7 Groundwater

7.1 Existing Resources

7.1.1 Previous Investigations

Geological and hydrogeological investigations have been undertaken in the vicinity of the Project Site since coal was first encountered in 1966. The most recent investigations were undertaken in 2004 when six groundwater monitoring bores were installed on the adjacent Poitrel Mine site. The 2004 investigation also involved monitoring of water levels and groundwater sampling and was undertaken to provide information for the Poitrel Mine Environmental Impact Statement (EIS), which was completed in 2005. This information is also relevant to this EIS.

There has been no hydrogeological investigation undertaken within the Project Site, however geological investigations have been undertaken as part of resource definition.

The field investigations undertaken as part of the Poitrel EIS included the following:

- drilling and installation of groundwater monitoring bores;
- surveying of groundwater monitoring bores for height (m AHD) and location (AMG coordinates);
- monitoring of groundwater levels;
- groundwater sampling and laboratory analysis; and
- surveying of surrounding bores on neighbouring properties (including bore locations, water levels and groundwater usage).

Desktop studies for the adjacent Poitrel Mine have included:

- reviewing the available geological and hydrogeological information and data;
- interpreting the results of the recent groundwater monitoring program;
- reviewing the groundwater potential of the area;
- assessing the potential of groundwater as a source of water supply for the Poitrel Mine;
- analytical modelling of pit groundwater inflow rates for the life of the Poitrel Mine;
- assessing the impact of groundwater dewatering within the project on surrounding aquifers and groundwater users; and
- evaluating groundwater monitoring requirements during mine operation.

A summary of these on-site studies is presented in **Table 7-1**. The groundwater assessment for this EIS has been based upon the on-site studies presented in **Table 7-1** as well as the available site-specific geological information. No site-specific hydrogeological investigations have been undertaken on the Project Site, however a monitoring program including installation of groundwater bores is planned for 2009. The Daunia monitoring program will compliment a groundwater monitoring program that has recently commenced for the adjacent Poitrel Mine, and which includes two bores that lie within the Red Mountain Lease.

Table 7-1 Summary of Groundwater Related Studies, Daunia and Poitrel Prospects and Surrounds

Period	Activity
Mid 1960s 1980s	Numerous exploratory holes were drilled on the Poitrel Prospect. Groundwater levels and yields observed during drilling were recorded for a number of these holes.
Mid 1970s	EIS of various prospects (including Poitrel) in the Nebo Project area. The groundwater was characterised on the basis of excavations and boreholes drilled by the Irrigation and Water Supply Commission, local graziers and Thiess Peabody Mitsui.
Early 1980s	EIS of the Daunia mine lease. Existing hydrogeological information and data was reviewed and applied in the groundwater impact assessment.
Mid 1990s	Four exploratory holes were drilled on the Poitrel Prospect and groundwater yield was recorded (by V-notch weir) for each.
Mid 2004	Six groundwater monitoring bores were installed on the Poitrel Prospect at three nested site locations. Detailed geological logs, construction and survey details were recorded for these bores.
Mid 2004	A groundwater monitoring program was conducted on the six bores involving purging, groundwater sampling and analysis and level monitoring. Bore locations, water levels and groundwater usage was surveyed on neighbouring properties. A groundwater resource evaluation and potential impact assessment of mining at the Poitrel Prospect was conducted.

7.1.2 Geology and Hydrogeology

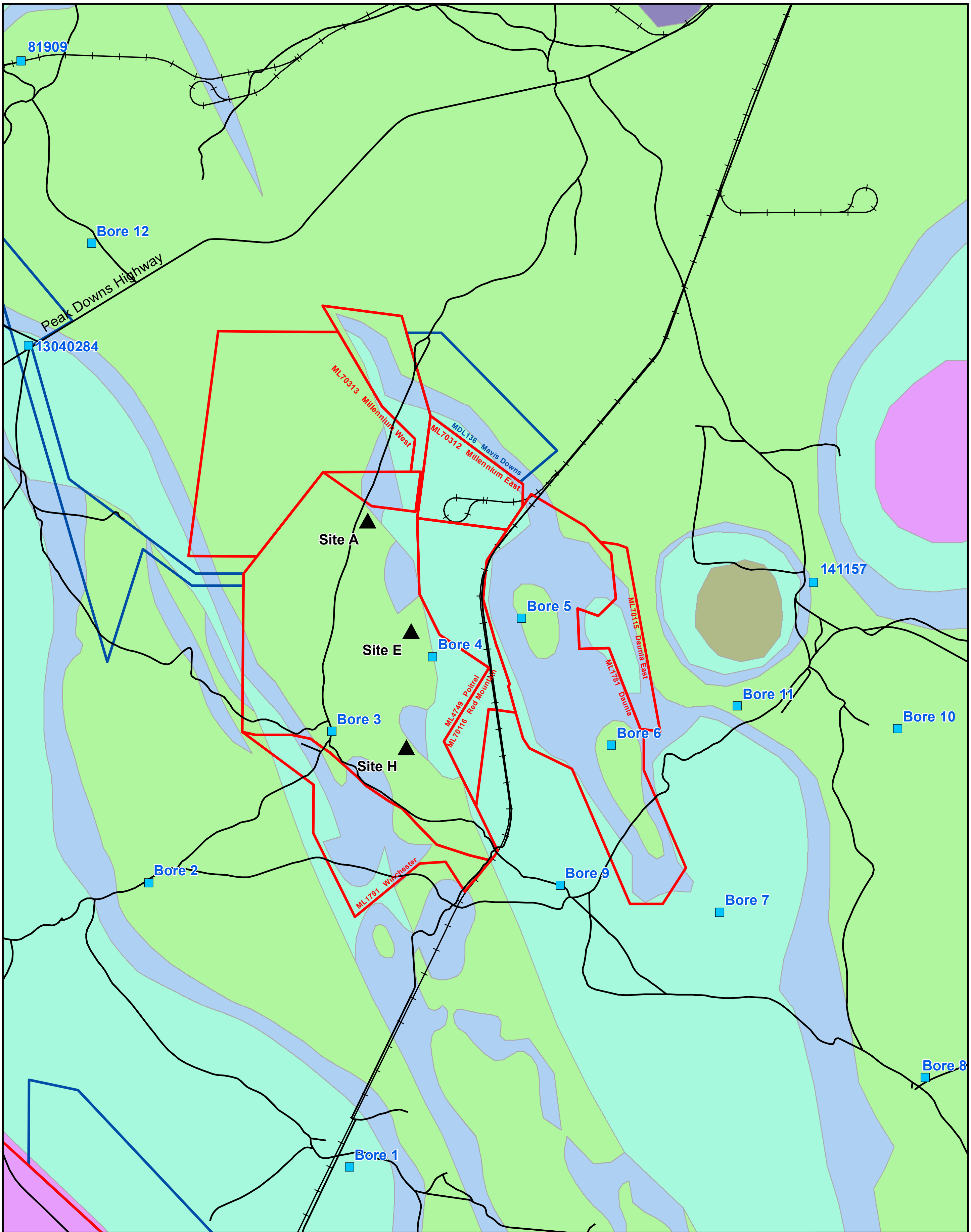
The regional geology is shown on the Clermont (1:250,000) geological map sheet (DME, 1968). The Project Site is located in the northern part of the Bowen Basin containing principally fluvial and some marine sediments. The Bowen Basin is part of a connected group of Permo-Triassic basins in eastern Australia, which includes the Sydney and Gunnedah Basins.

The Project Site lies near the western boundary of a sedimentary trough known as the Taroom Trough, which was filled by a thick accumulation of mainly terrestrial sediments during the Permo-Triassic period. The Project Site occurs within a shallow basinal structure immediately east of the New Chum Fault, which separates Daunia from the Poitrel deposit to the west. The New Chum Fault may influence groundwater levels and flow directions. However, it is reasonable to assume that there is some hydraulic continuity between the coal seam aquifers across the deposits and that the groundwater levels and flow directions beneath Daunia are similar to Poitrel.

The coal deposits are contained in the Late Permian, Rangal Coal Measures (also known as the Blackwater Group), which are approximately 100m thick. The Rangal Coal Measures are underlain by the Fort Cooper Coal Measures and overlain by the Late Permian to Early Triassic Rewan Group. The transition between the Rewan Group and the Rangal Coal Measures is difficult to define and is often based on a change in colour, from green-grey of the Rewan sandstones to blue-grey of the Rangal sandstones. Given the similar geological and hydrogeological properties of the Rewan Group and the Rangal Coal Measures, these formations have been grouped together for the purpose of this assessment.

In the southern half of the Project Site, Quaternary aged Alluvium overlies the Permo-Triassic sediments.

The geology in the vicinity of the Project Site is shown in **Figure 7-1** and description of these units is described below.



LEGEND

- Landholder Bore
- Poitrel Monitoring Bore
- Roads
- Existing Railway
- Mining Lease
- Mineral Development Licence

Regional Geology Boundaries

- Qpa - Quaternary Pleistocene alluvium
- Qa - Quaternary alluvium
- TQa - Tertiary/Quaternary alluvium
- Ts - Suttor Formation
- Re - Rewan Group
- Pwb - Rangal Coal measures

FIGURE 7-1

DAUNIA COAL MINE EIS

GEOLOGY AND GROUNDWATER BORES IN THE VICINITY OF THE PROJECT SITE

0 1 2 3 4

Kilometres

Scale 1:125,000 on A4

Projection: Australian Map Grid - Zone 55 (AGD84)

BMA

BHP Billiton Mitsubishi Alliance

I:\QENV\Projects\QE06520\1800 Spatial\Arc_MXD\Figures\Fig_7-1_Geology_and_Groundwater_Bores.mxd Produced: 13/10/2008 This figure should be read in conjunction with the data disclaimer at the front of this report.

7.1.2.1 Quaternary Floodplain Alluvium

According to the Clermont 1:250,000 scale geological mapsheet, the Quaternary age floodplain Alluvium unit consists of clay, silt, sand and gravel. The sediments are present on the southern part of the Project Site in association with the Isaac River and are generally less than 20 m thick (Minserve Group, 1996). The floodplain sediments are more extensive on the south western bank of the Isaac River.

Where present, the Quaternary sediments act as an unconfined (water table) aquifer. There is little information available on the Quaternary aquifer, including depth to water table and hydraulic properties. During a site inspection undertaken for the Poitrel Mine and surrounds, a narrow ditch was dug in the Isaac River alluvium by an excavator to enable the water table depth in the Alluvium unit to be estimated (SKM, 2005). A water table depth of 2 metres below the base of the Isaac River was approximated. The riverbed elevation at this location is approximately 183 m AHD, and by inference, the water table elevation in the Alluvium unit was estimated to be in the order of 181 m AHD. The Alluvium unit is likely to represent a perched aquifer separated from the coal seam aquifers by low permeability sandstone/siltstone.

