RED HILL
MINING LEASE

ENVIRONMENTAL IMPACT STATEMENT

Section 05
Land Resources

Section 05 Land Resources

5.1 Land Use

5.1.1 Introduction

This section of the environmental impact statement (EIS) describes the current and proposed land use planning elements for the proposed Red Hill Mining Lease (the project) and details the potential impacts that the project elements may have within the EIS study area (as defined in **Section 1** of this EIS), over adjoining land uses, the region and the wider area. A number of mitigation methods are proposed to ameliorate potential impacts.

5.1.1.1 Purpose

The purpose of this section is to describe the existing conditions, assess potential impacts and propose mitigation methods for:

- land tenure and ownership, including land with special purposes, mining tenements and Native Title determinations;
- land uses within the EIS study area and adjoining land uses;
- infrastructure and infrastructure reserves (e.g. road reserves, gas, oil and water pipeline easements and stock routes); and
- the regulatory framework of the project from local, regional and state-wide planning perspectives.

Despite the project being classified as 'Exempt Development' under Schedule 4 of the State Planning Regulation, a planning assessment has been undertaken to determine the consistency of the project in relation to relevant State Planning Policies (SPPs), regional and local planning instruments as a means to assess impacts on land use.

5.1.1.2 Methodology

The assessment of land use and tenure characteristics included:

- identification of publicly available information including aerial photography, state and local government planning instruments and state government database searches;
- desktop analysis of this information relevant to the project and nature of the project;
- meetings with relevant members of the project team; and
- field visits in 2011.

For the purposes of the land use and land tenure assessment, two separate areas were adopted to assess direct and indirect impacts. These were:

- Land subject to the EIS study area to determine the potential direct impacts.
- A wider area that was used to determine indirect impacts. The extent of this wider area varied from a consideration of potential impacts on adjoining land holdings to, in other instances, a consideration of land use impacts on a regional scale.

5.1.2 Description of Environmental Values

5.1.2.1 Location

The project is located in the Bowen Basin, an area that extends over 60,000 square kilometres, from Collinsville to Theodore, in Central Queensland.

Details surrounding the BHP Billiton Mitsubishi Alliance (BMA) existing and proposed mining operations in the Bowen Basin are provided in **Section 3**.

The project is located approximately 20 kilometres north of Moranbah and 135 kilometres south-west from Mackay. Mackay is the main urban and administrative hub for the Mackay, Whitsundays and Isaac Region. Mackay is located on the coast, approximately 20 kilometres north of Hay Point and a 2.5 hour drive from Moranbah via the Peak Downs Highway. Moranbah is the closest town to the project and includes a number of regionally important land use activities and facilities such as an airport, which serves nearby centres including Coppabella, Nebo, Dysart, Clermont and Middlemount as well as accommodation villages for non-resident workers. These centres and accommodation villages are within a one to two hour driving distance from Moranbah and service the coal mining and agricultural sectors of the Bowen Basin. The Moranbah airport will service the travel needs of the up to 100 per cent remote workforce required for the GRM incremental expansion and the RHM underground expansion option. Additional details regarding the Moranbah airport are included within **Section 14** and **Section 18**.

The location of the project in its regional context is shown on **Figure 5.1-1**. The populations and proximity to communities within the region are briefly described in **Table 5.1-1** below and images from those communities shown on **Plate 5.1-1** to **Plate 5.1-3**.

Table 5.1-1 Population in Regional Centres, June 2012

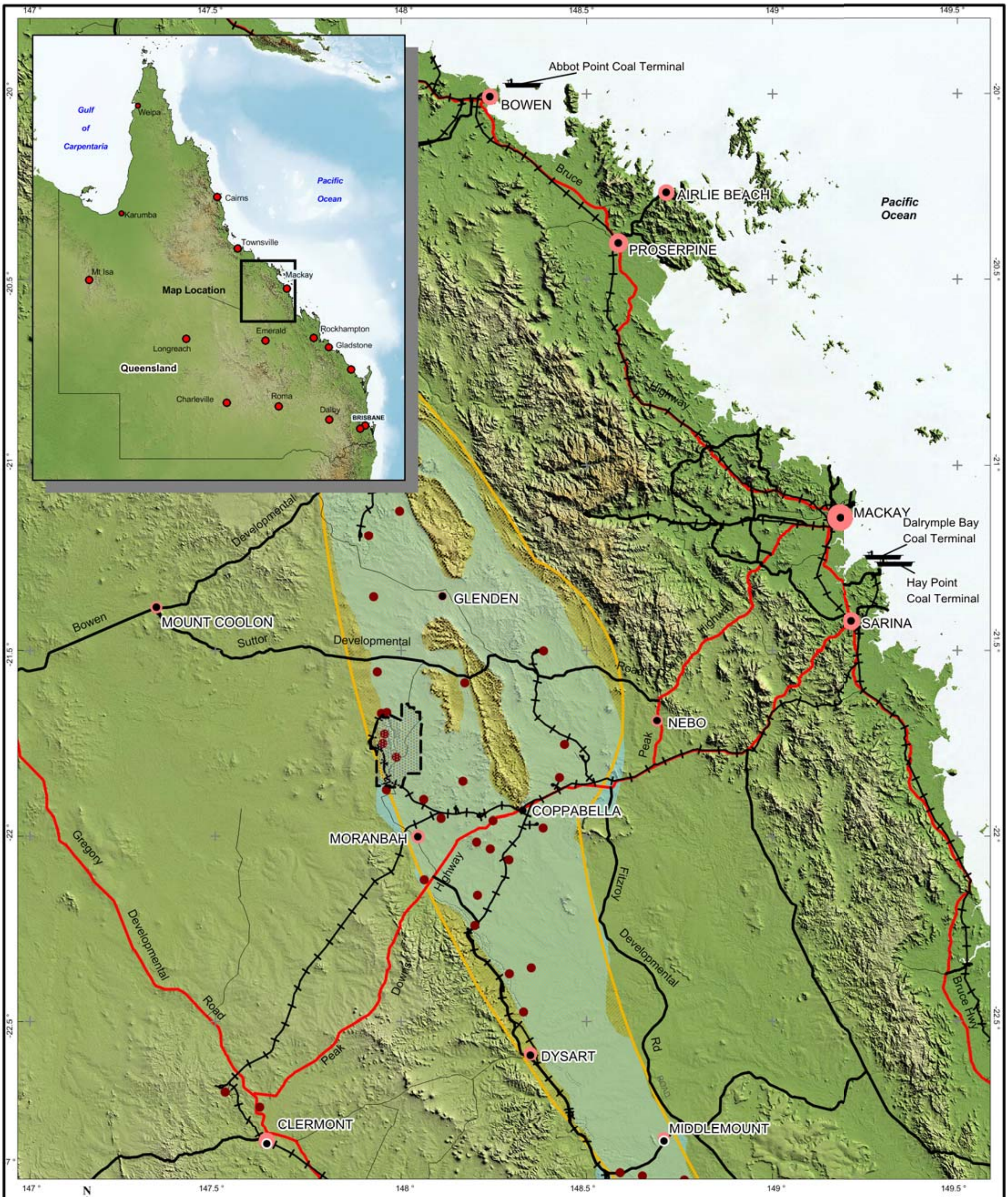
Town	Population	Non-Resident Worker Population	Separation Distance from Project	Direction from Project
Moranbah	8,990	4,585	20 km	south
Coppabella	630	2,575	40 km	south-east
Nebo	495	555	73 km	east
Dysart	3,280	2,365	100 km	south-south-east
Clermont	2,260	130	124 km	south-west
Middlemount	1,960	2,110	139 km	south-east
Mackay	87,324	N/A	135 km	east-north-east

