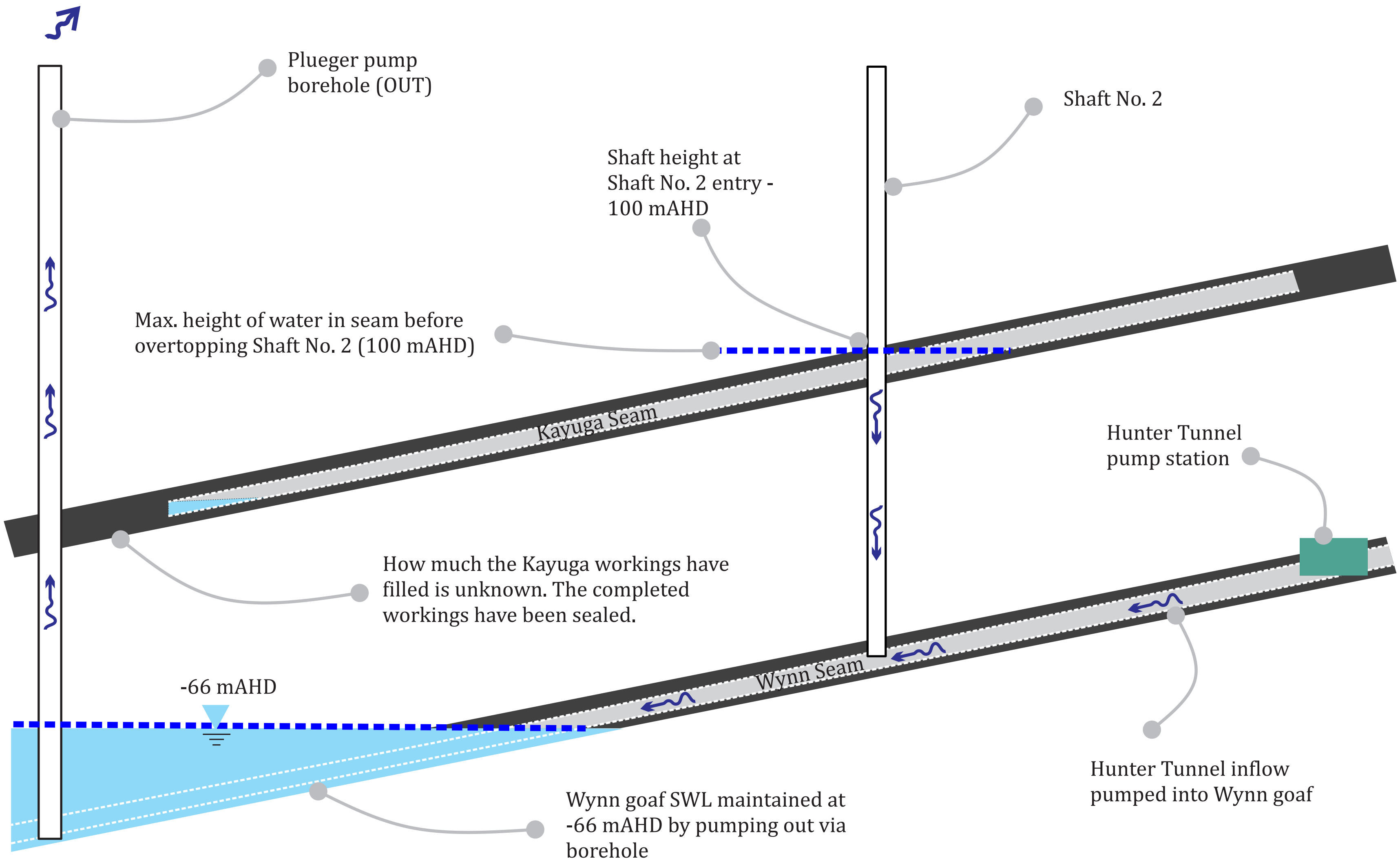
5.2 Water balance

5.2.1 Background

During the care and maintenance period water within the underground mine and tunnels has been managed to protect the remaining underground infrastructure. The pumping information recorded during care and maintenance provides an indication of the volume of groundwater seeping from the coal seams and rock mass into the underground mine. The pumping of water within the underground mine is shown graphically on Figure 5.1.

Groundwater that seeps into the Hunter Tunnel accumulates at a low point in the tunnel. The accumulated water is pumped into the Wynn Seam goaf for storage. The storage volume within the Wynn Seam goaf is significantly larger than the available storage within the Hunter Tunnel and this pumping is essential to ensure the Hunter Tunnel does not flood with groundwater seepage. Pumping from the Wynn Seam goaf occurs when the water level reaches -66 mAHD. As the water level rises in the Wynn Seam Goaf, water is pumped out via the Plueger pump station to surface facilities.

The Kayuga coal seam workings are connected to the Wynn seam workings via Shaft No. 2. The level of Shaft No. 2 in the Kayuga workings is 100 mAHD, meaning any seepage water within the Kayuga workings would need to fill to this level before overtopping Shaft No.2 and adding to the Wynn goaf water storage. To maintain the water balance, contributing water from the Kayuga seam, would add to the Wynn goaf storage and would need to be pumped out. Thus, by examining the cumulative pump volumes from up and down slope of Shaft No. 2 any contributions from the Kayuga coal seam (via Shaft No. 2) can be quantified.



Care and maintenance water management

Figure - 5.1

Dartbrook Bord & Pillar MOD (G1730H)

5.2.2 Results of water balance assessment and discussion

Weekly inflow volumes from the Hunter Tunnel and Wynn goaf extraction pump stations are shown on Figure 5.2. The volumes show that Hunter Tunnel seepage rates are consistent at around 3 ML/week (156 ML/yr). The Wynn seam goaf extraction is more irregular due to the larger storage volume within the goaf. As noted pumping occurs when the water level within the goaf rises above -66 mAHD.

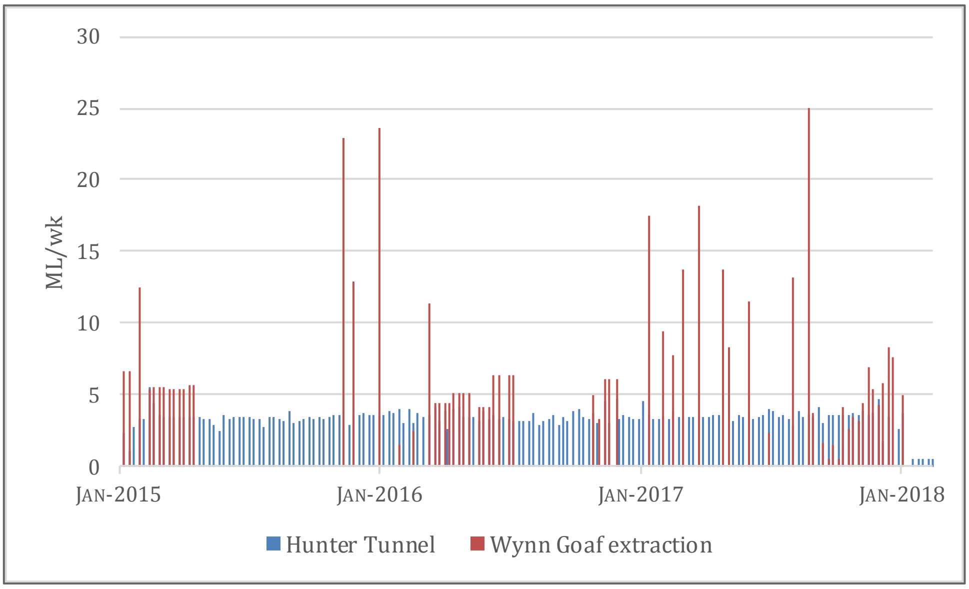


Figure 5.2 Wynn seam goaf pumping regime

The cumulative pumped volume from both the Hunter Tunnel and the Wynn seam goaf are shown on Figure 5.3.