Recharge to the aquifer occurs in areas of thin soil cover or along creek beds (i.e. the Isaac River) where surface water can readily infiltrate to the aquifer during and following rainfall events. Groundwater flow in the aquifer is expected to be in a south south-easterly direction towards the Isaac River. Bore yields are variable but can be as high as 20 L/sec and the groundwater salinity is marginal to brackish (1,500 to 3,000 mg/L TDS) (SKM, 2005). Although the Quaternary Alluvium sediments are present in the southern half of the Project Site, it is not known whether the sediments are saturated.

7.1.2.2 Permian Triassic Rewan Group and Rangal Coal Measures

The Permian Triassic Rewan Group and Rangal Coal Measures (Blackwater Group) outcrops in the central and northern parts of the Project Site and underlies the Quaternary sediments in the south. The formations consist of siltstone, sandstone, calcareous and carbonaceous shale and coal. There are limited outcrops of the formations within the Project Site as they generally weather rapidly to form gently undulating plains and lowlands with predominantly medium to heavy clay profiles (Hollingsworth and Associated Consultants, 1980).

Two coal seams occur within the Rangal Coal Measures: the Leichhardt and the Vermont seams. They occur one above the other with the thickness between them ranging between 18 and 36 m.

The Rewan Group and Rangal Coal Measures act as a minor fractured rock aquifer. The permeability of the aquifer is highly variable and dependent on the size and degree of interconnectivity between the fractures within the aquifer. There is no information on the range of hydraulic properties of the aquifer. The highest yielding units within the Rangal Coal Measures are expected to be the coal seams (Hollingsworth and Associated Consultants, 1980). Minor bands of fractured material also exist outside of the coal seams, but based on information gained at the Poitrel Mine, interaction between the fracture zones is expected to be minimal. The groundwater salinity associated with these deposits is anticipated to range between 1,000 and 10,000 mg/L TDS (SKM, 2005).

In general, the aquifer does not yield significant volumes of groundwater. The highest recorded yields range between 1 and 4 L/s and are sourced from the coal seams (SKM, 2005). Yields of less than 1 L/s have been recorded from the fractured sandstones/siltstones at depths of between 50 and 100 metres. Supplies, however, are not always permanent and many bores yielding 0.5 L/s have been productive for periods of up to two to three years before drying out. Given the largely impermeable nature of the Permian age sandstone/siltstone occurring between, above and below the coal seams, the aquifer constituting the coal seam unit is considered confined to semi-confined. Recharge to the coal measures occurs via direct rainwater infiltration in regions where the formation outcrops or sub-crops. Groundwater flow is expected to flow in a south south-easterly direction.

7.1.3 Existing Groundwater Monitoring Network

In April 2008, a groundwater monitoring program commenced at the adjacent Poitrel Mine, which included the construction of eight monitoring bores, two of which lie within the Red Mountain Lease. Data from this monitoring program was not available at the time of preparing this EIS and therefore is not included in this groundwater assessment. The newly constructed bores are not shown on **Figure 7-1**.

Apart from the aforementioned newly constructed bores, there are no groundwater monitoring bores on the Project Site. However, there are six monitoring bores previously constructed at three nested sites on the Poitrel Mine, as shown on **Figure 7-1**. These six bores were constructed in 2004 and the construction details are presented in **Table 7-2** below. In general, the nested site locations consist of two bores with one bore screened in the Leichhardt seam and the other screened in the Vermont seam. Bentonite seals isolate the screened interval from underlying and overlying units. None of the six bores are screened within the Quaternary Alluvium aquifer.

The bores constructed in 2004 are not regularly monitored for water level or water quality, however, a groundwater monitoring program comprising bore purging, groundwater sampling and monitoring for water level and water quality was conducted in July 2004 to assist in the preparation of the Poitrel EIS (SKM, 2005).

Table 7-2 Construction Details of Groundwater Monitoring Bores

Bore ID	Nested Site	Location		Natural Surface Elevation (m AHD)	Screening Interval (mbgl)	Screened Aquifer Unit
		Easting	Northing			
7984	Site A	628626	7562006	240.12	23.3 – 28.0	Leichhardt Seam
7985		628626	7562006	240.12	45.0 – 48.0	Vermont Seam
7987	Site E	629690	7559289	210.55	38.3 – 44.0	Siltstone (above Leichhardt Seam)
7979		629689	7559294	210.55	56.0 – 59.0	Vermont Seam
7978	Site H	629578	7556426	203.87	29.0 – 34.0	Leichhardt Seam
7998		629578	7556426	203.87	59.0 – 65.0	Vermont Seam

Water levels in the six monitoring bores were recorded during the groundwater monitoring program conducted in July 2004. Bores 7984 and 7985 (nested Site A) were dry. The potentiometric surface levels (as reduced water level m AHD) of the remaining four bores are presented in **Table 7-3**.

Although Bores 7984 and 7985 were dry, a hydraulic gradient across the Poitrel Mine site was estimated, assuming a water level depth just below the base of the screened interval. **Figure 7-2** presents a cross section of the natural surface and water levels in the six bores on the Poitrel Mine site. This shows that the topography is highest at the northern end of the site and slopes gradually to the south towards the Isaac River. The water levels also show a slight gradient towards the south south-east. There is little vertical difference between the observed water levels in the nested bores, which highlights that the Leichhardt and Vermont coal seam aquifers are hydraulically connected to some extent.

Table 7-3 Groundwater Level Records of Monitoring Bores

Bore ID	Nested Site	Screened Unit	Monitoring Date	Potentiometric Surface in the Coal Seams	
				Depth from Natural Surface (metres)	RWL (m AHD)
7984	Site A	Leichhardt Seam	19/07/04	Dry	Dry
7985		Vermont Seam	19/07/04	Dry	Dry
7987	Site E	Siltstone (above Leichhardt Seam)	20/07/04	24.29	186.26
7979		Vermont Seam	20/07/04	24.42	186.13
7978	Site H	Leichhardt Seam	21/07/04	21.85	182.02
7998		Vermont Seam	22/07/04	21.87	182.00

(1) Bores 7984 and 7985 were observed to be dry and may indicate the water level is below the screened interval and/or a fault with the bore (i.e. clogging of screen, bore collapse etc).

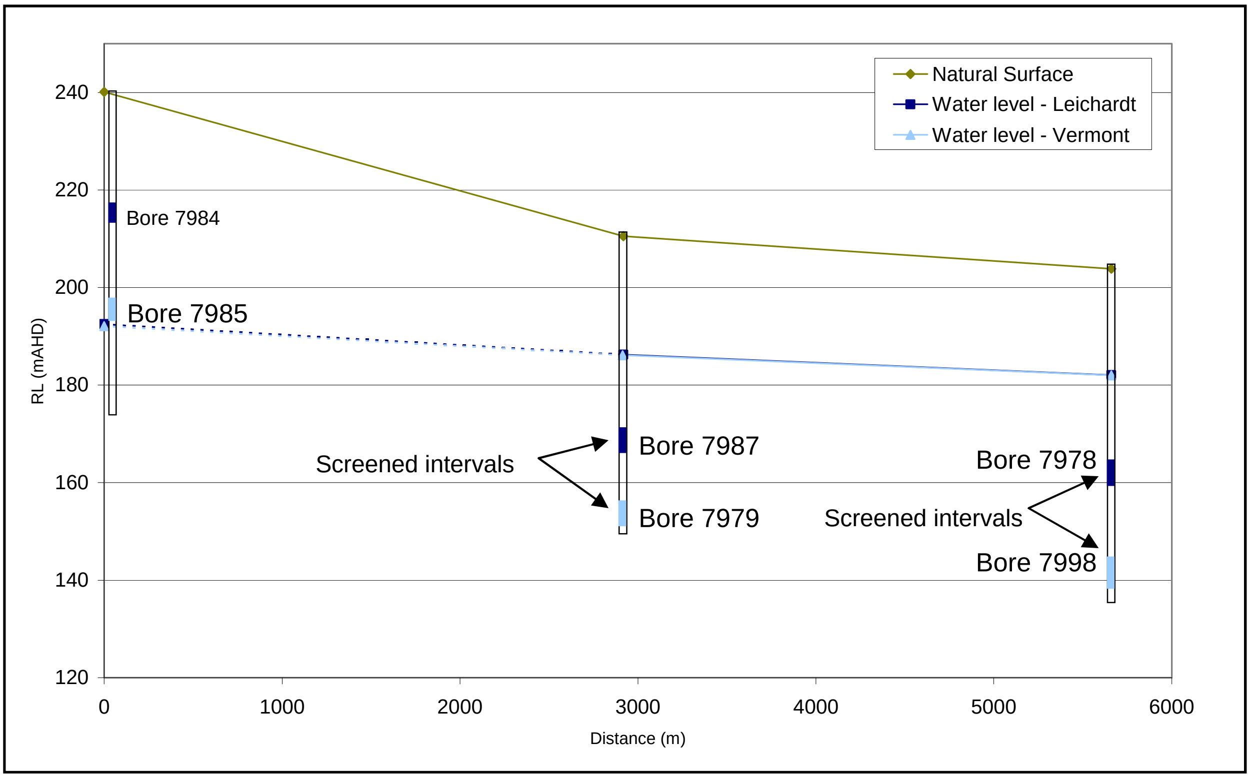


Figure 7-2 Cross Section through Poitrel Mining Area

Note: The water levels in bores 7984 and 7985 are inferred, and consequently the potentiometric surface between these bores and bores 7987 and 7979 is also inferred.

7.1.4 Groundwater Quality

7.1.4.1 Water Quality Collection Program

Groundwater was sampled from four of the six monitoring bores located on the Poitrel Mine site during the groundwater monitoring program conducted in July 2004. The remaining two bores (7984 and 7985) were dry and no groundwater samples were able to be collected for analysis. Each sample was subjected to the following laboratory analysis:

- Alkalinity;
- Total Dissolved Solids (TDS);
- pH;
- Sulphate (as SO_4^{2-}), Sulphide (as S^{2-});
- Chloride, Calcium, Magnesium and Sodium; and
- Iron, Antimony, Arsenic, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Nickel, Selenium, Zinc and Mercury.

The samples being subjected to the trace metal analysis were filtered (to 35 μm) following collection in the field.

7.1.4.2 Summary of Groundwater Quality

The groundwater analytical results for the four samples were compiled and compared against the following guidelines:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000):
  - Aquatic ecosystems: Protection of upland river aquatic ecosystems in tropical Australia, and using the 99 per cent protection levels for toxicants due to the unmodified (i.e. non-urban) nature of the catchment;
  - Water quality for irrigation and general water use; and
  - Livestock drinking water quality.
- Australian Drinking Water Guidelines (NHMRC, 2004).