Source: OESR 2012

Plate 5.1-1 Coppabella

Plate 5.1-2 Dysart

Plate 5.1-3 Middlemount



N
W E
S

0 25 50km

Scale: 1:1,500,000
Datum: GDA94

EIS Study Boundary	Highway
Industry and Economic Functions	Major Road
Town Centre	Minor Road
	Railway Line
Shipping Port	
Operational Coal Mine	
Bowen Basin	
Major Mining Growth	

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

CONTEXT AND LOCATION

URS

LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-1**

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5.1.2.2 Administrative Framework

Mackay serves as the primary administrative hub for the Mackay, Isaac and Whitsunday Region and includes many of the services found in a major regional centre. State government departments for the region are based here, along with other administrative and institutional service providers.

The project is located within the Isaac Regional Council area. The Isaac Regional Council, along with the Whitsunday Regional and Mackay Regional Councils, form the administrative boundaries of the Mackay, Isaac and Whitsunday Regional Plan. The Mackay, Isaac and Whitsunday Regional Plan is further discussed in **Section 5.1.7.5**. The local planning framework comprises the former shire areas of Belyando and Nebo.

Further information about the statutory administrative context is contained within **Section 5.1.7**.

5.1.2.3 Land Use Context

Since European settlement, the region has been used predominantly for primary production, particularly for cattle grazing. Grazing activity still occurs to the east and west of the EIS study area on native and buffel grass pastures. Cropping activities were also common in some parts of the region, but were, and remain, concentrated around only some of the alluvial floodplains of the Isaac River and associated tributaries. There is no evidence of previous cropping activity within the EIS study area.

Over the last 40 years, traditional agricultural activities have been replaced in parts of the Bowen Basin with large open-cut and underground coal mining operations, with coal mining and ancillary activities are undertaken to the north and south of the EIS study area.

These mines are serviced by the Goonyella Branch Line operated by Aurizon. The Goonyella Branch Line joins the Blair Athol and Peak Downs Lines en-route to Hay Point. These rail connections were established to service their respective coal mines and transport product for export.

The urban centres located within the Bowen Basin and close to the mines have grown with the increased level of activity of the nearby mines. Moranbah in particular is a mining town. It was created in 1969 to service the new mines established at Goonyella and Peak Downs. Early amenities in the town included the civic centre, school and hospital, followed by a high school and church. The town now supports a wide range of community and recreational facilities. Residential, commercial, industrial development is also present in the other smaller towns that service the area.

Areas of nature conservation and forestry land uses are also present within the region, and are described in greater detail below.

5.1.2.4 Existing Land Uses and Land Tenure

Existing land uses and land tenure is described in the sections below under the headings of:

- land tenure and ownership;
- existing land uses;
- utilities and services; and
- transport and infrastructure.

As described in the methodology in **Section 5.1.1.2** above, a distinction is made between the land uses and land tenure located wholly or partially within the EIS study area and the land uses and tenures of a wider area.

5.1.3 Land Tenure and Ownership

The EIS study area covers an area of approximately 26,000 hectares. Underlying land tenure and mining and petroleum tenements within the EIS study area are described in this section.

5.1.3.1 Underlying Land Tenure

The EIS study area includes 51 land parcels, as shown on **Figure 5.1-2**. These allotments are a mix of freehold (predominantly over the northern part of the EIS study area) and leasehold (predominantly over the southern part of the EIS study area). Details of the land and tenure descriptions for those 51 allotments (including the allotments' primary use and ownership) are shown on **Figure 5.1-2** and contained within **Appendix F1**, **Table 1**.

It should be noted that there are a number of allotments that make up the rail corridor within the study area. Due to the number of allotments and the fact that the allotments form the rail corridor, these allotments have not been shown on **Figure 5.1-2**. Further, the study area is also impacted by a number of easements. Details of identified easements within the EIS study area are contained in **Appendix F1**, **Table 2**.

5.1.3.2 Mining and Petroleum Tenements

Current Mining Tenements

The Central Queensland Coal Associates (CQCA) Joint Venture (JV) holds 11 mining lease tenements with whole or partial surface areas, two mineral development licences (MDL) and four exploration permits for coal (EPC) that intersect wholly or partially with the EIS study area. There are no other holders of mining tenements within the EIS study area.

BMA is the manager of these tenements on behalf of the CQCA JV under a management agreement dated 28 June 2001. Locations of current exploration and mining tenements are shown on **Figure 5.1-3**; details of tenement type, property descriptions and holders of the tenements are provided in **Appendix F1**, **Table 3**.

Proposed Mining Tenements

A new mining lease is required to allow for the development of the Broadmeadow extension and that part of the RHM underground expansion option which is located outside the existing GRM mine lease area.

The locations of the proposed exploration and mining tenements are shown on **Figure 5.1-4**. Details of the EPCs and MDLs are set out in **Appendix F1**, **Table 3** and **Appendix F1**, **Table 4**.

Petroleum Tenements

There are two exploration permits for petroleum (EPP), one petroleum lease (PL) resource tenement and two petroleum pipeline licences (PPL) held within the EIS study area.

Appendix F1, **Table 5** details the petroleum tenement type, the status and the holders of the tenements that are situated wholly or partly within the EIS study area. **Figure 5.1-5** shows the location of these petroleum tenements and their relationship with the project. Mining leases (ML) 1763, ML1764 and ML1802 are granted for the purpose of mining coal and gaseous hydrocarbons. As such, the combined area (12,456 hectares) is excluded from the overlapping EPPs.

Mining lease application (MLA) 70421 is overlapped by Petroleum Lease Application 486 (PLA 486). Under the *Mineral Resources Act 1989* (MR Act), a mining lease applicant is obliged to make reasonable attempts to reach agreement with holders of applicable petroleum tenures in relation to its proposed development. Failing agreement, a mining lease applicant may use the statutory process to request the Minister to make a 'preference decision' about whether the coal resource should be developed in preference to the potential petroleum resources.

Two PPL have been identified traversing the EIS study area:

- PPL89 (granted 2003) held by North Queensland Pipeline No 1 Pty Ltd which runs to the west of the EIS study area; and
- PPL83 (non-current) held by Stanwell Corporation Limited which runs through the eastern portion of the EIS study area.

PPL89 connects Arrow's Bowen Basin production facility north of Moranbah to Townsville. PPL83 is a designated gas pipeline corridor; however this pipeline has not been developed.

Further information on tenements is provided in **Appendix F1**.