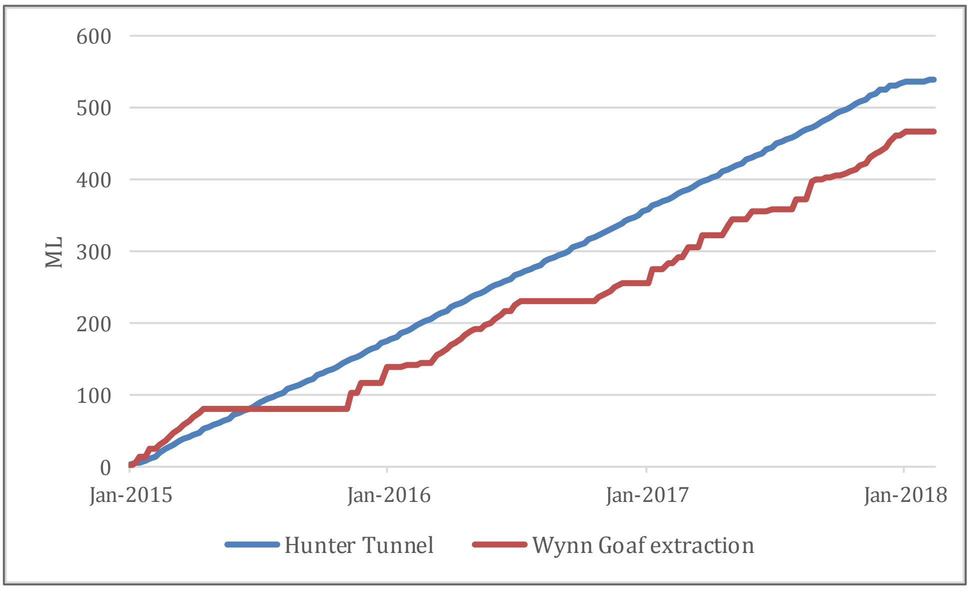


Figure 5.3 Wynn seam goaf cumulative volumes

Figure 5.3 highlights the consistent inflow from the Hunter Tunnel and the more irregular pumping from the Wynn seam goaf. The figure also indicates that the input to the Hunter Tunnel and the output from Wynn seam goaf discharge is roughly equal, as indicated by the two lines remaining parallel. If there was a significant volume of groundwater seepage entering the Wynn goaf, then the discharge volume would gradually diverge from and be greater than the inflow from the Hunter tunnel. This is not the case and the largely parallel lines suggest there is negligible inflow of groundwater from either coal seams into the Wynn seam goaf.

Table 5.1 lists the pumped volumes from both the Hunter Tunnel and the Wynn Seam Goaf storage. The period corresponds to a period of time when water levels in the Wynn seam goaf a stable, shown on Figure 5.4. Since the volumes are almost identical and the water levels do not change during this time, it indicates that there is no additional water being added from the Kayuga or Wynn coal seams.

Table 5.1 September 2016 to December 2017 volumes

Goaf water in (Hunter Tunnel)	Goaf water out (Plueger pumps)	Difference
238 ML	231 ML	7 ML

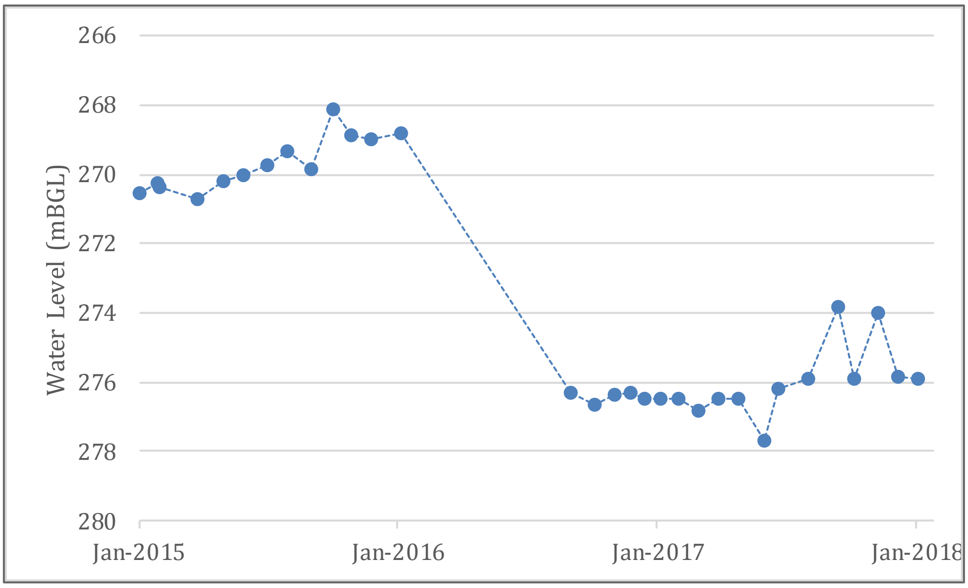


Figure 5.4 Wynn seam goaf water levels

The results support the conclusion that there is negligible inflow of groundwater from either coal seams into the Wynn seam goaf. The conclusion correlates well with anecdotal information from the period when longwall mining was occurring. During the operational life, the mine was considered an 'a dry mine' and required water pumped into the workings from the surface to operate machinery and supress dust, rather than pumping out excess water.

5.3 Analytical model

As described, the water balance pumping records indicate there is negligible groundwater inflow to the Kayuga seam workings during the care and maintenance period. To confirm the conclusions reached with the water balance an analytical method was used to estimate the rate of groundwater inflow to the Kayuga seam using water levels records from the site and estimates of coal seam hydraulic conductivity.

5.3.1 Methodology

Analytical methods use mathematical relationships to simulate idealised conditions and are based on a range of simplifying assumptions representing the groundwater system. The Darcy's equation for steady state groundwater flow was used to estimate the inflow of groundwater to the proposed bord and pillar workings within the Kayuga seam as follows:

$$Q = K * i * A \qquad [1]$$

Where, Q is seepage from the coal seam face (m^3/day), K is hydraulic conductivity of the coal seam (m/day), i is steady state hydraulic gradient and A is cross section area of the aquifer (m^2).

The proposed bord and pillar mining area was divided into multiple elongated rectangular prisms to allow the changing hydraulic gradient occurring down dip and the potentially reducing hydraulic conductivity in the coal seam to be represented. The prisms had an equal length of 3500 m which was equivalent to the average width of the bord and pillar mine area and a thickness equal to the average seam thickness of the Kayuga seam (3.2 m). The hydraulic gradient and hydraulic conductivity were assigned to each prism.