The analytical results and associated guidelines are presented in **Table 7-4**.

The salinity (TDS) of the groundwater was found to vary between the two nested boreholes. At nested Site H (bores 7978 and 7998, located in the south eastern corner of the Poitrel Mine site) the groundwater was in the order of 3,000 mg/L TDS lower than groundwater sampled from nested site E (bores 7987 and 7979, some six kilometres to the north). The lower salinity groundwater at nested Site H is likely to be due to infiltration of fresher groundwater sourced from the Alluvium unit associated with the Isaac River.

The levels of salinity, Arsenic, Chromium, Copper, Manganese and Zinc were above the ANZECC guidelines for aquatic ecosystems in the majority of the groundwater samples. The levels Chloride, Sodium, Iron and Manganese were above the ANZECC guidelines for irrigation in the majority of the groundwater samples. Elevated concentrations of iron and manganese are not uncommon in groundwater and are likely to be naturally occurring. Similarly, the salinity of the groundwater would generally limit its use for stock watering, without significant dilution by fresh water.

Lastly, the elevated salinity of the groundwater (up to 8,190 mg/L TDS) would preclude its use for drinking water, for which the Australian Drinking Water Guideline is less than 500 mg/L TDS.

7.1.5 Surrounding Groundwater Users

The groundwater users in the vicinity of the Project Site were identified from a search on the Department of Natural Resources and Water (DNRW) groundwater database. In addition to this, a field survey was undertaken during the Poitrel EIS which identified 12 users around the Poitrel Mine site (SKM, 2005).

The DNRW database search identified about 60 bores located within 25 km of the Project Site, however the majority of these bores were drilled for mining and geological purposes. Only one water supply bore was identified through the database search and this bore (81909) is located approximately 20 km north west of the Project Site. Apart from the monitoring bores within the Poitrel Mine site, two other monitoring bores were identified. Bore 141157 is located 6 km east of the Project Site, monitoring the Blackwater Group siltstone/sandstone aquifer. Bore 13040284 is located 16 km north west of the Project Site and is also monitoring the siltstone/sandstone aquifer.

The field survey undertaken as part of the Poitrel EIS (September and December 2004) identified 12 bore users in the vicinity of the Project Site, with 9 bores being used at the time of the survey. Information on these bores and those bores identified from the DNRW database search are provided in **Table 7-5**, and their locations are shown in **Figure 7-1**. Bore construction details are not available and accordingly there is some uncertainty as to the depths (and aquifer units) from which the bores extract groundwater. On the basis of existing hydrogeological information, it is considered likely that those bores situated adjacent to the Isaac River and its tributaries (Bores 3, 8 and 9) would be extracting from the perched Alluvium aquifer, while the remaining bores (Bores 1, 2, 4, 5, 6, 7, 10, 11, 12, 141157 and 13040284) would be screened and extracting (where appropriate) from the deeper coal seam aquifers of the Blackwater Group.

7.1.6 Legislation Relevant to Groundwater

The ‘taking’ of water from an aquifer under land is regulated by the Queensland *Water Act 2000* and Queensland *Water Regulation 2002* and requires a licence. Construction and development of bores required to extract water from an aquifer is an assessable development under the Queensland *Integrated Planning Act 1997*.

Water licences for the taking of groundwater for the Project will have to be obtained by BMA from DNRW. The licences will stipulate a maximum annual take from each relevant aquifer. Under the *Water Act 2000*, DNRW has authority to direct the licensee to provide and maintain access to alternative water supplies for other water entitlement holders who would be affected by the granting of the licence. This authority is similar to the former “make good” provisions of the now repealed *Water Resources Act 1989*. The *Water Act 2000* does not authorise directions to be made with respect to alternative supplies for persons without other water entitlements.

Table 7-4 Groundwater Analytical Results with Reference to Adopted Guidelines

Analytical Results	Units	ANZECC [1]			Drinking Water [2,4]	Borehole			
		Aquatic Ecosystem [3]	Irrigation	Stock Water		7987	7979	7978	7998
Physical-Chemical Properties									
Alkalinity (as $CaCO_3$)	mg/L	N/a	N/a	N/a	N/a	746	758	860	769
Total Dissolved Solids	mg/L	150	Highly dependent on crop type and soils	4,000 (beef cattle), 2,500 (dairy cattle), 5,000 (sheep), 4,000 (horses), 4,000 (pigs), 2,000 (poultry)	500	8,190	8,000	4,880	4,360
pH	-	N/a	N/a	N/a	6.5 to 8.5	6.5	6.5	6.7	6.6
Inorganic Analytes									
Sulphate (as SO_4^{2-})	mg/L	N/a	N/a	1,000	250	174	201	89	122
Sulphide (as S^{2-})	mg/L	N/a	N/a	N/a	N/a	<0.1	<0.1	<0.1	<0.1
Chloride	mg/L	N/a	175 (sensitive crops) to >700 (tolerant crops)	N/a	250	4,020	3,880	1,730	1,700
Calcium	mg/L	N/a	N/a	1,000	N/a	237	208	116	128
Magnesium	mg/L	N/a	N/a	2,000	N/a	433	377	169	163
Sodium	mg/L	N/a	115 (sensitive crops) to >460 (tolerant crops)	N/a	180	1,610	1,690	1,090	908
Iron	mg/L	ID	0.2	Not sufficiently toxic	0.3	1.35	0.05	0.02	1.47
Antimony	mg/L	ID	N/a	N/a	0.003	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001 (As III), 0.0008 (As V)	0.1	0.5 to 5	0.007	0.004	0.005	0.001	<0.001
Cadmium	mg/L	0.00006	0.01	0.01	0.002	0.0002	<0.0001	<0.0001	0.0001
Chromium	mg/L	0.00001 (CrVI)	0.1	1	0.05	0.006	0.006	<0.001	0.002

Analytical Results	Units	ANZECC [1]			Drinking Water [2,4]	Borehole			
		Aquatic Ecosystem [3]	Irrigation	Stock Water		7987	7979	7978	7998
Cobalt	mg/L	ID	0.05	1	-	0.007	0.016	<0.001	0.003
Copper	mg/L	0.001	0.2	0.4 to 5	1	0.003	0.003	0.002	<0.001
Lead	mg/L	0.001	2	0.1	0.01	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	1.2	0.2	Not sufficiently toxic	0.1	0.901	0.821	0.163	0.468
Nickel	mg/L	0.008	0.2	1	0.02	0.008	0.02	0.002	0.003
Selenium	mg/L	0.005	0.02	0.02	0.01	<0.010	<0.010	<0.010	<0.010
Zinc	mg/L	0.0024	2	20	3	0.013	0.035	0.007	0.007
Mercury	mg/L	0.00006	0.002	0.002	0.001	<0.0001	<0.0001	<0.0001	<0.0001

Notes:

(1) Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy.

(2) National Health and Medical Research Council (NHMRC) 2004, Australian drinking water guidelines

(3) The aquatic ecosystem guideline represents 99 per cent species level of protection.

(4) Both Health and Aesthetic guidelines are provided for drinking water. The value adopted was the lower of the two.

N/a: not available

ID: insufficient data

Table 7-5 Information on Neighbouring Boreholes

Borehole Number	Location Co-ordinates	Distance to the edge of mine (km)	Condition	Depth to Water table (metres)	Reported Yield	Source
Bore 1	628740E 7546688N	NA	Not active	7.5	Unknown	Poitrel field survey
Bore 2	621970E 7552907N	11.6	Active	10.0	0.3 L/s	Poitrel field survey
Bore 3	627714E 7556752N	4.3	Active	13.5	Unknown	Poitrel field survey
Bore 4	630297E 7558574N	NA	Not active	14.0	Unknown	Poitrel field survey
Bore 5	632495E 7559750N	On project site	Active	35.0	Unknown	Poitrel field survey
Bore 6	634350E 7556563N	On project site	Active	Not accessible	Unknown	Poitrel field survey
Bore 7	637519E 7552624N	NA	Not active	Dry	Unknown	Poitrel field survey
Bore 8	640189E 7547989N	5.7	Active	19.5	Unknown	Poitrel field survey
Bore 9	633898E 7553055N	0.8	Active	Not accessible	2 to 4 L/s	Poitrel field survey
Bore 10	639594E 7558477N	4.0	Active	29.0	2 L/s	Poitrel field survey
Bore 11	637684E 7558650N	2.1	Active	Not accessible	Unknown	Poitrel field survey
Bore 12	621511E 7568791N	11.6	Active	9.5	Unknown	Poitrel field survey
141157	639587E 7560479N	6.0	Not known	8.7	1.3 L/sec	Groundwater database
81909	620090E 7573318N	20.0	Not known	Not known	Unknown	Groundwater database
13040284	620264E 7566309N	15.0	Not known	25.0	3.6 L/sec	Groundwater database

Note the depth of the bores could not be recorded due to the presence of downhole pumps.

7.2 Potential Impacts

7.2.1 Impacts on Groundwater – During Mining Operations

The Project Site is located adjacent to the Poitrel Mine and Millennium Project. The Poitrel Mine is operated by BMA and the Millennium Project is operated by Peabody. Given the close proximity of the three coal mines, this assessment considers the cumulative impact of all three mines on the surrounding groundwater resources.

Mining commenced at the Poitrel Mine in October 2006 and the mine will continue to operate for approximately 20 years. Mining operations have also commenced at Millennium and are assumed to be continuing during the Daunia Project operation.

Throughout the operational phase of the three mines, the open cut pits will intersect the water table and some groundwater will discharge into the pits. This assessment assumes that sump pumps will be employed at the base of pits to remove the groundwater, which will be used for other purposes (i.e. dust suppression and coal processing) at the mine sites.

Groundwater discharge into the pits will cause drawdown around the pits, which in turn causes regional groundwater levels to lower. Following the cessation of mining, groundwater will continue to discharge to the rehabilitated final voids until water levels within the surrounding aquifers recover to equilibrium.

This assessment uses predictive numerical groundwater modelling to determine the potential magnitude and extent of impact of mining on the surrounding groundwater system, including the potential impact on neighbouring groundwater users.

7.2.1.1 Numerical Groundwater Modelling Methodology

A predictive numerical groundwater model (Visual MODFLOW Version 4.2) was constructed using the geological and hydrogeological data available for the region. An outline of the modelling process, including set-up and assumptions, is presented in **Appendix H**.

The groundwater model has been used to predict potential impacts of the three mines (Daunia, Poitrel and Millennium) on the regional groundwater system during:

- operational stages of the Daunia Project; and
- post mining phase of the Daunia Project.

This includes recovery of the aquifer after mining has ceased.

The outcomes of the predictive modelling are discussed in the following sections. Because there is limited information available for the Project Site, a range of aquifer properties were applied to the model to highlight the range of possible results.