5.1.3.3 Special Interest and Protected Areas

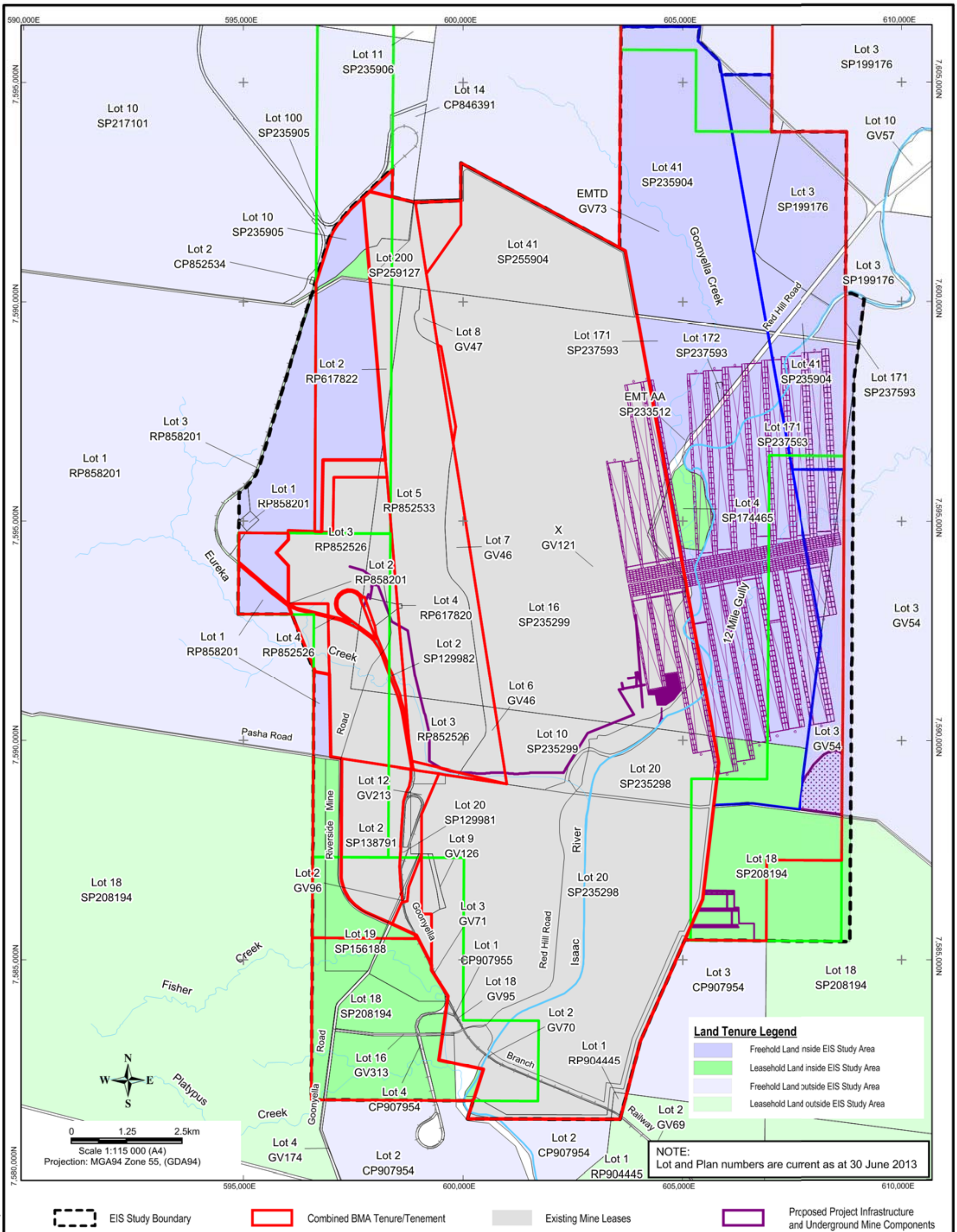
Protected Areas

The Queensland *Environmental Protection Act 1994* (EP Act) and its subordinate legislation Environmental Protection Regulation 2008 (EP Regulation), places environmentally sensitive areas (ESAs) into two different categories; Category A and Category B.

A search was carried out to determine whether there were any Category A and Category B ESAs within or adjoining the EIS study area and within a 50 kilometre and 100 kilometre radius of the site. Search results indicate that there are no Category A ESAs within the EIS study area or within a 50 kilometre radius of the EIS study area boundary. A number of Category B ESAs have been identified within the EIS study area. A number of Category A and Category B ESAs are also located beyond the EIS study area within a 50 and 100 kilometre radius as shown on **Figure 9-11**. The locations of the nearest Category A ESAs are also shown on **Figure 5.1-6**.

A search was carried out to identify any regional ecosystem (RE) community ESAs within or close to the EIS study area. The searches revealed there are a number of RE ESAs within and surrounding the EIS study area. The identified REs can be found within **Figure 9-5**, **Figure 9-6** and **Figure 9-7**. The ecological values of these features are discussed in **Section 9.3**.

Further information on Protected Areas is provided in **Section 9.5**.



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ENVIRONMENTAL IMPACT STATEMENT

LAND TENURE

URS

LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-2**

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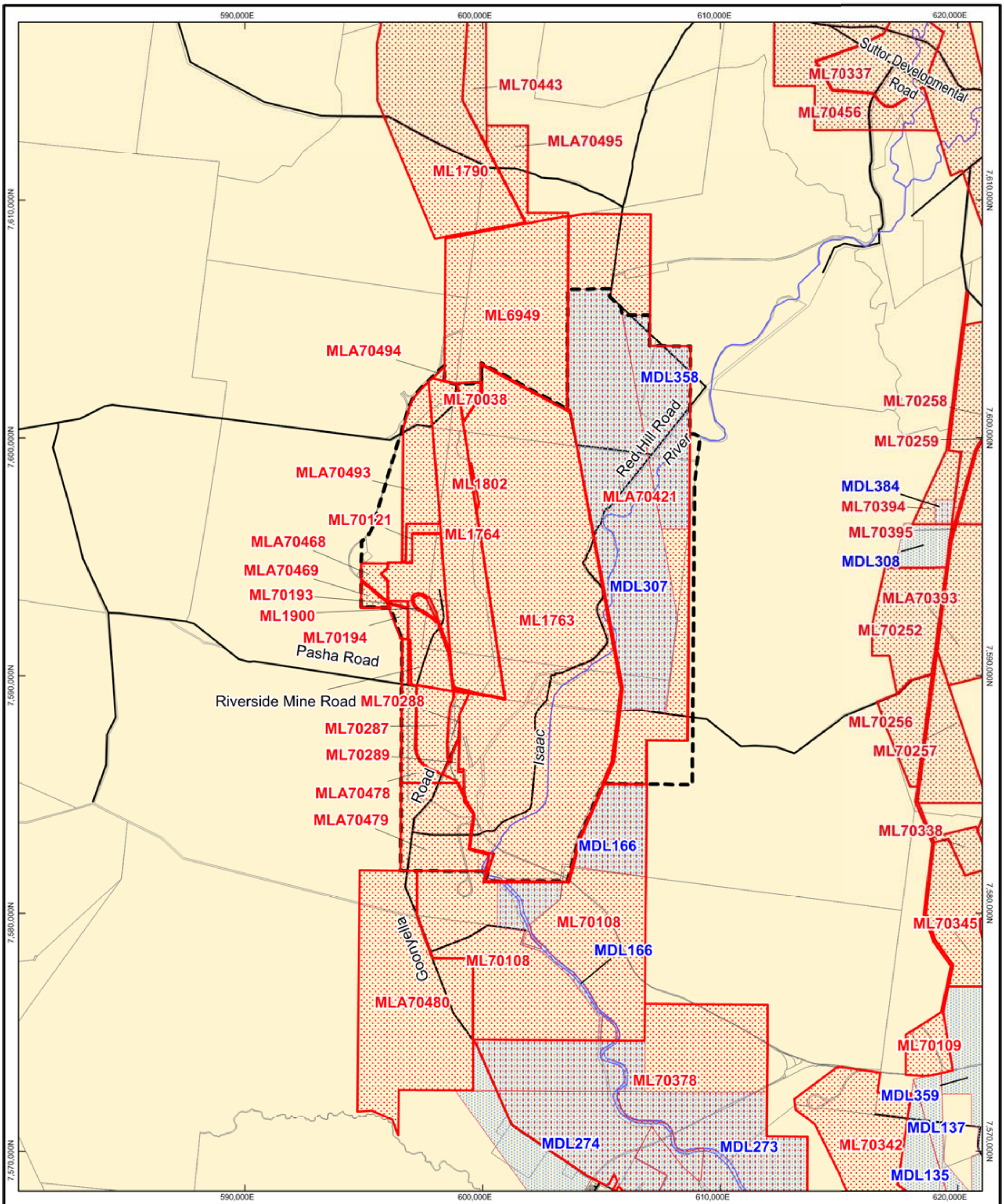