The inflow into each elongated prism was defined by the governing Darcy law equation (eq. 1) and was adjusted for each prism due to the change in hydraulic gradient and hydraulic conductivity.

$$Q_p = K_p * \ i_p * A \qquad [2]$$

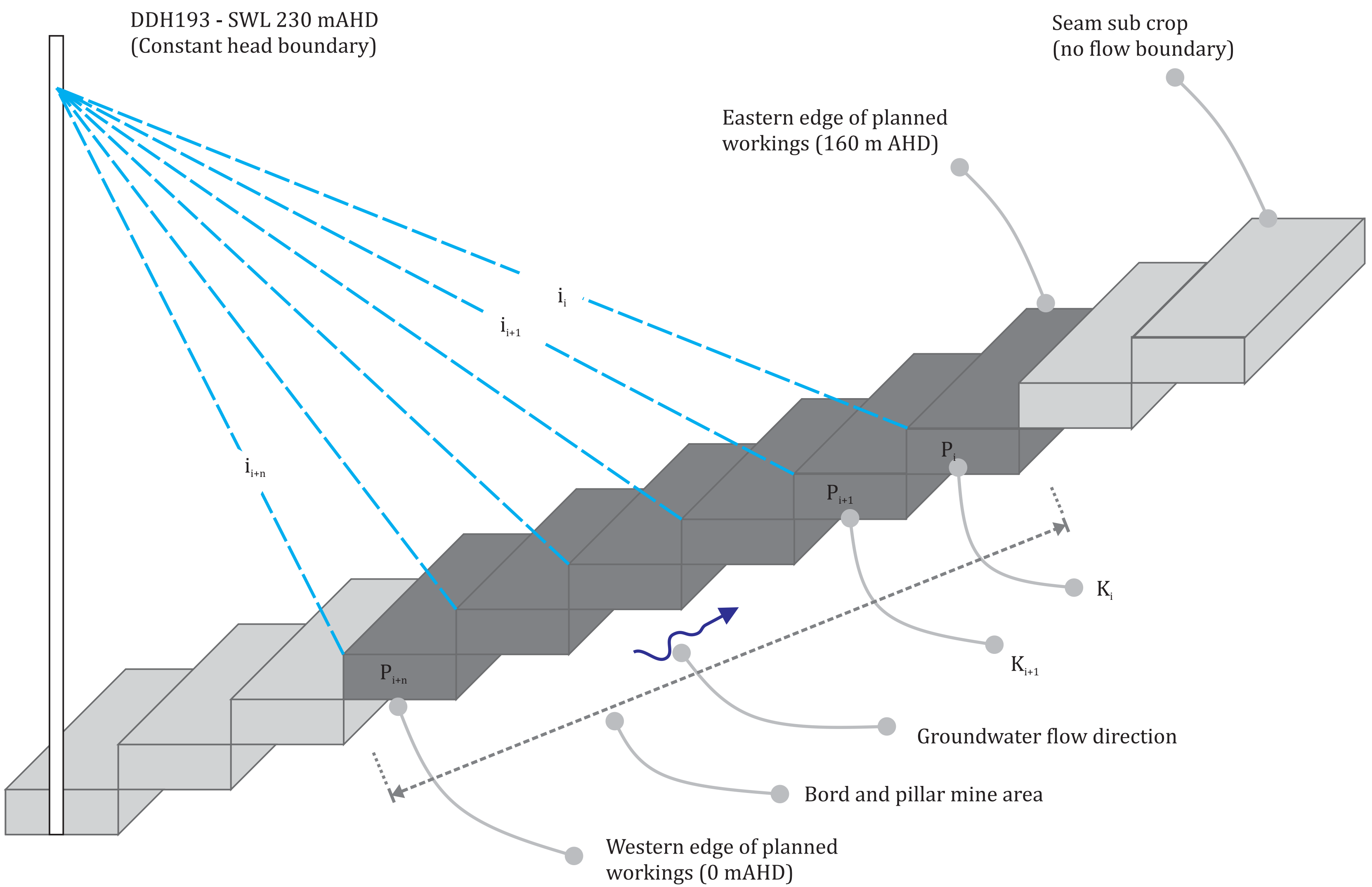
Where, Q_p is the inflow to one prism, K_p is the hydraulic conductivity to a specific prism and i_p is the groundwater gradient for a specific prism. The number of prisms were calculated by dividing the total elevation change of the proposed mine by the average seam thickness resulting in a total of 45 prisms. Figure 5.5 shows a generalised schematic of the model conceptualisation and components.

When estimating the groundwater inflow using the analytical equation it was assumed that:

- groundwater inflow occurs to the proposed bord and pillar mine only through the down dip face;
- groundwater flow is perpendicular to the mine face;
- groundwater levels at down-dip bore DDH193 remain constant at 230 mAHD and were therefore used to calculate hydraulic gradients for each prism;
- hydraulic gradient is linear between DDH193 and each prism face;
- the outcrop of the Kayuga seam to the east of the proposed bord and pillar mining area acts as a no flow boundary (Figure 1.4); and
- the lack of subsidence and cracking of the overlying strata means leakage through the roof and floor would be negligible and was therefore not included in the estimates of inflow.

Two scenarios were used to calculate groundwater inflow and were based on two different assumptions for hydraulic conductivity:

- Scenario 1 assumed the hydraulic conductivity of the Kayuga coal seam remains constant at 0.01 m/day, which was based values used in numerical modelling for the approved longwall mine (MER, 2000).
- Scenario 2 assumed the hydraulic conductivity reduced with depth due to overburden pressure closing cleats within the coal seam (AGE, 2018). Hydraulic conductivity values ranged from 0.03 to 0.0002 m/day.



Analytical model conceptualisation

Figure - 5.5

Dartbrook Bord & Pillar MOD (G1730H)

5.3.2 *Model results and discussion*

The results of the two model simulations of estimated groundwater inflow are shown on Figure 5.6 and shows contrasting results for each scenario, with inflow increasing with depth for Scenario 1, but reducing with depth for Scenario 2.