7.2.1.2 Hydrogeological Conceptual Model

The regional hydrogeology comprises three units:

- partly saturated shallow alluvial aquifer;
- the Rewan Group and Rangal Coal Measures (Blackwater Group) comprises interbedded siltstone/sandstone with coal seams; and
- the impermeable bedrock.

The hydrogeological conceptual model is shown in **Figure 7-3**.

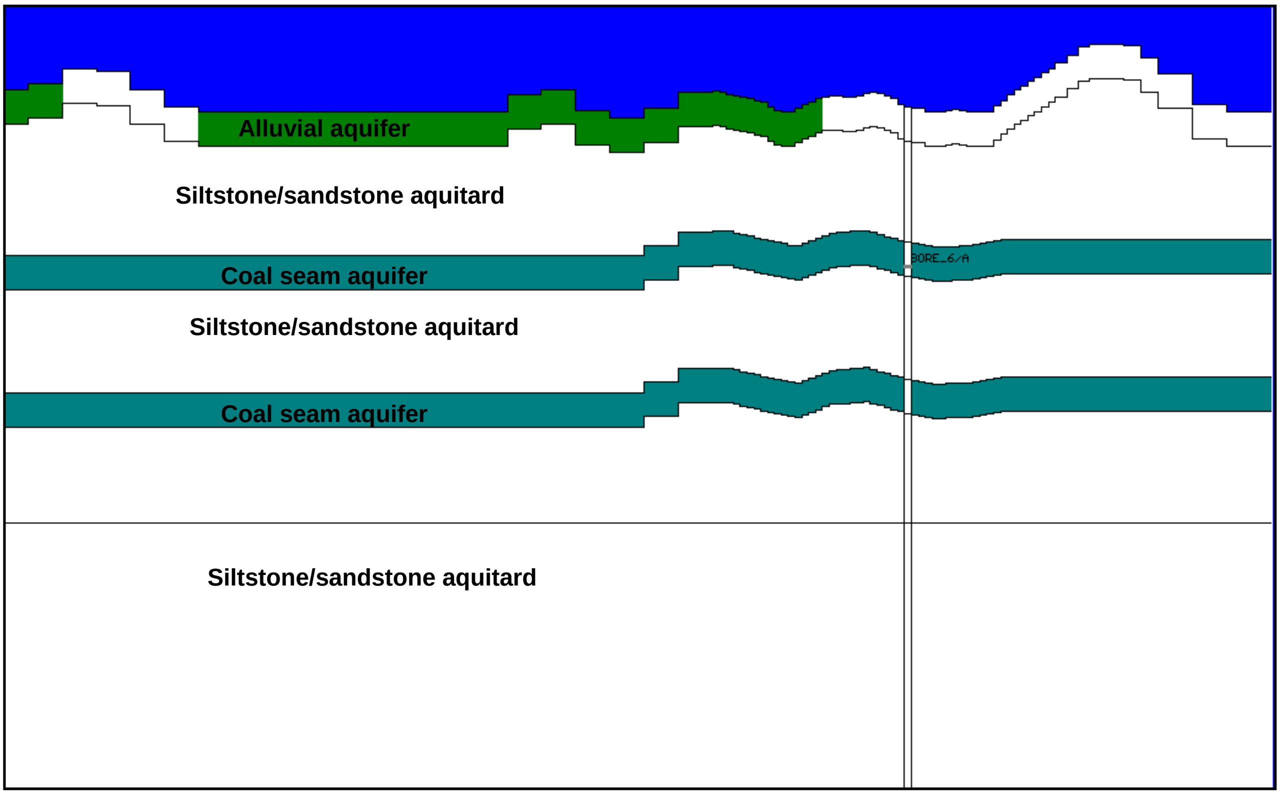


Figure 7-3 Hydrogeological Conceptual Model

A summary of the hydrogeological conceptual model is as follows:

- The alluvial aquifer is present in the southern half of the Project Site, and is associated with the Isaac River. The thickness of the aquifer is assumed to be 10 m. The depth to water table in the alluvial aquifer is shallow (< 2 mbgl) beneath the Isaac River, however, it is not known whether the aquifer is saturated beneath the Project Site. The Isaac River is ephemeral, and during flow periods, it is likely that groundwater levels in the shallow alluvial aquifer increase. Groundwater flow within the aquifer is expected to be to the south, towards the Isaac River. Recharge to the aquifer is via rainfall infiltration and the aquifer discharges to the south and possibly to the Isaac River. The hydraulic conductivity of the alluvial aquifer is assumed to range between 2 and 50 metres per day (m/d) with a best estimate of 10 m/d. The specific yield of the alluvial aquifer is assumed to range between 13 per cent and 52 per cent with a best estimate of 26 per cent.
- The underlying Rewan Group and Rangal Coal Measures (Blackwater Group) comprises interbedded siltstone/sandstone and coal seams. The coal seams are expected to represent aquifers, while the siltstone/sandstone is expected to behave as a low permeability aquitard. The Blackwater Group is assumed to be approximately 180 m thick, of which the coal seam aquifers are 10 m thick each and separated by 30 m of aquitard.
- Regional groundwater flow within the coal seam aquifers is to the south southeast. The only information on groundwater levels within the coal seam aquifers is from bores located on the Poitrel Mine site, which indicate that groundwater levels range between 180 and 195 mAHD. The aquifers are recharged from

rainfall infiltration where the aquifers outcrop and discharge to the south-southeast. The hydraulic conductivity of the low permeability siltstone/sandstone aquitard is assumed to be 0.1 m/d (with lower and upper estimates of 0.05 and 0.2 m/d), while the conductivity of the coal seam aquifers is assumed to be 5 m/d (with lower and upper estimates of 2 and 25 m/d). The storativity was assumed to be 5 x 10^{-6} for all layers.

The hydraulic base of the model is assumed to be at 0 mAHD which is assumed to be the top of impermeable bedrock.

7.2.1.3 Impacts on Regional Groundwater Levels during Mine Operation

For the purpose of this assessment, it is assumed that groundwater will be removed from the three open cut mines via sump pumps. The maximum depth of the each of the mines at five yearly intervals is provided in **Table 7-6**. The Daunia mine pit will gradually deepen from 134 mAHD to 80 mAHD as the mine progresses south. Likewise, the Poitrel mine pit is expected to deepen from 120 mAHD to 100 mAHD over the life of the mine. There is little information available for the Millennium Project, so the mine is assumed for the purposes of the numerical model, to remain in the same location and at the same depth (185 mAHD) for the life of the Daunia Project.

Table 7-6 Maximum depths of coal mines assumed in the groundwater model

Mine	**Elevation of base of pit mAHD**			
	Year 5	**Year 10**	**Year 15**	**Year 20**
Daunia	134	100	98	80
Poitrel	120	120	105	100
Millennium	185	185	185	185

The approximate volumes of water flowing into the Daunia mine pit for Years 5, 10, 15 and 20 years are presented in **Table 7-7**, and graphically illustrated in **Figure 7-4**. For the best estimate of the aquifer properties (representative), the inflow rates are expected to range between 2 ML/d and 9.2 ML/d depending on the size of the pit. Under a worst case scenario (upper estimate) the volume flowing into the pit could range between 8 ML/d and 34 ML/d depending on the size of the pit. Under the best case scenario, the inflows are expected to range between 0.5 and 2.3 ML/d.

The inflow into the Daunia mine pit is predicted to increase up to year 10 of operation as a result of expansion of the pit. Between years 10 and 15, the rate of groundwater inflow into Daunia mine pit decreases because although the depth of the pit increases slightly, there is a significant increase in the depth of the Poitrel Mine, which in turn reduces groundwater inflow into the Daunia mine. The groundwater inflows into the Daunia mine pit are greatest between years 15 and 20, when the pit moves south and is deepened to about 80 mAHD. Around year 20, the Daunia mine pit may also intersect the alluvial aquifer.

Although the Alluvial sediments are expected to be excavated between years 15 and 20 of the Daunia Project, there is no information to confirm whether the sediments are saturated and will therefore need to be dewatered. There is, however, some drawdown predicted in the alluvial aquifer beneath the Isaac River to the south of the Project Site as a result of drawdown in the underlying aquifer. Groundwater discharge rates associated with the excavation of this material and the underlying Blackwater Group are presented as one value.

In summary, if the aquifer properties are in the range of the lower estimates of the representative values, sump pumps are considered a suitable mechanism to manage the inflows and re-distribute the water for other purposes at the Project Site. If the aquifer properties are higher than the lower estimates, then dewatering via groundwater extraction bores around the pit may be required to control inflows into the pit. The experience to date at the Poitrel Mine and Millennium Project indicates that groundwater inflows are manageable with sump pumps.

When the Daunia mine pit moves south, there also may be additional dewatering requirements. The aquifer properties will be further defined following the implementation of a groundwater monitoring program at the Project Site starting in 2009, which will enable re-calibration of the groundwater model and determination of groundwater management requirements.

Table 7-7 Summary of Groundwater Inflow rates into the Daunia Mine Pit

Range	Units	Estimated Groundwater Inflow Rates			
		Up to Year 5	Up to Year 10	Up to Year 15	Up to Year 20
Representative	ML/day	2.5	3.7	2.0	9.2
	ML/year	900	1,400	700	3,400
Lower Estimate	ML/day	1.5	0.8	0.5	2.3
	ML/year	550	280	170	820
Upper Estimate	ML/day	10.4	16.3	8.3	33.8
	ML/year	3,800	6,000	3,000	12,300

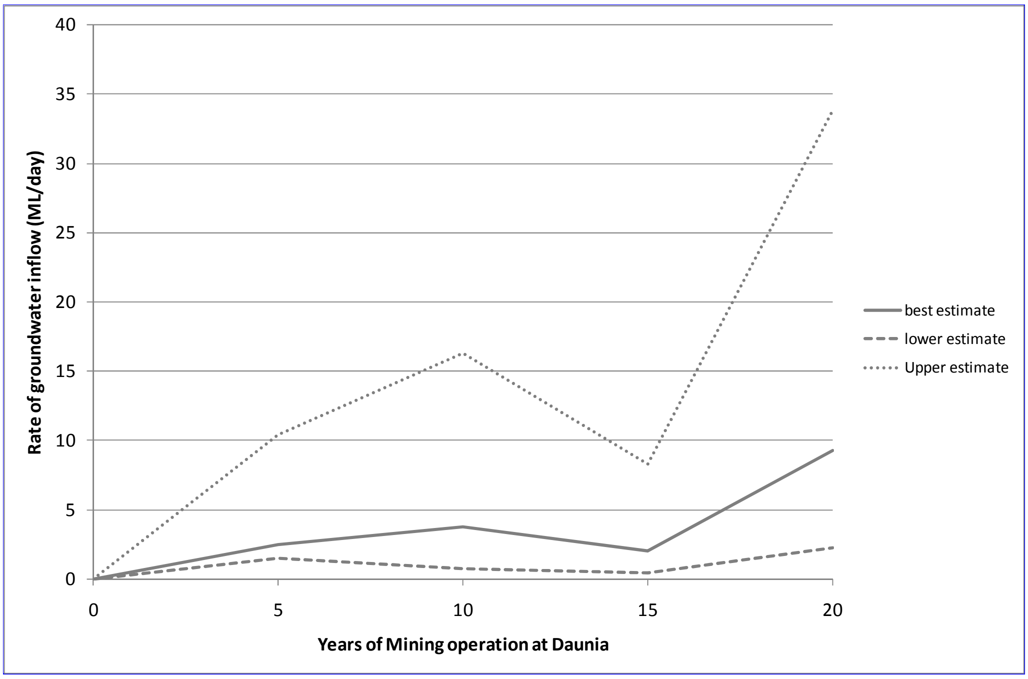


Figure 7-4 Groundwater Inflow rates into the Daunia Mine Pit at Years 5, 10, 15 and 20 years

During the life of the Daunia Project, the rate of groundwater inflow into the mine pit from the intersected aquifers will significantly exceed the rate that these aquifers can recharge from surrounding aquifers and other recharge processes. This will lead to a depression or “drawdown’ of the potentiometric surface within the vicinity of the mines compared to pre-mining levels.