NOTE: Resource data boundaries downloaded from QLD Dept Mines & Energy Website (http://www.webgis.nrm.qld.gov.au/webgis/webqmin/Run.htm.) and are correct as at 18 May 2011

- EIS Study Boundary
- ML & MLA Boundaries
- Mineral Development Licence (MDL)

N S W E

0 2.5 5km

Scale 1:225,000 (A4)
Projection: MGA Zone 55, (GDA94)

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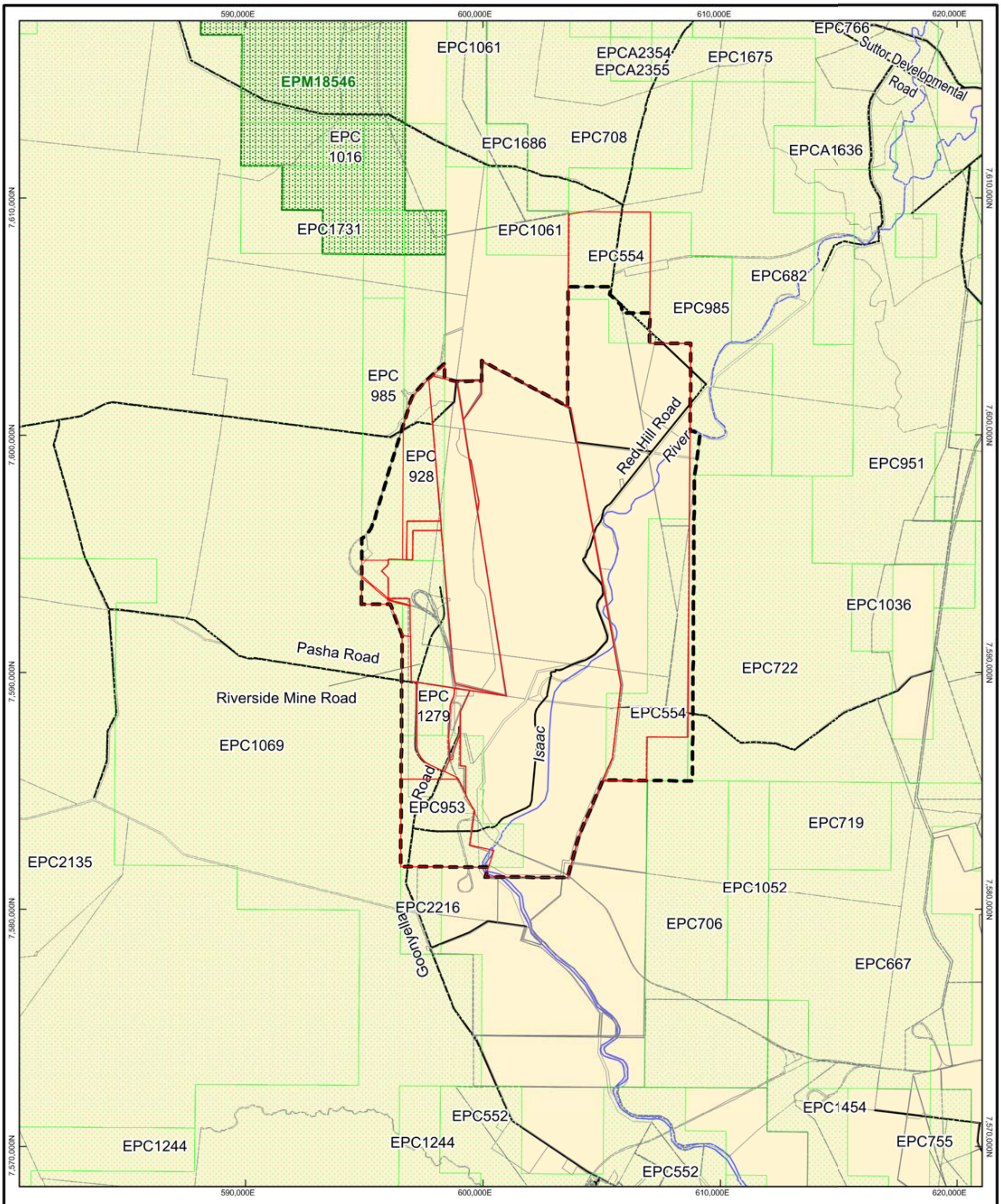
RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

MINING TENEMENTS AND MINERAL DEVELOPMENT LEASES

LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-3**

File No: **42627136-g-1017.wor** Drawn: **VH** Approved: **CT** Date: **29-07-2013** Rev.**A** A4



NOTE: Resource data boundaries downloaded from QLD Dept Mines & Energy Website (http://www.webgis.nrm.qld.gov.au/webgis/webqmin/Run.htm.) and are correct as at 18 May 2011

N
W E
S

0 2.5 5km

Scale 1:225,000 (A4)
Projection: MGA Zone 55, (GDA94)

EIS Study Boundary

BMA Tenure/Tenement

Exploration Permit Coal (EPC)

Exploration Permit Minerals (EPM)