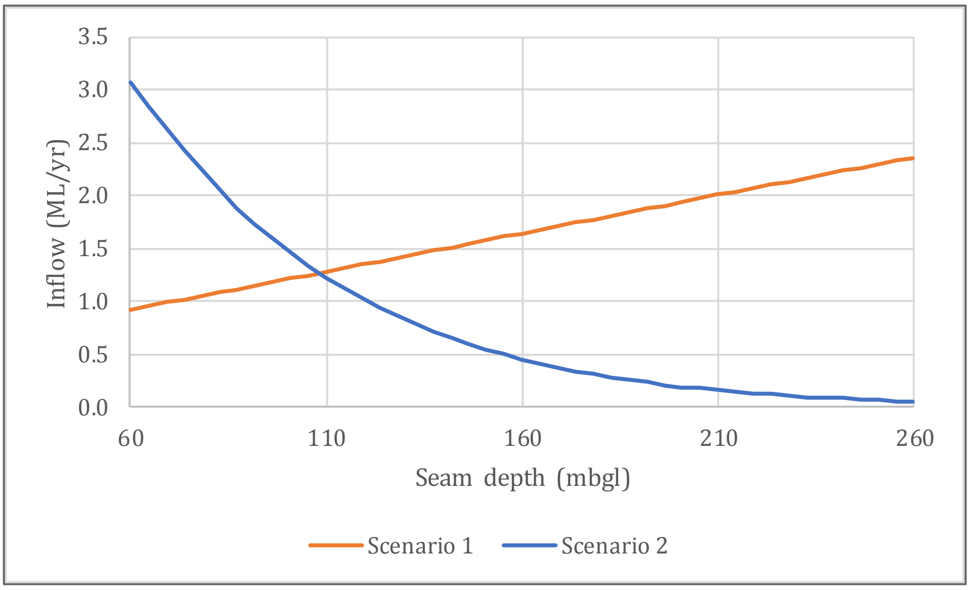


Figure 5.6 Analytical model results

Scenario 1, which is based on the approved modelling results (MER, 2000), and uses a constant hydraulic conductivity for the Kayuga coal seam with depth, results in an increasing seepage rate with decreasing elevation (increasing depth). This is due to the increasingly steep groundwater hydraulic gradient between the open face and the constant head boundary at DDH193. Scenario 2, assumes hydrulic conductivty reduces as a function of depth resulting in a decreasing seepage with decreasing elevation (increasing depth), due to the reduction in hydraulic conductivity as the mined seam deepens.

Whilst there are some inherent differences predicted by these scenarios, they both indicate very limited groundwater inflow for each elongated prism of exposed coal seam. This supports the conclusions reached from the water balance data and anecdotal information that groundwater inflow through the coal seams to mining areas are negligible.

The method demonstrates the seepage rates change over time as mining progresses westward and effectively dewaters the coal seam i.e. no water can continue to flow into an open face once it is removed. The seepage rates estimated using the analytical method indicate the range of potential inflow during mining based on location, rather than the inflow at any time. Whist a time based inflow graph has not been determined with this method, the potential annual peak inflows have, which is what is required to account for impacts under the Aquifer Interference Policy.

It is important to note the previous numerical modelling for longwall mining, and the analytical approach for the proposed bord and pillar mining are for different projects and have different underlying assumptions and therefore should not be considered to be directly comparable. Despite these differences the results do suggest inflow to bord and pillar mining areas would be substantially lower than longwall mining.

5.4 Drawdown

The proposed bord and pillar mining covers an area of around 5.7 km^2 and will result in depressurisation and drawdown within the Kayuga coal seam in the area immediately surrounding the workings. As noted previously the methodology adopted for the Modification relied upon analytical methods and data collected during mining/care and maintenance, rather than numerical modelling. To increase the confidence in the conclusions drawn, multiple lines of evidence were used to confirm the expected impact of the Modification on the groundwater regime. Potential drawdown impacts were estimated using previous numerical modelling predictions for the approved longwall mining which covers about three times the area of the proposed Modification at around 16.2 km^2 and water level records within bores surrounding the existing longwall mining areas and within the alluvial aquifer.

5.4.1 Permian coal seams

The former operators of the Dartbrook mine have monitored groundwater levels within the Kayuga coal seam at four monitoring bore sites that surround the completed longwall mine workings. The locations of the monitoring bores are shown in Figure 1.5. Figure 5.7 shows the groundwater levels measured during the period of mining and during care and maintenance.

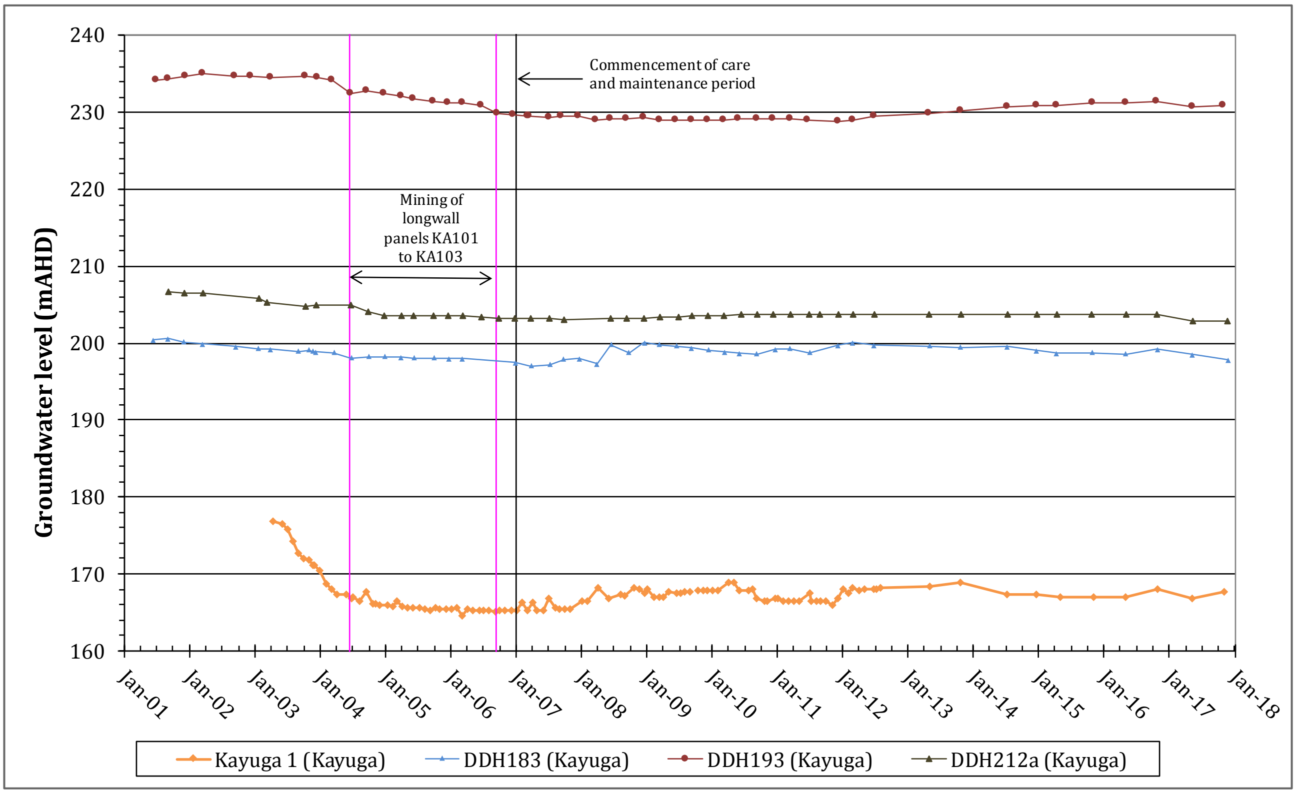


Figure 5.7 Kayuga Seam monitoring bores

Figure 5.7 indicates relatively limited drawdown has been detected with some drawdown occurring around the time of longwall mining panels KA101 to KA103 (2005-2006) in the Kayuga seam monitoring bores. Drawdown in Kayuga 1 prior to longwall mining is likely related to first workings (development headings) put in place before the longwall progressed. Water levels have stabilised following mining and during the care and maintenance period. The relatively stable water levels suggests that there is very limited drainage of groundwater into the Kayuga seam workings and that the zone of drawdown is constrained to within close proximity to the underground workings.