Figure 7-5 to **Figure 7-8** present the impact of groundwater removal at four stages during the Daunia Project operation, assuming representative aquifer parameters. The figures present the groundwater drawdown in the coal seam aquifers of the Blackwater Group. The figures present the groundwater drawdown as contours, which represent the extent of the drawdown ‘cone’ within the coal seam aquifers. A drawdown contour of 2 m indicates that a drop in water level would be experienced by a bore screened within the siltstone/sandstone and coal seam aquifers at that specific location. There were observed modelling artefacts (i.e. negative drawdown) associated with boundary conditions that resulted in anomalies in the predicted water levels. These anomalies occur to the north-east of the Project Site near the model boundary and do not affect the water levels in the vicinity of the Project Site or the nearby bores.

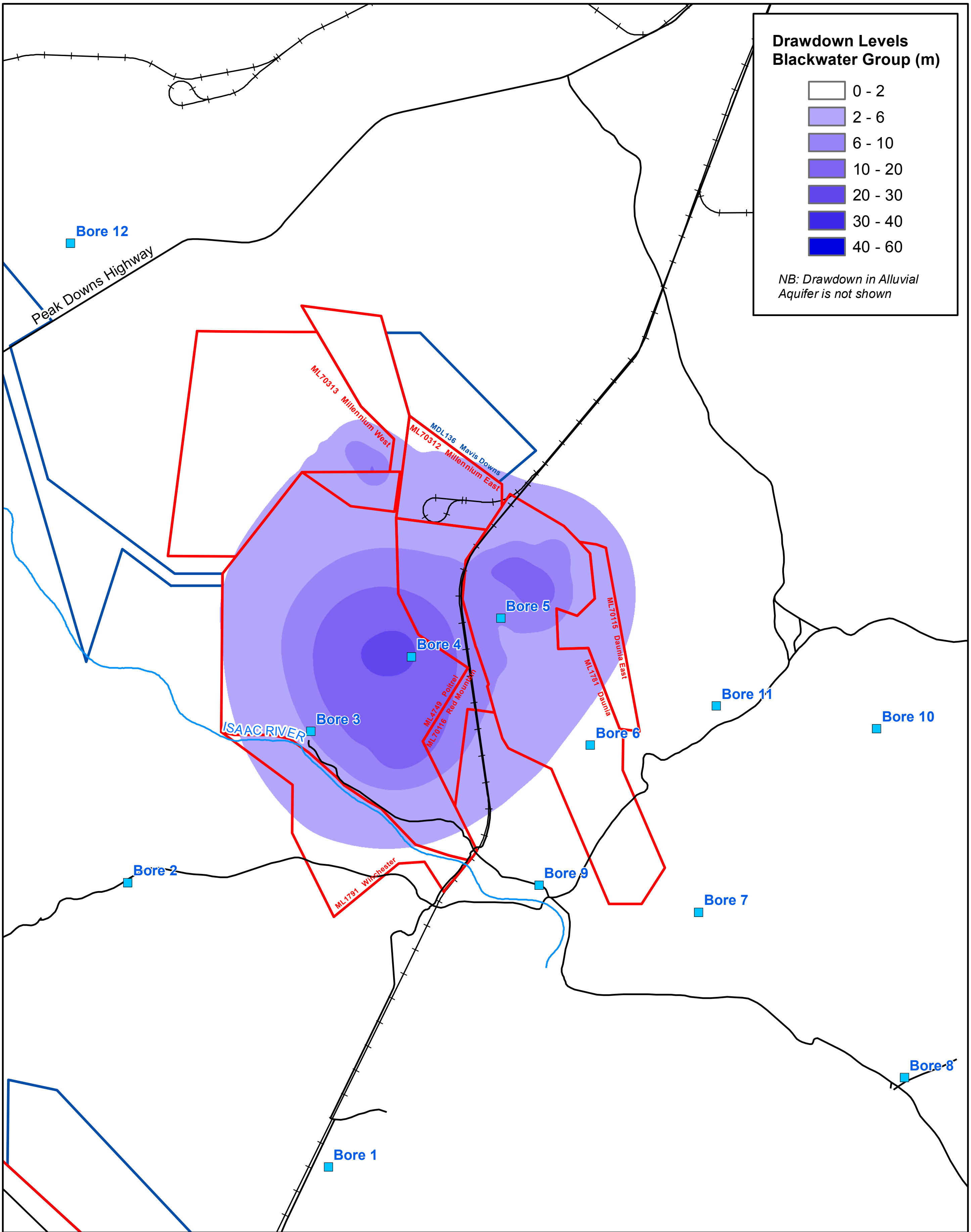
Figure 7-5 to **Figure 7-8** show that the groundwater drawdown cone within the coal seam aquifers is generally centred on the Poitrel Mine, rather than the Daunia Mine or Millennium Project. This is due to the shape and depth of the Poitrel Mine. The Poitrel Mine is significantly deeper than both Daunia and Millennium, which means that groundwater levels beneath both Daunia and Millennium would already be influenced by the Poitrel Mine. The additional impact that the Daunia Project will have on the regional groundwater is thus expected to be minimal in comparison to the Poitrel Mine.

The exception to this is between years 15 and 20 of the Daunia Project when the Daunia mine pit moves south towards the Isaac River (**Figure 7-8**). Mining in this location is expected to have a significant impact on the regional groundwater levels within the coal seam aquifers of the Blackwater Group.

The impact of groundwater removal on the regional aquifer increases from the initial mining operation through to the cessation of mining. At year 20 of the Daunia Project’s operation, a groundwater drawdown of up to 2 m extends beyond the Project Site out to a distance of approximately 4.5 km to the east, 10 km to the west, 2 km to the south and 4 km to the north (**Figure 7-8**). Groundwater drawdown impacts of less than 2 m will not significantly affect the groundwater environment as this drawdown is well within the natural (seasonal) fluctuation of water levels in aquifers within the region.

The groundwater drawdown within the overlying alluvial aquifer is not presented graphically in this section, however the model has predicted the drawdown levels in the groundwater bores that are screened in the alluvial aquifer (e.g. bores 8 and 9), which are presented in **Table 7-8**. The modelling predicts a lower rate of drawdown in these bores compared to those screened in the underlying coal seams aquifers, due to the very low conductivity of the aquitard between the alluvial aquifer and the coal seams aquifers.

The modelling predicts that the drawdown in the alluvial aquifer reaches a maximum at year 20 of the Daunia Project, as the Daunia mine pit is in close proximity to the alluvial aquifer. At the Olive Downs groundwater bore (i.e. bore 9), the modelling predicts that the drawdown would range between 0 and 9.5 m (depending on the aquifer parameters), with a representative estimate of 3 m (**Table 7-8**). By comparison, **Figure 7-8** indicates that the drawdown in the Blackwater Group at this location would be greater, with a representative estimate of 7 m.



LEGEND

- Landholder Bore Users (Poitrel)
- Drainage
- Roads
- Existing Railway
- Mining Lease
- Mineral Development Licence

FIGURE 7-5

DAUNIA COAL MINE EIS

GROUNDWATER DRAWDOWN
YEAR 5 OF PRODUCTION

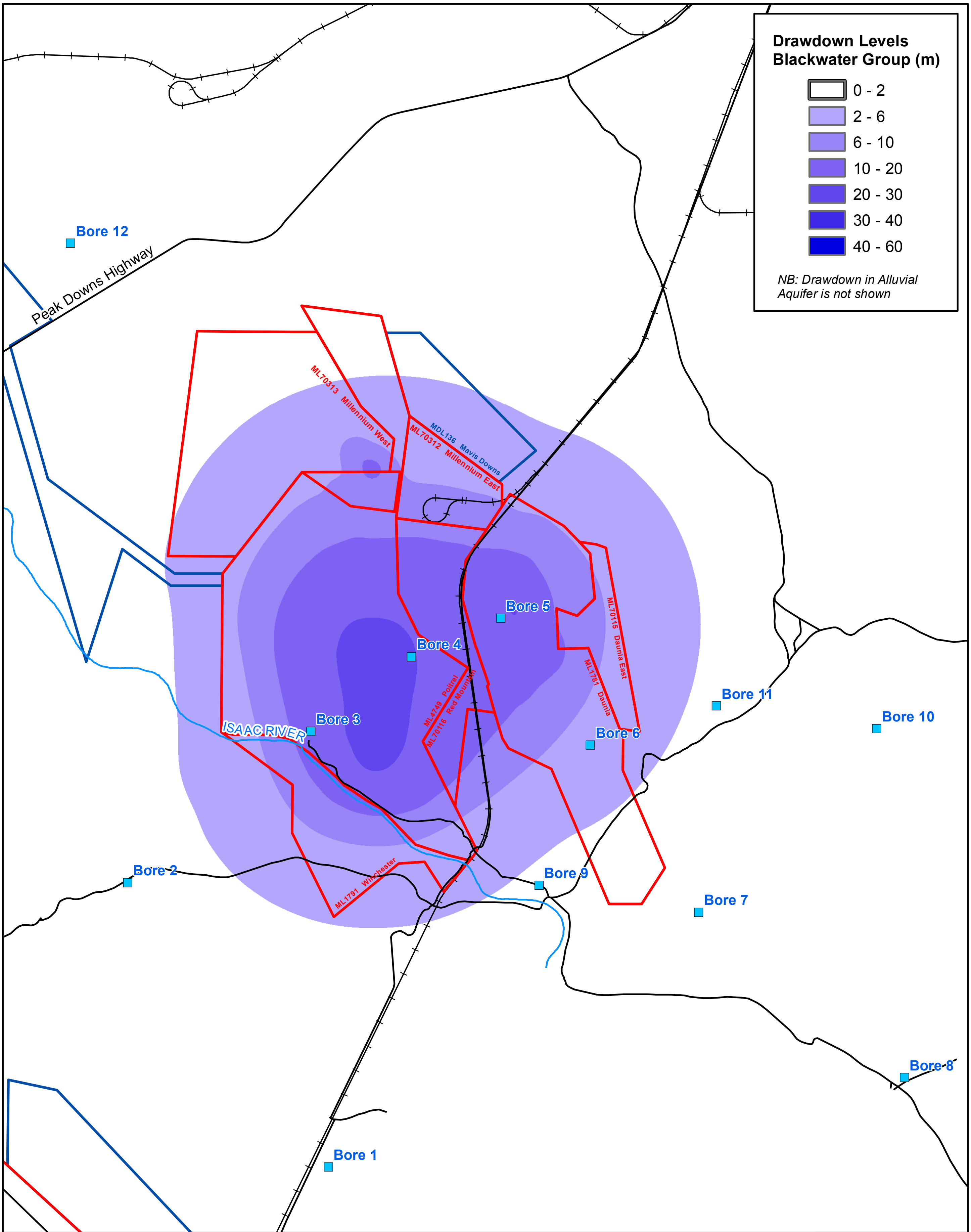
0 1 2 3 4 5

Kilometres

Scale 1:125,000 on A4

Projection: Australian Map Grid - Zone 55 (AGD84)