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

EXPLORATORY MINING TENEMENTS

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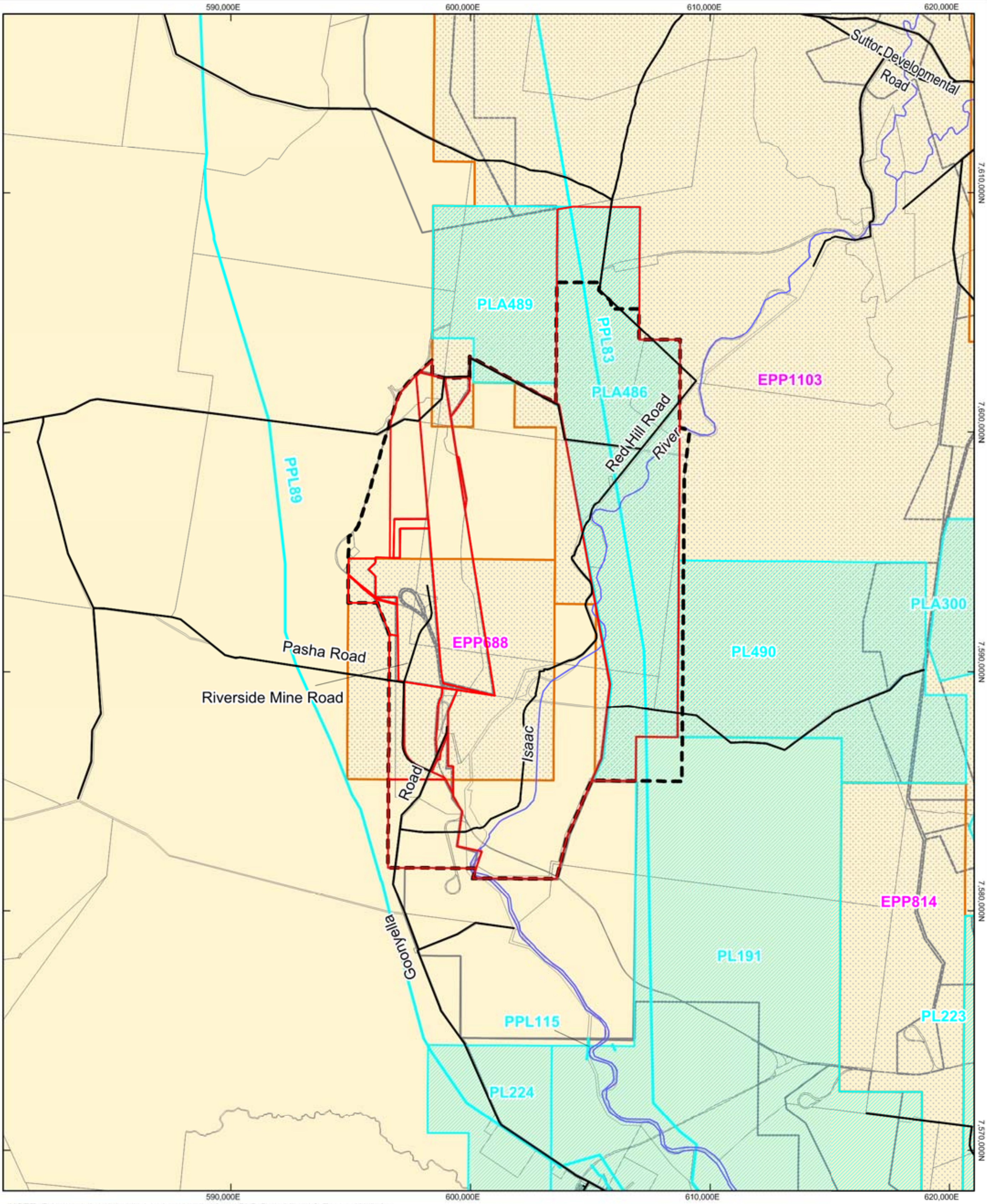
LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-4**

File No: **42627136-g-1017.wor** Drawn: **VH** Approved: **CT** Date: **11-06-2013** Rev.**A** A4



NOTE: Resource data boundaries downloaded from QLD Dept Mines & Energy Website (http://www.webgis.nrm.qld.gov.au/webgis/webqmin/Run.htm.) and are correct as at 18 May 2011

N / W / E / S

0 2.5 5km

Scale 1:225,000 (A4)

Projection: MGA Zone 55, (GDA94)

EIS Study Boundary

BMA Tenure/Tenement

Exploration Permit for Petroleum (EPP)

Petroleum Lease (PL) and Petroleum Lease Applications (PLA)

Petroleum Pipeline Licence (PPL)

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

PETROLEUM TENEMENTS

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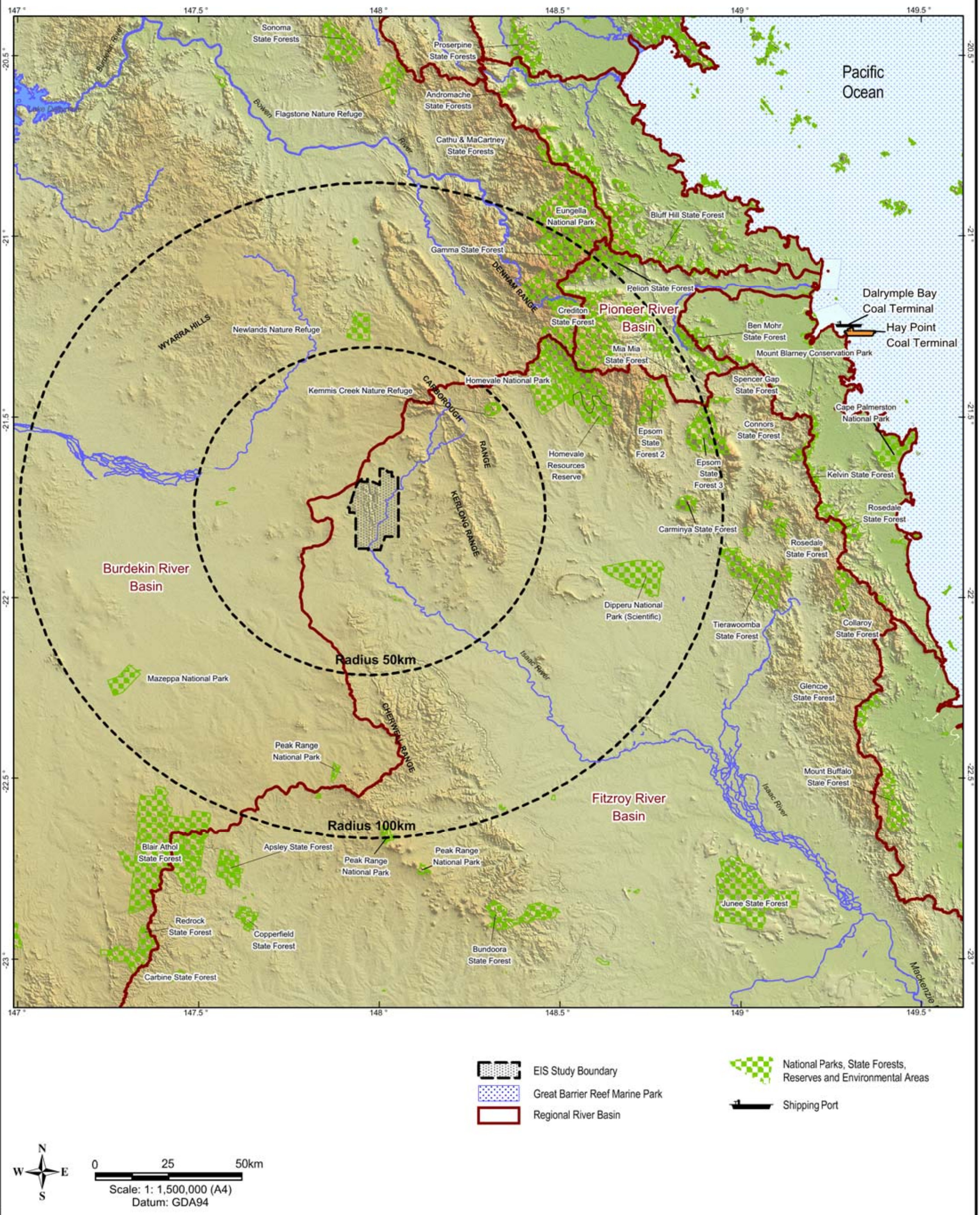
LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-5**

File No: **42627136-g-1017.wor** Drawn: **VH** Approved: **CT** Date: **29-07-2013** Rev.**A** A4



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

SPECIAL INTEREST TENURE

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LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-6**

File No: **42627136-g-1023.wor** Drawn: **VH** Approved: **CT** Date: **11-06-2013** Rev.**A** A4

Key Resource Areas

There are no key resource areas (KRA) within the EIS study area. The nearest KRA is the Waitara KRA situated approximately 80 kilometres to the east, located within the Nebo Shire.