The limited drawdown is expected given there is no significant seepage detected into either the Kayuga and Wynn seams goafs from the water balance or from operational experience. Given the negligible seepage from overlying strata (due to limited connective cracking for mined panels), it is considered that drawdown in the overlying strata would not be any greater than the approved drawdown of the longwall mine.

5.4.2 Quaternary alluvium

Groundwater levels within the alluvial aquifer to the east of the proposed bord and pillar mining have been monitored at four monitoring bores shown in Figure 1.5. Figure 5.8 shows the groundwater levels measured in each of the monitoring bores during the period of mining and during care and maintenance.

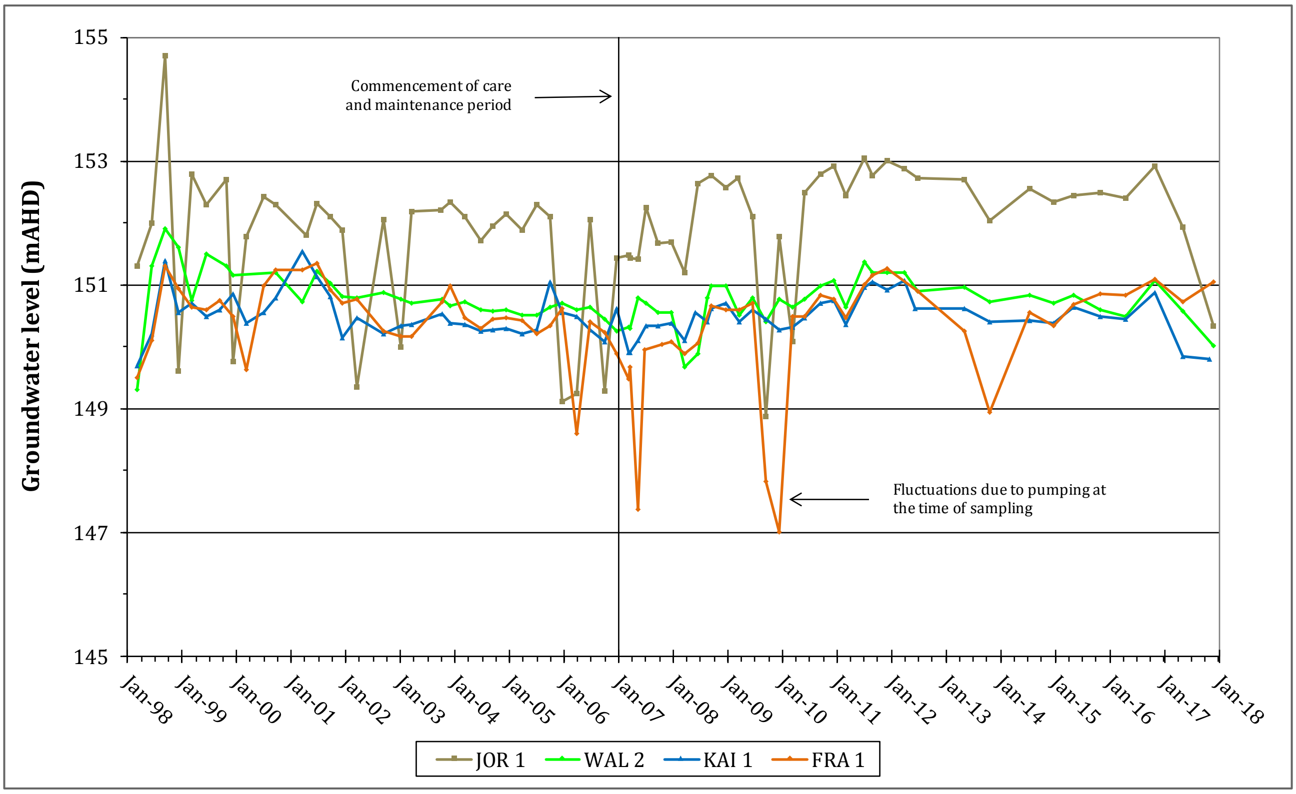


Figure 5.8 Hunter River alluvial monitoring bores

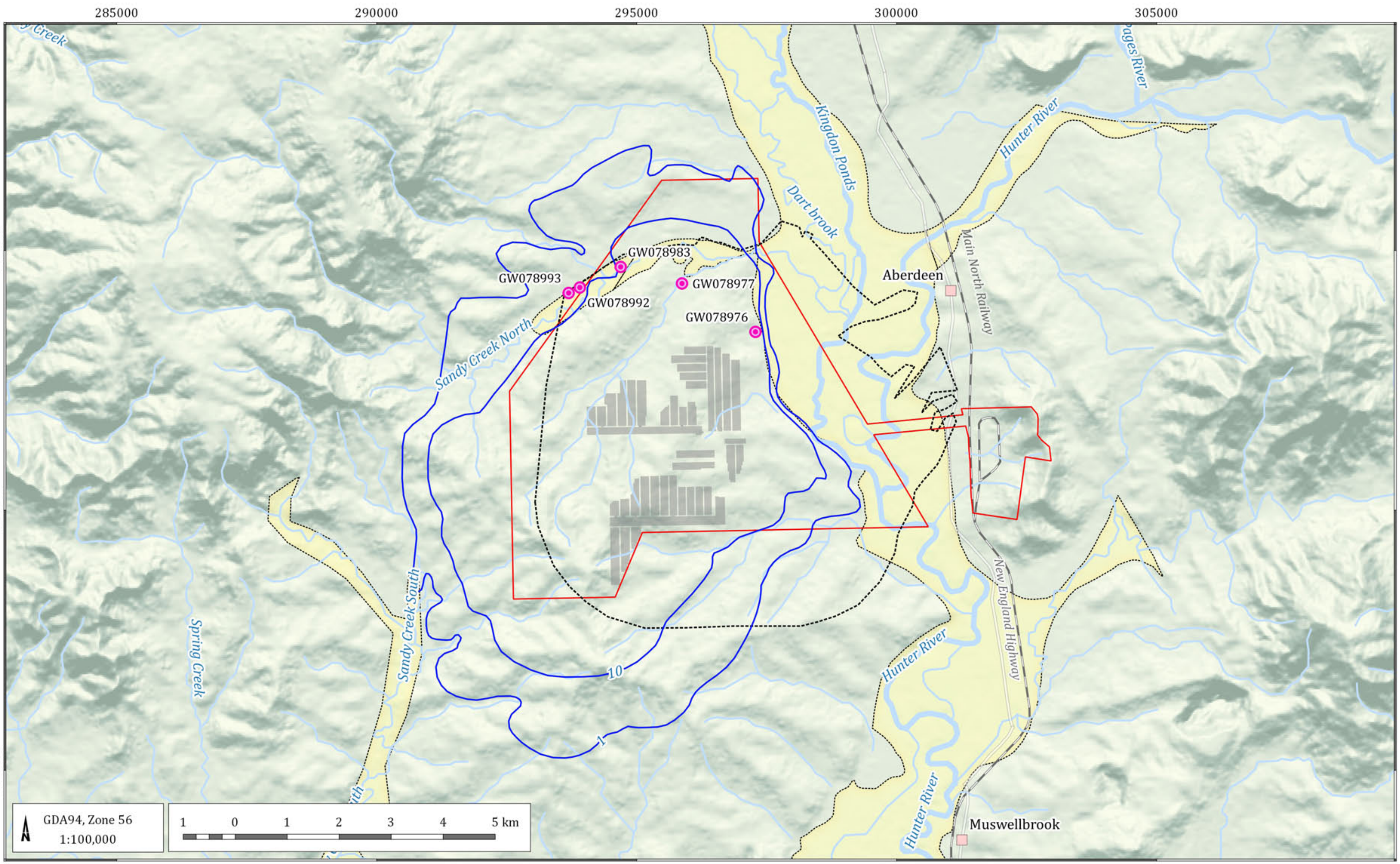
During longwall mining (1996-2006) and continuing in the care and maintenance period (2006-2018) groundwater levels in the alluvium have not shown a decline that could be related to coal seam depressurisation resulting either from mining or the conveyor tunnel as shown on Figure 5.8. The observations support the prediction that "*alluvial lands will remain unaffected by depressurization within the coal measures*" (MER, 2000). This conclusion is expected to remain valid for the proposed bord and pillar mining. This is because alluvial recharge is greater than any losses from depressurisation associated within mining. The recharge occurs from the constant source of surface water from regulated releases of water from the Glenbawn Dam into the Hunter River and also as diffuse recharge from rainfall.