BMA
BHP Billiton Mitsubishi Alliance



LEGEND

- Landholder Bore Users (Poitrel)
- Drainage
- Roads
- Existing Railway
- Mining Lease
- Mineral Development Licence

FIGURE 7-6

DAUNIA COAL MINE EIS

GROUNDWATER DRAWDOWN
YEAR 10 OF PRODUCTION

0 1 2 3 4 5
Kilometres

Scale 1:125,000 on A4

Projection: Australian Map Grid - Zone 55 (AGD84)

BHP Billiton Mitsubishi Alliance

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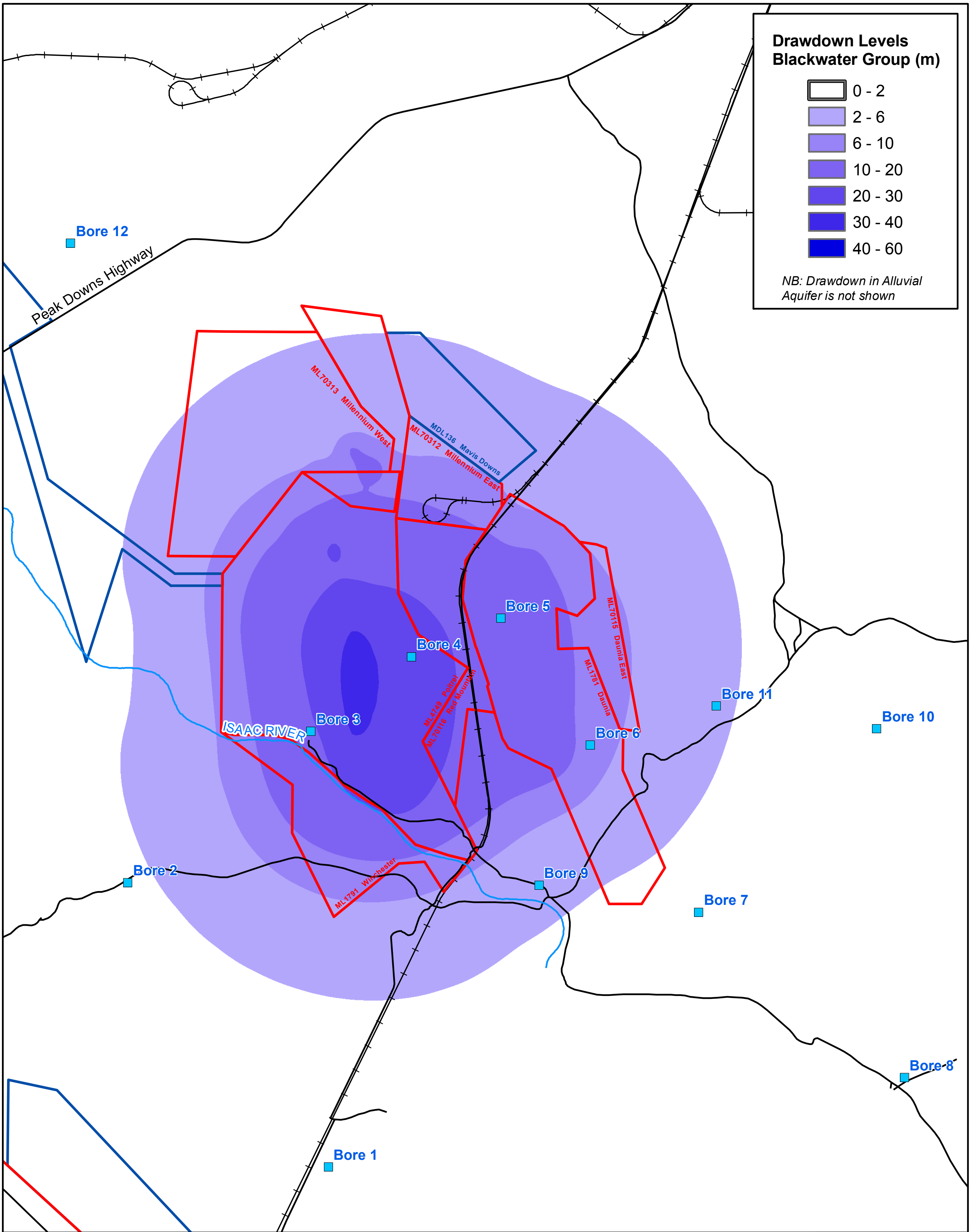

LEGEND

- Landholder Bore Users (Poitrel)
- Drainage
- Roads
- Existing Railway
- Mining Lease
- Mineral Development Licence

FIGURE 7-7

DAUNIA COAL MINE EIS

GROUNDWATER DRAWDOWN
YEAR 15 OF PRODUCTION

0 1 2 3 4 5
Kilometres

Scale 1:125,000 on A4

Projection: Australian Map Grid - Zone 55 (AGD84)

BHP Billiton Mitsubishi Alliance

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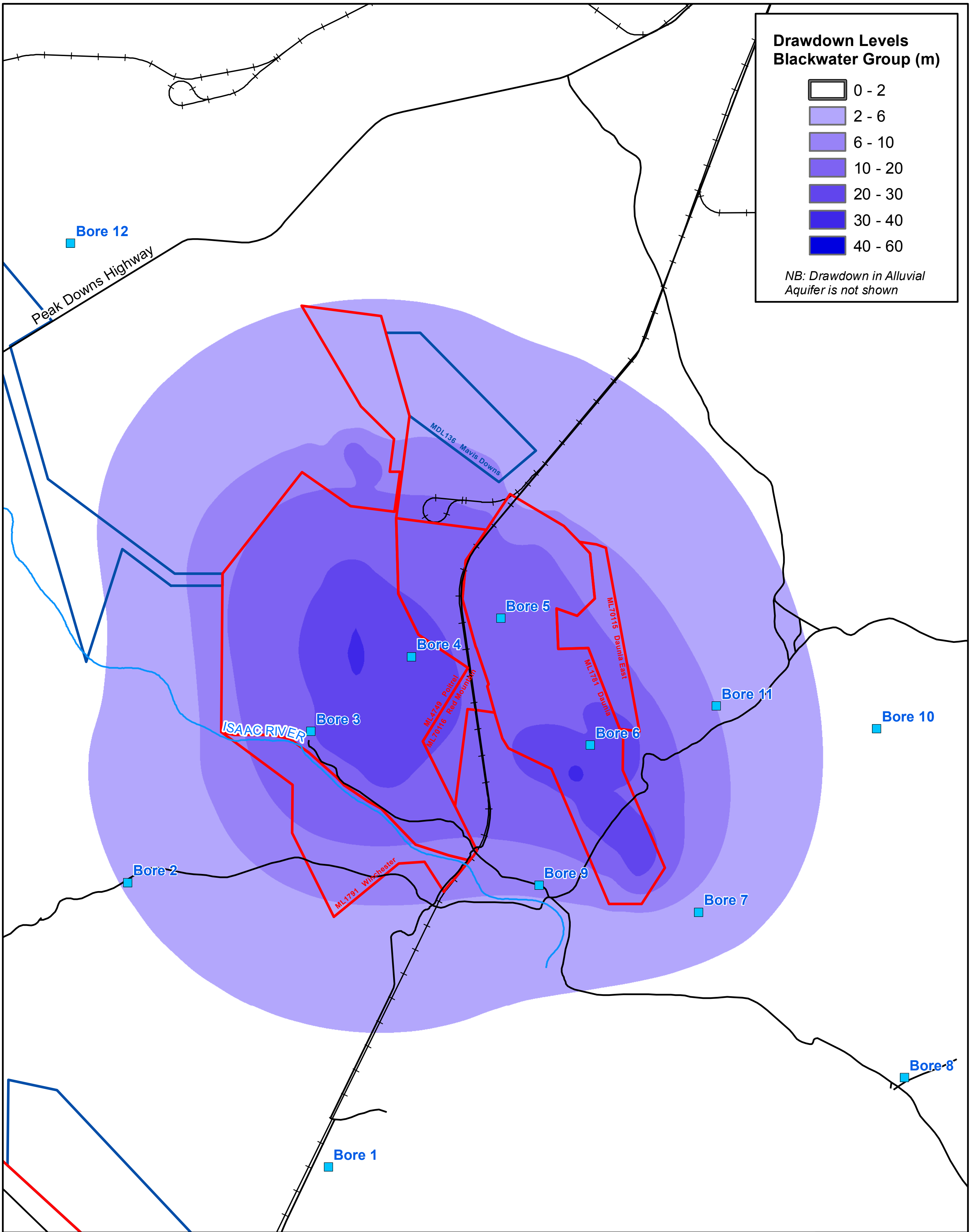


LEGEND

- Landholder Bore Users (Poitrel)
- Drainage
- Roads
- Existing Railway
- Mining Lease
- Mineral Development Licence

FIGURE 7-8

DAUNIA COAL MINE EIS

GROUNDWATER DRAWDOWN
YEAR 20 OF PRODUCTION

0 1 2 3 4 5

Kilometres

Scale 1:125,000 on A4

Projection: Australian Map Grid - Zone 55 (AGD84)

BMA
BHP Billiton Mitsubishi Alliance

7.2.1.4 Impacts on Groundwater Quality during Mine Operation

The mining and dewatering operations are not expected to have a detrimental impact on the groundwater quality in the proximity of the Project Site.