Declared Water Storage Catchments

Areas of land that immediately surround water storage areas may be protected by having them designated as 'declared catchments'. Certain types of development proposed within declared catchment areas are referred to the Department of Energy and Water Supply (DEWS) during the integrated development assessment system (IDAS) process to ensure the quality of water entering the storage facility is not degraded by proposed development.

Within Queensland there are 20 declared catchment areas administered by the DEWS, none of which are directly impacted upon by the project or in an area downstream of the project.

5.1.3.4 Native Title

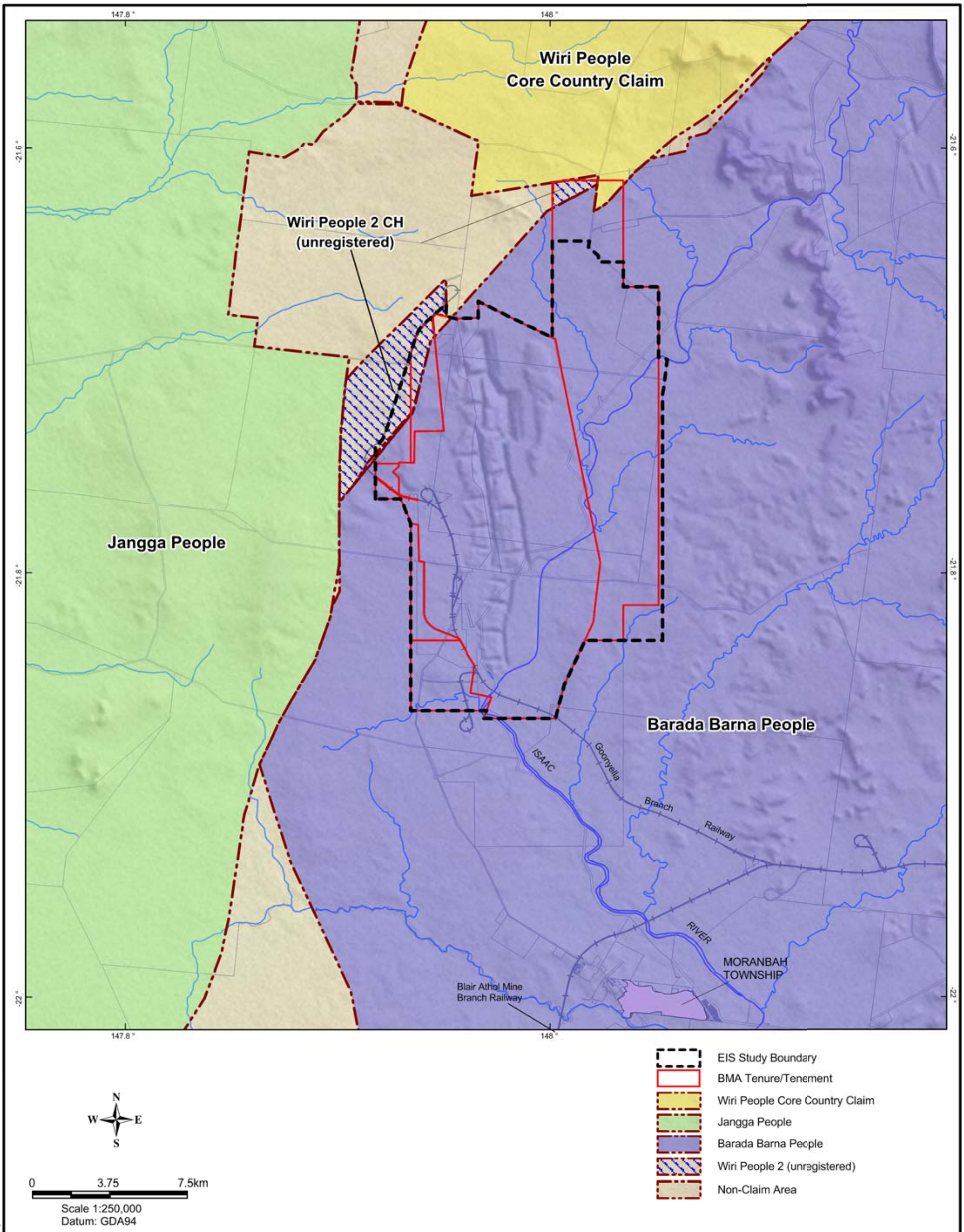
Native title is the recognition by the Commonwealth and State Governments of the laws, rights and interests over land and water possessed by Indigenous people in Australia, under their traditional laws and customs.

A search of the Department of State Development, Infrastructure and Planning (DSDIP) online Interactive Resource and Tenure Maps (IRTM) Database identified two active native title claims within or adjoining the EIS study area (January 2012). These are listed below in **Table 5.1-2**. **Figure 5.1-7** shows the geographic extent of considered native title claims and determinations.

Table 5.1-2 Native Title Claims

Interested Party	Claim & Federal Court No.	Status	Area (ha)	Local Government Regions
Barada Barna People	QC08/11 QUD380/08	Active	1,438,000	• Isaac Regional Council • Mackay Regional Council • Whitsunday Regional Council
Wiri People Core Country Claim	QC06/14 QUD372/06	Active	1,644,000	• Central Highlands Regional Council • Isaac Regional Council • Mackay Regional Council

BMA has undertaken negotiations with relevant native title groups in relation to the grant of a mining lease over the claim area.



Source: Belyando Shire Plan (2006) & Field Investigations (2008)

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

NATIVE TITLE CLAIMS AND DETERMINATIONS

URS

LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-7**

File No: **42627136-g-1018b.wor** Drawn: **VH** Approved: **CT** Date: **11-11-2013** Rev.**B** A4

5.1.4 Existing Land Uses

Existing land uses within the EIS study area and surrounds are depicted in **Figure 5.1-8** and have been described below under the headings:

- biophysical elements (such as the Isaac River);
- mining and coal exploration activities;
- agricultural activities such as:
  - cattle grazing; and
  - farming infrastructure (access tracks, fences, stockyards and sheds); and
- residential and urban land uses, that include:
  - several rural residential dwellings (homesteads) that are located within the EIS study area (Riverside Homestead and Broadmeadow Homestead, and associated cottages);
  - rural residential dwellings (homesteads) that are located in the surrounding rural area; and
  - nearby urban and peri-urban development, namely Moranbah town and the surrounding development.

5.1.4.1 Biophysical

The natural topography of the lands within and surrounding the project has been drastically altered since mining operations began in the 1970s. The original topography of the lands within the EIS study area comprised undulating country intersected with drainage lines and minor depressions. The surrounding topography is relatively flat with rolling undulations varying in elevation. Further description of topography is provided in **Section 5.3**.