5.4.3 *Impact on groundwater users*

Previous modelling (MER, 2000) indicated the potential for predicted drawdown impacts on some privately owned registered bores within the Permian strata, to trigger the AIP Level 2 threshold of the minimal impact considerations (i.e greater than 2 m decline from baseline conditions) for less productive groundwater (Figure 5.9). The approved 1 m and 10 m drawdown contours (MER, 2000) and private water supply bores surveyed during a recent bore census are shown on Figure 5.9 and listed in Table 5.2. Figure 5.9 shows that there are five bores within the 1 m predicted drawdown limit, three of which use windmills to extract groundwater. The 1 m contour was georeferenced and digitised from the MER (2000) report. It is a more conservative than the AIP minimal impact considerations which allows for a 2m piezometric head level decline.

Table 5.2 Privately owned bores with approved 1 m drawdown limit

Station name	Bore type	Lot no.	Depth bore (mbgl)	Water level (mbgl)
GW078977	Windmill	183//DP750951	19.03	6.65
GW078976	Windmill	189//DP750951	No access available	No access available
GW078993	Windmill	181//DP750951	13.46	5.97
GW078992	Agricultural well	181//DP750951	7.39	6.16
GW078983	Wooden Well	178//DP750951	4.71	1.98



LEGEND

- Populated place
- Mining Authorisation
- Proposed Bord and Pillar Mining Panels
- Alluvium (Source: 1:250k Singleton Geology Sheet,modified after AGE (2007))
- Bore census boundary
- Rail
- Drainage/creek
- Approved drawdown (m)
- Private water supply bores

Dartbrook Bord & Pillar MOD (G1730H)

Approved drawdown (MER, 2000)

DATE
08/06/2018

FIGURE No:
5.9

N:/Groundwater Jobs/G1730H.Dartbrook_Bord_&_Pillar_MOD/3_GIS/Workspaces/001_Deliverable1/05.09_G1730H Approved drawdown (MER, 2000).qgs

5.5 Post mining recovery

Post mining the workings will be sealed off and groundwater ingress will slowly fill the voids remaining underground. Groundwater will gradually seep into the underground mining areas and re-pressurise the Permian strata slowly over time. During the period when the strata is re-pressurising the workings, the mined panels would act as a 'sink' for groundwater flow, meaning groundwater would flow into the mine, not out. MER (2000) simulated post mining recovery and predicted an inward hydraulic gradient towards the mined panels remaining for greater than 100 years. As the mined strata re-pressurise groundwater flow will be governed by the established hydraulic gradients, that will facilitate the slow movement of groundwater from the underground mine into surrounding rock units.

As the project involves only underground mining there will be no overburden material that has the potential to influence groundwater quality. Unlike open cut mining there is no potential for evaporation to concentrate salts within the underground mining areas, and therefore an increase in salinity of the Permian water seeping into the mine is not expected to occur. Any oxidised zones of sulfidic material occurring on the roof and floor of the underground mines will be flooded preventing oxidation and minimising the potential to influence the groundwater quality within the underground mining area.

5.6 Materials delivery shaft

A new materials delivery shaft will be constructed on the eastern side of the Hunter River. The delivery shaft will be used for transferring ROM coal into the Hunter Tunnel. The location is shown on Figure 1.1 and is on the edge of the alluvium boundary. If the shaft encounters water bearing alluvium, it will need to be lined to prevent groundwater inflow and prevent connectivity between aquifers.

6 Aquifer interference policy – minimal impact considerations

The Aquifer Interference Policy (AIP) outlines requirements for obtaining water licences for aquifer interference and the minimal impacts considerations. The sections below compare the expected impacts against the requirements of the AIP and discuss compliance with the policy.

6.1 Water licensing

The AIP requires water licences for aquifer interference activities that remove water from a water source, or result in movement between water sources or aquifers. Table 6.1 below compares the Water Access Licences held by AQC with the estimated water takes for the approved mining and the proposed bord and pillar mining.

As noted previously to complete this assessment multiple lines of evidence were used to estimate the groundwater inflow from the Kayuga coal seam into the bord and pillar mine. The water balance and analytical methods and operation experience all suggest the inflow will be negligible and unlikely to be detectable during mining. For the purposes of the Aquifer Interference Policy the potential inflow from the Permian strata has been defined as being <10 ML/yr on the methods described. The estimate does not include an inflow over time but does represent a peak at any time during the bord and pillar operations. The volume from the Hunter Regulated River Alluvial water source is based on the measured volumes of water entering the Hunter Tunnel (Section 5.2).

Table 6.1 Summary of WALs currently held by AQC and predicted 'water take'

Water sharing plan	Water source	Licence category	Total share component	Estimated water take (ML/year)		
				Completed mining	Proposed bord and pillar mining	Total
North Coast Fractured and Porous Rock WSP	Sydney Basin – North Coast Groundwater Source	aquifer	180*	<10	<10	<20
Hunter Regulated WSP	Hunter Regulated River Water Source (Zone 1a)	regulated river	3,071.8	0	0	0
Hunter Unregulated WSP	Muswellbrook	aquifer	Basic rights	0	0	0
	Dart Brook	unregulated river	85	0	0	0
		aquifer	950	0	0	0
	Hunter Regulated River Alluvial	aquifer	1,249	156	0	156

Note: ** WALs are currently attached to the Alstonville Basalt Plateau Groundwater Source. Applications to DoI Water have sought to correctly attach these WALs to the Sydney Basin – North Coast Groundwater Source.*

Table 6.1 indicates AQC hold sufficient water licences to account for the impact of the approved mining and the proposed bord and pillar mining. When preparing the above table we have assumed that:

- all groundwater entering the Hunter Tunnel is sourced from the Hunter River alluvial aquifer within no significant inflow from the Permian strata;
- any flow from the Hunter River into the underlying alluvium due to the tunnel is accounted for in the Hunter River alluvial aquifer;
- the peak groundwater take from the bord and pillar mining areas will be negligible and undetectable - for the purposes of the AIP we have assumed a nominal peak of 10 ML/year based on the assessment described in Sections 5.2 and Section 5.3.