A geochemical assessment was undertaken for the Project Site, which is detailed in **Section 5** of the EIS. The geochemical assessment found that there was a low risk of acid generation from the overburden, coal and interburden materials (i.e. the Rewan Group and Rangal Coal Measures) and thus any oxidation of the coal seams due to mine dewatering is expected to pose a low risk of acid mine drainage.

There will be no direct discharge of waste water to groundwater during Project construction or operation. Storage, handling and use of hydrocarbons and other chemicals will be as outlined in **Section 19** of the EIS, with management measures implemented to prevent and minimise spills or leaks and thus the risk of pollution of groundwater.

The groundwater quality within the aquifers surrounding the Project Site will be monitored to ensure the groundwater is suitable for all the purposes that it was deemed suitable for pre-mining.

7.2.1.5 Potential Impact to Groundwater Users during Mine Operation

The numerical modelling predicts that the impact of groundwater removal on surrounding properties (i.e. greater than a 2 m drawdown) at the end of mining extends to a maximum of 10 km from the edge of the Project Site. Surrounding properties with bores screened in the Blackwater Group would experience up to 10 m drawdown close to the Project Site boundary, reducing to less than 2 m at a distance of between 4 and 10 km from the Project Site, depending on their location.

The potential impact on groundwater users on these properties is outlined below:

- The pressure head within the aquifer surrounding the Project Site will reduce, which will result in an increased depth to water in bores located within the drawdown area.
- Reduced pressure head within aquifers will potentially reduce the rate at which groundwater can be extracted from bores due to reduced head of water above the pump.
- Inlet valves within the bores may have to be lowered in order to maintain sufficient head of water above the pump when the pump is operational. This may increase the cost of extracting groundwater from within bores.
- New pumps may be required if existing pumps are not powerful enough to lift groundwater from the increased depth beneath the surface.
- In some situations, bores may need to be deepened or relocated in order to ensure sufficient long term water supply.
- The predicted drawdown at each of the surrounding groundwater users as a result of the Daunia Project is presented in **Table 7-8**. Less drawdown is predicted in the bores screened in the alluvial aquifer (e.g. bores 8 and 9) due to the very low conductivity of the aquitard between the alluvial aquifer and the coal seams aquifer.
- In general, the groundwater level drawdown in the coal seam aquifers is anticipated to expand with progression of the mining as a consequence of the progressive deepening and increased area of the mine pit, and in turn, the rate of groundwater discharge. Hence, the greatest groundwater level drawdown in the coal seam aquifers will be experienced at year 20 of the Daunia Project.

In addition to this, it is also possible that there would be increased flows into the Daunia mine pit during flood/flow periods in the Isaac River. The Isaac River is an ephemeral river that only flows during times of high rainfall. It is likely that when there is flow in the river, groundwater levels in the alluvial aquifer may rise, which could potentially cause more inflow into the Daunia mine pit. The interaction between groundwater in the alluvial aquifer and surface water in the Isaac River is not well understood and the potential for increased flows into the Daunia mine pit during high rainfall periods would need to be assessed in more detail.

Table 7-8 Estimated Groundwater Level Drawdown in Neighbouring Bores Screened in the Blackwater Group and Alluvial aquifer at Year 20

Bore Number	Aquifer Intersected	Distance from Edge of Daunia Mine Site (metres)	Estimated Groundwater Level Drawdown (metres)		
			Representative	Lower Limit	Upper Limit
Bore 1	Blackwater Group	Not active	N/a	N/a	N/a
Bore 2	Blackwater Group	11,600	3.0	7.8	1.4
Bore 3	Alluvial aquifer	4,300	N/a	N/a	N/a
Bore 4	Blackwater Group	Not active	N/a	N/a	N/a
Bore 5	Blackwater Group	On Site	N/a	N/a	N/a
Bore 6	Blackwater Group	On Site	N/a	N/a	N/a
Bore 7	Blackwater Group	Not active	N/a	N/a	N/a
Bore 8	Alluvial aquifer	5,700	0	0	1.8
Bore 9	Alluvial aquifer	800	3.1	0	9.5
Bore 10	Blackwater Group	4,000	2.2	0	7.6
Bore 11	Blackwater Group	2,100	5.0	11.6	0.9
Bore 12	Blackwater Group	11,600	0.3	0	2.6
81909	Blackwater Group	20,000	0.1	0	1.4

N/a: not applicable to the in-active status of the borehole

Further hydrogeological assessments will be undertaken by BMA to assess the potential availability of alternative groundwater supplies that would be unaffected by the Daunia Project mine dewatering programme. Based on the results of these assessments, options to ensure access to adequate alternative water supplies will be developed and discussed with the affected parties.

7.2.1.6 Potential Impact to Riparian Vegetation during Mine Operation

All creeks and rivers in the vicinity of the Project Site are ephemeral and there are no perennial water holes present. Under typical conditions, groundwater does not contribute to surface water flow within these creeks and rivers.

As depicted in **Figure 7-9**, riparian vegetation is situated along the banks of the Isaac River to the south of the Project Site. Given that the water table of the alluvial aquifer was observed at 2 m below the bed of the river during the site inspection undertaken for Poitrel in 2004, the water table is likely to be some 3 m below the riparian vegetation on the river banks. At such shallow water table depths, the riparian vegetation is likely to be using the groundwater system for water uptake.

As discussed in **Section 7.1.2**, the alluvial aquifer situated in the southern corner of the Project Site will be excavated between years15 and 20, and as a consequence, groundwater discharge and drawdown is likely to occur from this aquifer unit. In association with the discharge into the mine pit, the groundwater level will draw down in the alluvial aquifer. Due to the proximity of the Project Site's southern boundary to the Isaac River, the modelling predicts a representative groundwater level drawdown of approximately 3 m with a lower and upper limit of 0 m and 9.5 metres, respectively. While a 3 m drawdown is likely to be within the natural seasonal variability of groundwater level fluctuations in the alluvial aquifer, drawdown caused by the mining operations would occur for an extended period (i.e. greater than 20 years) compared to temporary seasonal fluctuations.

Further assessment of the interaction between groundwater and surface water is required in order determine the potential impacts to riparian vegetation. The groundwater level within the Alluvium unit close to the Isaac River will be monitored on a regular basis throughout the duration of the Project's operation. The monitoring (discussed in **Section 7.3**) will provide an opportunity to (i) determine the nature (or dependency) of riparian vegetation to the groundwater system; and (ii) an early detection of the level of drawdown (if any) and potential impacts to riparian vegetation. In the unlikely event that a detrimental impact is forecast by the monitoring program, preventative measures will be taken to ensure the impacts are mitigated. This may include altering the mining schedule to avoid the mining of Alluvium material in the southern corner of the Project Site.

Figure 7-9 Riparian Vegetation Situated Along the Banks of the Isaac River

7.2.1.7 Operational Impact Mitigation

BMA will seek to reach mutually agreeable arrangements with affected neighbouring groundwater users for the provision of alternative supplies throughout the Project life, and after mine closure. Regular groundwater level monitoring will enable groundwater level drawdown to be identified prior to any impacts being experienced in surrounding landholder bores. Further details of the monitoring programme proposed is given in **Section 7.3.1**. In turn, alternative supplies can be put in place before supplies from relevant existing landholder bores are adversely affected. Due to the progressive nature of drawdown within the aquifers, the provision of alternative supplies is likely to be staged. Options for alternative supplies include:

- installation of new pumps capable of extracting groundwater from greater depths within existing bores;
- deepening of existing bores; and
- installation of a new bore at another location on the property.

The specific arrangements for affected properties will be discussed with each relevant landholder with a view to reaching a mutually acceptable agreement.

7.2.2 Impacts of Groundwater – Post Mining

7.2.2.1 Groundwater levels – Post Mining

After mining of the Daunia deposit is complete, groundwater extraction within the Project Site will cease. For the purpose of this assessment, it is assumed that all mining activities in the immediate area will cease, including Poitrel and Millennium.

The rehabilitated final void in the southern half of the Project Site will be backfilled to an elevation of about 160 mAHD. Before mining commenced, groundwater levels across the site ranged between 185 and 195 mAHD, thus it is likely that groundwater inflows above the backfilled material will form a small lake within the final void.

Surface water runoff from the spoil dumps will be directed into the rehabilitated final void to assist groundwater recovery. There is the potential that surface water runoff from the spoil dumps will have a low pH and this water should be monitored to ensure the quality is appropriate. In addition, rainfall over the rehabilitated final void and groundwater inflow from surrounding aquifers will slowly raise the water level in the rehabilitated final void. The high evaporation rates in the region will slow the rate of recovery of groundwater levels by constantly removing water from the rehabilitated final void water surface.

The final void will comprise two north-south oriented, partly backfilled and rehabilitated voids which are connected at the southern extent of the Project Site. The western void will be 4 km long and the eastern void will be 2.5 km long. Both voids will be about 200 m wide. During the early stages in the recovery of groundwater levels, there will be a steep hydraulic gradient between the water level within the final rehabilitated and water levels within surrounding aquifers. This will result in significant groundwater contribution to the final void during the early stages of recovery, and therefore a quicker rate of recovery in the early years. As the water level within the rehabilitated final void and surrounding aquifer flattens over time, less groundwater will flow into the void, with a consequent slowing of the recovery rate of the water level in the void. Void recovery was modelled using Visual Modflow and the modelling is described in **Appendix H**.

The rehabilitated final void represents a location at which the Permian Triassic Rewan Group and Rangal Coal Measures (Blackwater Group), comprising relatively permeable coal seams between low permeability sandstone/siltstone, have been removed and backfilled with higher permeability sediments. The rehabilitated final void will receive groundwater inflow predominantly from the coal measures, but also the siltstone/sandstone and alluvial aquifer (if saturated) via inflow through the walls of the rehabilitated final void. Groundwater inflow will also occur from areas of backfilled material into the final void.

When water levels within the rehabilitated final void recover to a sufficient elevation, the rehabilitated final void will represent a location where all sub aquifers within the Blackwater Group sediments are connected and have the same potentiometric head. It is likely that a permanent depression in the potentiometric surface will be present at this location due to the high rate of evaporation from the rehabilitated final void water surface, for which surface runoff and groundwater inflow to the pit cannot fully compensate.