The eastern portion of the EIS study area is bisected by the Isaac River, its floodplain, terrace and adjacent low relief rounded hill slopes with few escarpments. A stretch of the Isaac River located to the south of the proposed RHM was previously diverted as part of earlier mining operations within ML1763.

Several ephemeral creeks, including Eureka, Platypus, Fisher, Goonyella and Cleanskin and 12 Mile Gully, are also located within the EIS study area. Eureka, Platypus and Fisher creeks have been previously diverted as part of mining operations. Dams of various sizes and scales are located within the EIS study area and are used for mining and agricultural purposes.

The EIS study area has been largely cleared for mining and grazing activities. Prior to the current use of the land for mining activities, the dominant land use was cattle grazing and this land use still coexists with exploration activities. These areas are dominated by *Pennisetum ciliare* (buffel grass), an imported pasture species that provides an important feed stock for cattle. However, small and isolated patches of remnant bushland and grassland remain, particularly along riparian corridors. Remnant native vegetation is typically dominated by *Eucalyptus populnea* (poplar box).

The creeks and dams on lands within the EIS study area provide habitat, movement corridors and water for terrestrial fauna species. The dams provide a water source for livestock and other terrestrial fauna and migratory birds, and can be valuable during periods without rainfall.

Further details on the ecology of the EIS study area are provided in **Section 9** and **Section 10**.

5.1.4.2 Mining and Resource Extraction

Mining and resource extraction activities within the EIS study area consist of the Goonyella Riverside open-cut mine (GRM) and the BRM. Mining and associated ancillary activities include:

- open-cut and underground coal resource extraction;
- road, bridges, rail and service infrastructure;
- 66 and 132 kilovolt transmission lines and associated infrastructure;
- Goonyella branch railway including Riverside, Goonyella and Moranbah north balloon rail loops; and
- water and tailings management infrastructure.

The location and extent of these land use activities are shown on **Figure 5.1-8**. The operations of the complex are described in **Section 3**.

Coal mining is also undertaken to the north and south of the project, specifically:

- North Goonyella underground and open-cut mine operated by Peabody Energy immediately adjoins the EIS study area to the north.
- Moranbah North underground coal mine operated by Anglo American adjoins the EIS study area to the south. BMA has already entered in to arrangements, and intends to further engage, with adjacent ML holders to maximise the potential for border coal recovery from existing and planned operations.

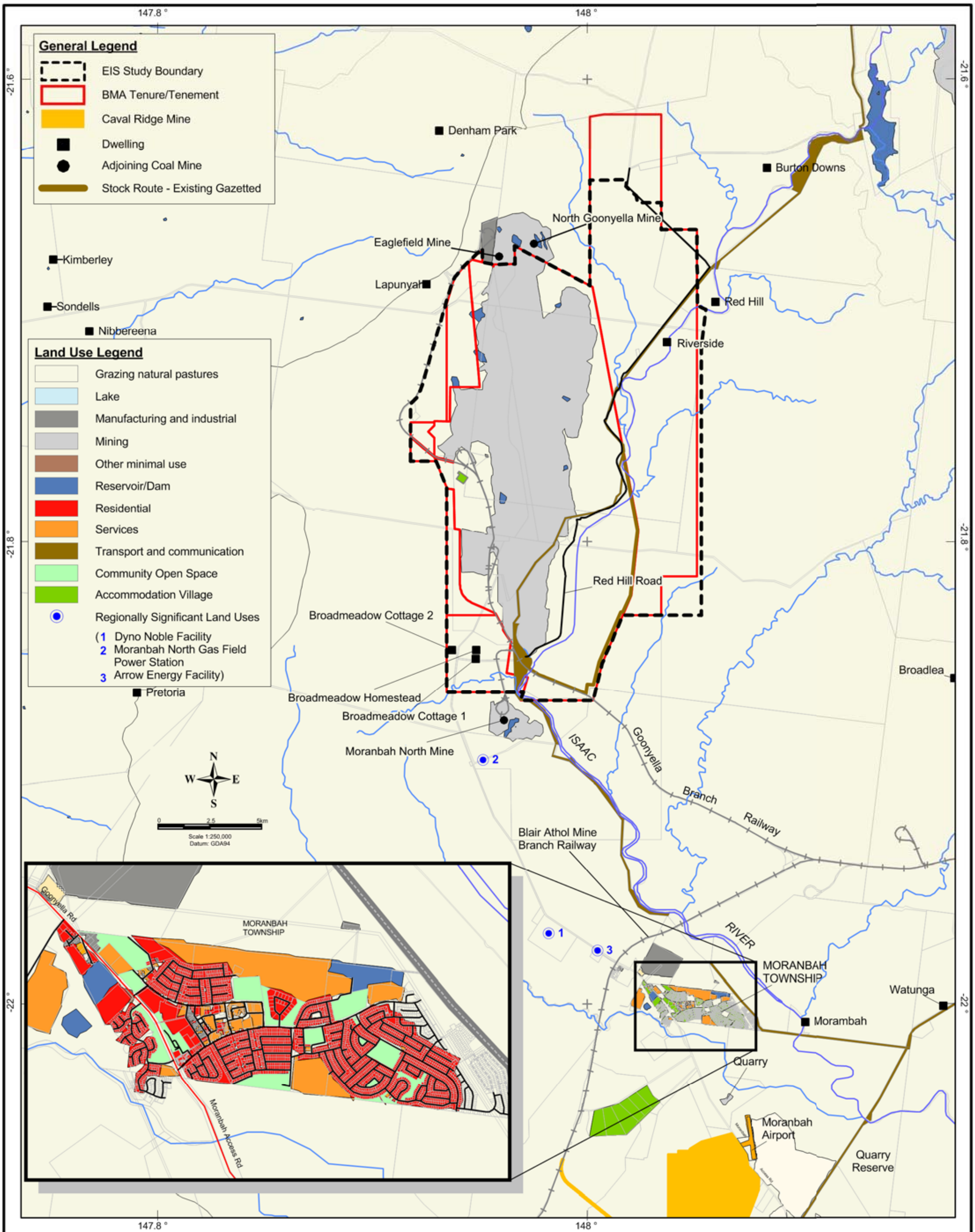
5.1.4.3 Agricultural Activities

The EIS study area and surrounds continue to be used for cattle grazing where mining activity is not currently occurring. The majority of the landscape which is not disturbed by mining activity has been previously cleared. However, regrowth is evident in many areas where grazing pursuits have been limited or restricted. These areas include corridors of remnant vegetation along waterways.

Land cover within and surrounding the EIS study area is principally open grazing pasture. Large sections of pasture are maintained for grazing with several isolated areas enhanced through the introduction of fodder species to supplement grazing on native and introduced pastures. The existing land uses within and surrounding the EIS study area, including the locations of natural grazing pastures, are shown on **Figure 5.1-8**. While the lands within the EIS study area are currently used for cattle grazing purposes, not all lands are considered to represent as good quality agricultural land (GQAL).

Areas designated as GQAL and land identified as potentially containing strategic cropping land (SCL) are located within the EIS study area. The extent and implications of these two designations is discussed in **Section 5.1.8.3**.