6.2 Minimal impact considerations

The minimal impact considerations are a series of thresholds that define minimal impacts from aquifer interference activities. There are two levels of minimal impact considerations specified in the AIP, being Level 1 and Level 2. If the predicted impacts are less than the threshold level specified by the Level 1, then these impacts are acceptable under the AIP. Where the predicted impacts are greater than the Level 1 minimal impact considerations, then additional studies are required to fully assess and manage these predicted impacts. If this assessment shows that the predicted impacts do not prevent the long-term viability of the relevant water-dependent asset, then the impacts will be considered to be acceptable.

Table 6.2 below compares the potential project impacts with the minimal impact considerations for highly productive alluvial water sources, with Table 6.3 addressing the less productive porous and fractured rock water sources.

Table 6.2 Minimal impact considerations – highly productive alluvial water sources

Water sharing plan: Hunter Unregulated and Alluvial Water Sources	
Aquifer	Alluvial aquifer (Hunter Unregulated and Alluvial Water Sources)
Category	Highly Productive
Level 1: Minimal Impact Consideration	***Preliminary assessment***
<u>Water table</u> Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan **or** A maximum of a 2 m decline cumulatively at any water supply work.	As outlined within Section 5.4 detectable drawdown within the adjacent alluvial aquifers is not predicted. At the time of writing, there was no Culturally Significant Sites or high priority GDEs located within the study area according to Hunter Unregulated and Alluvial Water Sources WSP. Hence there are no known risks to such sites at this time. Groundwater level drawdown resulting from the approved operations and Modification is predicted to not exceed 2 m at any water supply work within the highly productive alluvial aquifers. **Conclusion: does not exceed Level 1 minimal impact consideration thresholds**
<u>Water pressure</u> A cumulative pressure head decline of not more than 40% of the "post-water sharing plan" pressure head above the base of the water source to a maximum of a 2 m decline, at any water supply work	'Pressure head' does not apply to the unconfined alluvial system
<u>Water quality</u> Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity.	No disturbance of overburden will occur and no residual voids will remain post mining. There is therefore no potential to concentrate salts and the beneficial use category is not predicted to be affected, nor is salinity expected to increase. No alluvial material is proposed to be excavated. **Conclusion: does not exceed Level 1 minimal impact consideration thresholds**

Table 6.3 Minimal impact considerations – less productive porous and fractured rock water sources

Water sharing plan: North Coast Fractured and Porous Rock Groundwater Sources	
Aquifer	Permian (Sydney Basin) Porous rock - North Coast Groundwater Source
Category	Less Productive
Level 1: Minimal Impact Consideration	***Preliminary assessment***
<u>Water table</u> Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan **or** A maximum of a 2 m decline cumulatively at any water supply work.	At the time of writing, there were no Culturally Significant Sites or high priority GDEs located in the study area according to the North Coast Fractured and Porous Rock Groundwater Sources WSP. Hence there are no known risks to such sites at this time. Groundwater level drawdown resulting from the approved operations and proposed Modification may exceed 2 m at water supply works within the less productive Permian strata. Monitoring will continue to assess the drawdown that may occur. **Conclusion: exceeds Level 1 minimal impact consideration thresholds - Level 2 minimal make good provisions may apply.**
<u>Water pressure</u> A cumulative pressure head decline of not more than a 2 m decline, at any water supply work	Groundwater level drawdown resulting from the approved operations and Modification may exceed 2 m at water supply works within the less productive Permian strata. Monitoring will continue to assess the drawdown that may occur. **Conclusion: exceeds Level 1 minimal impact consideration thresholds - Level 2 minimal make good provisions may apply.**
<u>Water quality</u> Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity	No disturbance of overburden will occur and no residual voids will remain post mining. There is therefore no potential to concentrate salts and the beneficial use category is not predicted to be affected, nor is salinity expected to increase. **Conclusion: does not exceed Level 1 minimal impact consideration thresholds**

While the predicted impacts of the approved longwall mining on the alluvial aquifer might exceed the Level 1 minimal impact assessment criteria for highly productive groundwater, the impacts of the proposed bord and pillar mining will be less than the impacts of the approved longwall mining, and most likely within the Level 1 minimal impact criteria.

The drawdown estimates determined for previous longwall mining suggest there is the potential to draw down the water levels within some private bores in non-alluvial lithologies by more than the 2 m threshold. The simplest means of addressing and managing the identified potential bore impacts is to 'make good' on the impacted users' water source. This could involve deepening and/or replacing bores and wells, and/or providing an alternative water source to affected users (possibly derived from mine inflow). In addition, the Water Management Plan will need to be updated to include a revised groundwater monitoring strategy, groundwater level triggers, and a trigger action response plan.

The Modification will require a monitoring plan to estimate the volumetric take of groundwater over time. These water takes should be reported on an annual basis to DoI Water, and periodically used, in conjunction with the monitoring data, to verify the predictions and the potential risks of mining activities identified in this assessment. This could include revision of the groundwater model, if necessary and identified risks as required.

7 Discussion and conclusion

A water balance assessment using the measured pumped volume from the Hunter Tunnel pump station and the Wynn seam goaf Plueger pump station, under the current care and maintenance water management system, was used to calculate the contributing volumes from the Kayuga and Wynn coal seams. The water balance results, discussed in Section 5.2, indicate that there is no measurable contribution occurring from either the Kayuga or Wynn coal seams, down gradient the Hunter Tunnel pump station. Discharge volumes from the Wynn seam goaf water storage are entirely made up of water seeping into the Hunter Tunnel.

A steady state analytical model was used to estimate groundwater seepage into the proposed bord and pillar mine. The model results (Section 5.3) indicate that seepage volumes (in both simulations) would be within AQC WALs aquifer entitlements (Section 4.1) from the North Coast Fractured Rock Water Source and are sufficient to account for the predicted peak water take during mining. The estimates from the model and also based on expert knowledge, indicate the seepage would still occur due to the mine forming a sink within the coal seam; however, it would be less than that would occur into a longwall panel.

The materials delivery shaft located on the eastern side of the Hunter River is not within the defined alluvium boundary. If water bearing alluvium is encountered during the construction of the shaft it will need to be lined to seal any water bearing zones to prevent water flowing into the shaft.

Given that groundwater seepage into the bord and pillar mine is estimated to be significantly less than that of the approved longwall mining (and its associated impacts), the amount of drawdown in surrounding landholder bores should be no greater than the currently approved longwall mining activities. There is no reason to expect that drawdown would be significantly greater than, or even similar to, the approved longwall mine. Figure 5.9 shows the privately owned bores within the one metre drawdown predicted from the longwall mining, which is based on a longwall mine area of 16.2 km2. The proposed Modification mine area is about 5.7 km2. Monitoring will continue at these sites, to determine if the drawdown is greater than the minimal impact considerations set out in the AIP.