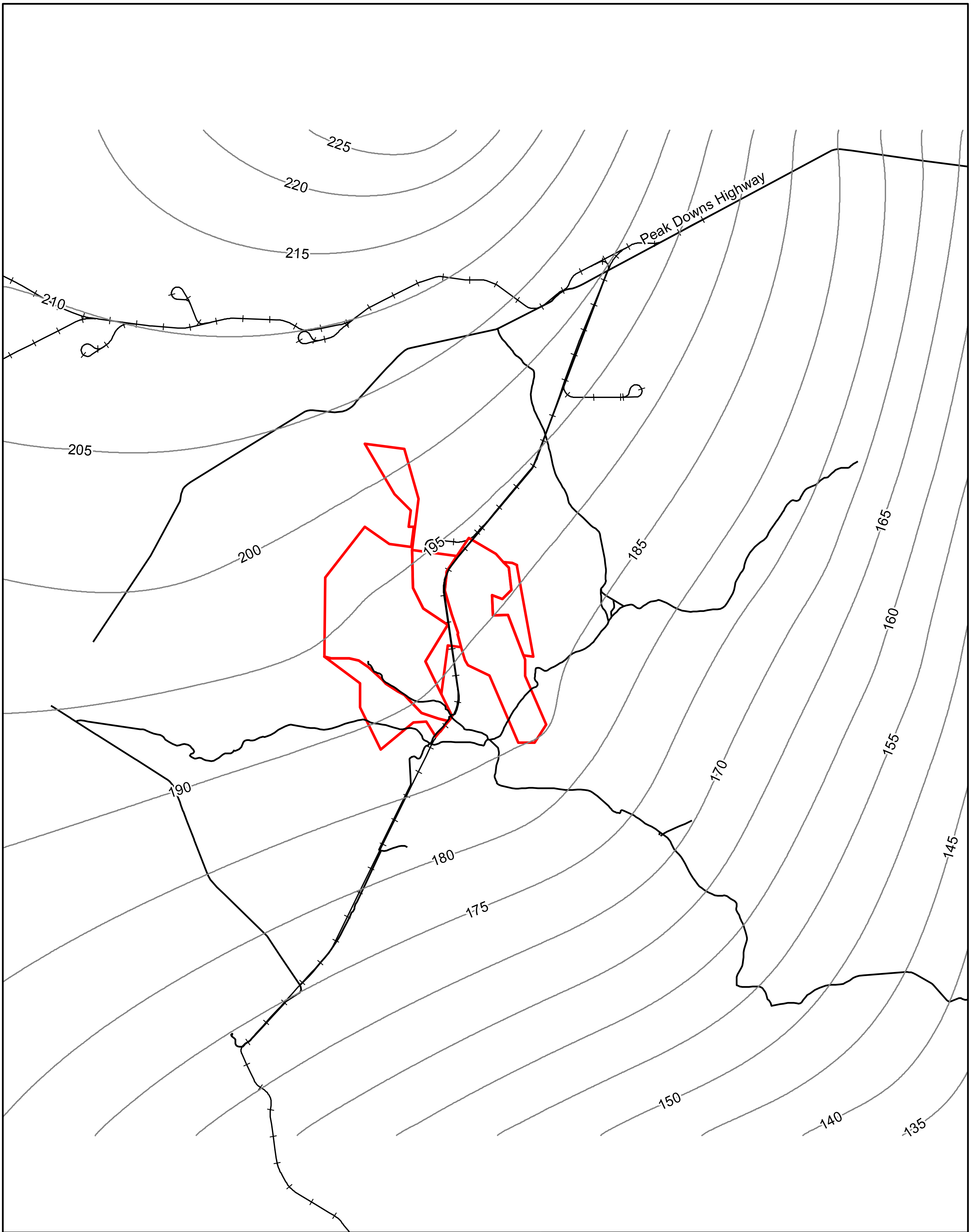
The post mining regional groundwater flow pattern will re-establish itself but some groundwater from the north, north east and to a lesser extent from the south, may flow towards the rehabilitated final void. The permanent depression of the potentiometric surface around the void is likely to act like a sink and will not permit water within the final void to flow outwards into the regional groundwater system. Exceptions to this may be during major storm events where high runoff causes a reversed hydraulic gradient and the lake recharges the groundwater system.

The modelling shows that water levels within the void reach 90 per cent of their final stable water level (final recovery level) after 50 years of cessation of mining. This is equivalent to 177 mAHD. Water levels within the rehabilitated final void will eventually recover fully and range between RL 185 and RL 195 m as shown in **Figure 7-9** below.

The modelling shows that the potentiometric surface within areas that have more than 10 m of drawdown begin to recover immediately following cessation of mining. These are within and immediately surrounding the Project Site.

In contrast, outside the Project Site, the potentiometric surface will continue to decline up to 5 m following the cessation of mining as the rehabilitated final void and backfill within the pit become saturated and the regional hydraulic gradient flattens in response. Maximum groundwater drawdown surrounding the Project Site occurs around 25 years after the cessation of mining.

The spoil material backfilled into the mine pits has significantly different hydrogeological parameters to that of the in situ rock of the pre-mining aquifer in this area. The different hydrogeological parameters of the backfilled material combined with the high rate of evaporation within the rehabilitated final void could potentially create a different final equilibrium potentiometric surface than was present prior to mining. However the modelling predicts that the regional potentiometric surface, after aquifers have attained new long term equilibrium conditions, has the same general direction of groundwater flow as the pre-mining flow direction, specifically from north-east to south west (**Figure 7-9**). There is not expected to be any residual drawdown from the Project in the long term (i.e. 500 years).



LEGEND

- Contour
- Roads
- Existing Railway
- Mining Lease

FIGURE 7-9

DAUNIA COAL MINE EIS

REGIONAL POTENTIOMETRIC SURFACE
EQUILIBRIUM - POST MINING

0 2 4 6 8 10
Kilometres

Scale 1:250,000 on A4

Projection: Australian Map Grid - Zone 55 (AGD84)

BHP Billiton Mitsubishi Alliance

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7.2.2.2 Groundwater Quality – Post Mining

The rehabilitated final void will collect and accumulate water only from groundwater ingress, direct rainfall into the void, and from overland surface flows from those slopes of the waste dump draining into the void. All other surface flows within the vicinity of the rehabilitated final void will be diverted around the void. In general, as a consequence of evaporation, the salinity level of the water in the rehabilitated final void is expected to rise over time. There could also be issues associated with oxidation of the coal seams and potential changes to the groundwater chemistry, however any impacts are likely to be localised in the vicinity of the rehabilitated final void.

The groundwater quality within the aquifers surrounding the Project Site will need to be monitored to ensure the groundwater is suitable for all the purposes it was deemed suitable for pre-mining.

7.2.2.3 Impacts on Groundwater Users – Post Mining

During the period of aquifer recovery, certain bore pump intake valves that might have been previously lowered in response to drawdown may be able to be raised again.

The groundwater quality within bores is not expected to change from pre-mining conditions.

BMA will seek to reach mutually agreeable arrangements with affected neighbouring groundwater users for the provision of alterative supplies throughout the mine life, and after mine closure. The provision of alternative supplies from deepened bores and/or replacement bores would provide the most secure and most independent supply after mine closure.

7.3 Monitoring

7.3.1 Groundwater Monitoring

Groundwater monitoring will be conducted on a regular basis during operation of the Project. The aim of the monitoring will be to determine the extent and magnitude of any impacts that the Project has on the surrounding groundwater users and riparian vegetation situated along the Isaac River. In addition, the groundwater monitoring will enable the identification of any cumulative groundwater level drawdown impacts as a consequence of other mining operations in the area.

The monitoring network will be established prior to the commencement of mining at the Project Site to ensure there is sufficient baseline information on groundwater levels and quality. Two of the bores that were installed for the Poitrel Mine in April 2008 are on the Red Mountain Mining Lease and will form part of this network. Further monitoring bores will be installed by early 2009 upstream and downstream of the Project and within the mining areas of the Project.

The routine nature of the monitoring will enable early detection of any significant variation of the groundwater system, and in turn, appropriate mitigation measures may be undertaken by BMA to minimise the impact on the environment and surrounding groundwater users.

A suitable number of monitoring bores will be progressively added to the existing monitoring network. The monitoring network will aim to incorporate the following features:

- on-site and regional groundwater level monitoring of the coal seam aquifers and Alluvium aquifer (where present); and

- on-site and regional groundwater quality monitoring of the coal seam aquifers and Alluvium aquifer (where present). The groundwater samples will undergo laboratory analysis for pH, electrical conductivity, total dissolved solids, cations, anions, nutrients (Total Nitrogen, Ammonia, Total Phosphorous and Reactive Phosphorous) and selected metals (Arsenic, Cadmium, Copper, Lead, Mercury, Selenium and Zinc).

Groundwater level and quality monitoring will initially be undertaken on a regular basis to enable the detection of seasonal fluctuations and any groundwater level or quality impacts. In turn, the monitoring data (level and chemistry) will be entered into a BMA managed groundwater database to enable a regular assessment of the potential groundwater impacts.

The current assessment has indicated that there is likely to be little or no potential for detrimental impacts to the riparian vegetation as a consequence of groundwater level drawdown in the Alluvium aquifer (**Section 7.2.1.6**). A monitoring program will be initiated during Project operation to ensure that riparian vegetation is not threatened by the groundwater level drawdown (if any). This component of the monitoring program will be developed and conducted to (i) determine the nature (or dependency) of riparian vegetation to the groundwater system; and (ii) provide an early detection of the level of drawdown (if any) and the potential impacts to riparian vegetation.

The monitoring program will be such that significant groundwater level drawdown will be identified prior to any impacts being experienced by neighbouring landholders. Alternative supplies can be put in place before supplies from relevant existing landholder bores are adversely affected.

Prior to relinquishment of the mining leases, BMA will discuss with the parties with whom it has had alternative water supply arrangements the nature, scope and resourcing of an on-going groundwater monitoring program. This program may be a continuation of the operational program, or an agreed variation. It is anticipated that continuation of the agreed on-going program would become a condition of the Environmental Authority.

Post mining groundwater monitoring will be undertaken within monitoring bores that were installed during the operational phase of the Project.

Site based hydraulic parameter values will be derived to enable the calibration of the numerical groundwater model.

7.3.2 Post Closure

After mining has ceased and decommissioning and rehabilitation works are complete, BMA may seek to relinquish its Daunia Mining Leases. Prior to relinquishment, BMA will discuss with the parties with whom it has had alternative water supply arrangement, the nature, scope and resourcing of an on-going groundwater monitoring programme. This programme may be a continuation of that outlined for operational mining, or an agreed variation, depending on circumstances at the time. It is anticipated that continuation of the agreed on-going programme would become a condition of the Mining Lease relinquishment.

Post mining groundwater monitoring will be undertaken within monitoring bores that were installed during the operational phase of the project.

Post mining groundwater monitoring will be subject to detailed closure/relinquishment conditions. It is expected that by the end of the operational phase of the Project, the groundwater model for the region will be sophisticated enough (though incorporation of operation phase data) to accurately predict the long term recovery of the aquifer. This will assist the refinement of post-mining groundwater monitoring programs.