Appendix A Groundwater Monitoring Bores

Dartbrook Bore ID	Registered number	Easting	Northing	ToC (mAHD)	Bore depth (mbgl)	Screened interval (mbgl)	Casing type	Status	Purpose	Groundwater System
Hunter River Alluvium - Conveyor tunnel alignment monitoring bores										
FRA1	GW079017	300639	6436419	161	-	-	Concrete	well	-	Hunter River alluvium
JOR1	GW078927	298758	6436632	160.3	-	-	Concrete	well	-	Hunter River alluvium
KAI1	GW078932	299936	6436227	161.2	13.15	-	Concrete	well	-	Hunter River alluvium
WAL2	GW078954	299269	6436098	160.3	-	-	Concrete	well	-	Hunter River alluvium
Rejects Emplacement Area (REA Monitoring Bores) under Development Consent Condition 4.2(a)										
RDH508	-	301159	6436954	167.3	21.91	15.65-21.75	80 mm PVC	bore	PSMP	Weathered Permian Coal Measures
RDH508a	-	301159	6436954	170	33.89	-	25 mm uPVC	bore	PSMP	Weathered Permian Coal Measures
RDH509	-	301251	6436535	160.3	17.07	13.92-16.82	80 mm PVC	bore	PSMP	Weathered Permian Coal Measures
RDH509a	-	301251	6436535	163	14.9	-	25 mm uPVC	bore	PSMP	Weathered Permian Coal Measures
RDH510	-	301344	6435736	159.8	16.84	13.75-16.65	80 mm PVC	bore	PSMP	Weathered Permian Coal Measures
RDH510a	-	301344	6435736	161	19.53	-	25 mm uPVC	bore	PSMP	Weathered Permian Coal Measures
RDH511	-	301144	6435233	157.7	15.8	13.3-15.8	80 mm PVC	bore	PSMP	Weathered Permian Coal Measures

Dartbrook Bore ID	Registered number	Easting	Northing	ToC (mAHD)	Bore depth (mbgl)	Screened interval (mbgl)	Casing type	Status	Purpose	Groundwater System
RDH511a	-	301144	6435233	160	15.38	-	25 mm uPVC	bore	PSMP	Weathered Permian Coal Measures
Dart Brook alluvium monitoring bores										
ADN1	GW078973	298159	6437724	161.6	-	-	Concrete	well	-	Dart Brook alluvium
DAN2	GW078995	297982	6438959	163.5	-	-	Concrete	well	-	Dart Brook alluvium
WM1A	GW078965	297696	6438335	163	15.66	9.96 – 15.66	40 mm, uPVC	bore	-	Dart Brook alluvium
Sandy Creek alluvium monitoring bores										
BRO3	GW078980	296022	6439457	180	5.75	-	Steel	bore	-	Alluvium – grouped with Sandy Creek alluvium bores
COR3	GW078993	293688	6439181	199.6	-	-		bore	-	Sandy Creek alluvium
WM3	GW078967	294773	6439840	191.7	8.37	7.19-8.37	50 mm, uPVC	bore	-	Sandy Creek alluvium
GW038412	GW038412	291495	6437735	228.8	6.7	-	Wood	well	-	Sandy Creek alluvium
Sandy Creek (south) overburden monitoring bore										
GW032889	GW032889	290784	6433799	217.4	18.3	11.6 – 18.3 (open hole)	152 mm, steel	inaccessible bore, no access	PSMP	Shallow overburden (sandstone and shale)
Regolith – Kayuga longwall panels monitoring bores										
CAS2	GW078986	295913	6435416	238.6	65.34	57.42-65.32	Steel	bore	PSMP	Shallow overburden
CAS4	GW078988	294927	6435956	249.8	34.36	-	Steel	windmill	PSMP	Shallow overburden

Dartbrook Bore ID	Registered number	Easting	Northing	ToC (mAHD)	Bore depth (mbgl)	Screened interval (mbgl)	Casing type	Status	Purpose	Groundwater System
JLON1	GW078926	298195	6434788	166.6	5.44	-	Concrete	windmill - dry	-	Shallow overburden
TLON1	GW078952	294058	6436689	221.5	-	-	Steel	windmill	PSMP	Shallow overburden
Coal seams monitoring bores										
Kayuga 1	-	297615	6434637	179.6	20.53	-	PVC	bore	-	Kayuga Seam
DDH183	-	296105	6434609	226.02	108.95	-	50 mm, uPVC	bore	-	Kayuga Seam
DDH193	-	293096	6435799	273.3	185.06	-	50 mm, uPVC	bore	-	Kayuga Seam
DDH212a	-	293555	6437311	230.4	75.76	-	25 mm uPVC	bore	-	Kayuga Seam
Property subsidence monitoring										
Belgrave	-	295027	6434536	230.5	23.71	-	1.2m timber well	bore	PSMP	Shallow overburden
GW038582	-	295822	6434159	207.8	27.1	-	125 mm uPVC	-	PSMP	-
Staged discharge dam										
RDH505	-	298504	6435779	172.54	-	-	-	-	-	-
Other monitoring bores										
CAD2	GW078984	294132	6439790	206	14.22	-	Steel	bore	-	Weathered Permian Coal Measures
BEL1	GW078975	297114	6434566	179.4	10.6	-	Wood	well	-	Shallow overburden
Athlone	-	295828	6434161	207.8	20.38	-	PVC	bore	-	Shallow overburden
DDH124	-	297225	6435756	206	14.18	-	PVC	bore	-	-
DDH212b	-	293555	6437311	233	280.87	-	25 mm uPVC	bore	-	-

Dartbrook Bore ID	Registered number	Easting	Northing	ToC (mAHD)	Bore depth (mbgl)	Screened interval (mbgl)	Casing type	Status	Purpose	Groundwater System
DDH212c	-	293555	6437311	233	341.83	-	25 mm uPVC	bore	-	-
RDH271	-	296824	6436248	213.17	88.99	-	50 mm uPVC	bore	-	-
MB series bores (not in WMP)										
MB1a	-	296321	6439927	177.78	6.1	-	60 mm uPVC	bore	-	Sandy Creek alluvium
MB1b	-	296320	6439932	177.74	23.6	-	60 mm uPVC	bore	-	Permian regolith
MB1c	-	-	-	-	-	-	60 mm uPVC	bore	-	na
MB2a	-	297056	6440018	173.80	9.2	-	60 mm uPVC	bore	-	Sandy Creek alluvium
MB2b	-	297060	6440020	173.66	29.3	-	60 mm uPVC	bore	-	Permian regolith
MB3a	-	298194	6438784	163.18	13.2	-	60 mm uPVC	bore	-	Dartbrook alluvium
MB3b	-	298189	6438784	163.26	31.3	-	60 mm uPVC	bore	-	Permian regolith
MB4a	-	298064	6437815	160.83	10.6	-	60 mm uPVC	bore	-	Dartbrook alluvium
MB4b	-	298067	6437815	160.95	27.5	-	60 mm uPVC	bore	-	Permian regolith
MB5	-	297694	6438326	163.33	31.2	-	60 mm uPVC	bore	-	Permian regolith
MB6	-	298450	6438349	162.44	9.0	-	60 mm uPVC	bore	-	Dartbrook alluvium
MB7	-	292590	6438229	214.46	6.6	-	60 mm uPVC	bore	-	Sandy Creek alluvium
MB8	-	-	-	-	-	-	60 mm uPVC	bore	-	na

***Notes**: Coordinates are in GDA94 Zone 56*
ToC – Top of casing reference point for groundwater elevations
mbgl – metres below ground level
PSMP – bore monitoring required under the Property Subsidence Management Plan