The statutory framework relating to the protection of both of these resources is contained within **Section 5.1.7** and **Section 5.3**.



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

EXISTING LAND USES

URS

LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-8**

File No: **42627136-g-1015.wor** Drawn: **VH** Approved: **CT** Date: **29-07-2013** Rev.**A** A4

5.1.4.4 Residential and Urban Land Uses

Two existing homesteads were identified within the EIS study area:

- Riverside Homestead properly described as Lot 171 on Plan SP237593 and located in the north-eastern portion of the site.
- Broadmeadow Homestead, cottages 1 and 2, properly described as Lot 18 on SP156188, located in the south-south-west portion of the site.

Other properties which include homesteads adjacent to the EIS study area include:

- Red Hill Homestead (Lot 3 on SP199176);
- Lapunyah Homestead (Lot 10 on SP217101);
- Burton Downs Homestead (Lot 9 on RP903903);
- Denham Park Homestead (Lot 11 on SP217101); and
- Nibbereena Homestead (Lot 7 on DK147).

The locations of these homesteads are shown on **Figure 5.1-8**.

The nearest regional centre to the EIS study area is Moranbah, situated 20 kilometres to the south of the EIS study area at its closest point. The town is centrally located to many of the northern Bowen Basin coalfields and is the home to many of the mine employees, ancillary mining industry employees and their families. Moranbah supports a wide array of urban land uses including industrial, commercial and residential type uses sited within well-defined urban boundaries. Within the urban footprint and surrounds, there is an estimated permanent resident population of approximately 8,626 people. In addition the non-resident workers population is approximately 4,585 people (OESR 2012). Moranbah is one of the largest inland towns servicing mining within the Bowen Basin.

Moranbah includes urban and industrial land uses that support the mining sector such as large scale transportation, earthmoving, engineering facilities and short term accommodation villages. Examples of the land uses in Moranbah are shown on **Plate 5.1–4**.

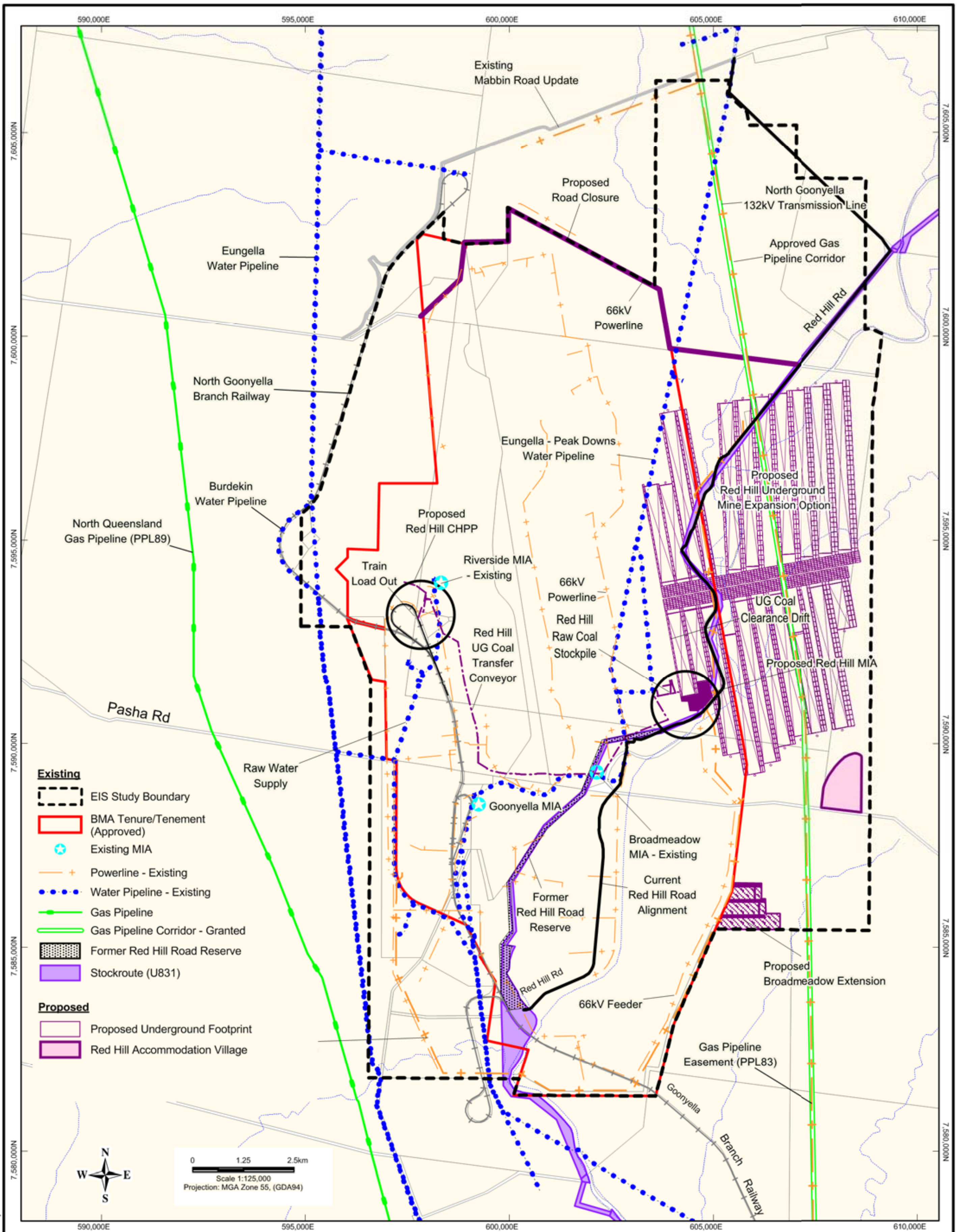
Surrounding the town and limiting its growth are a number of industrial and mining activities including North Goonyella and North Moranbah coal mines, the North Moranbah Coal Seam Gas Fired Power Station, Goonyella Road, the Dyno Nobel Ammonium Nitrate Facility, Arrow Energy's Coal Seam Gas Facility, the Peak Downs Highway, and the Goonyella Branch Railway and are shown on **Figure 5.1-8**. **Figure 5.1-8** also recognises the aforementioned grazing lands within and surrounding the EIS study area, these lands are used for cattle grazing and do not represent GQAL and SCL which is identified on **Figure 5.3-13** and **Figure 5.3-14** and discussed in **Section 5.1.7**

In an effort to address these land shortages, Isaac Regional Council and the Urban Development Land Authority have released areas of vacant industrial and residential land for such purposes.

Plate 5.1-4 Moranbah Land Uses

5.1.5 Utilities and Services

The project will utilise the existing power, water pipelines and dams and gas pipeline services afforded to the existing BMA operations. The provision of new infrastructure and services associated with the GRM incremental expansion and the RHM underground expansion option is detailed within **Section 5.1.9**. Information on the easements associated with the services described below is provided in **Appendix F1**, **Table 2** and shown on **Figure 5.1-9**.



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

EXISTING AND PROPOSED INFRASTRUCTURE

URS

LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-9**

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5.1.5.1 Power

There are a number of major transmission lines that terminate within and traverse the EIS study area:

- The Goonyella overhead transmission line, a 66 kilovolt line owned by BMA, starts at the Moranbah substation and ends at the GRM, running alongside the Isaac River Diversion and north along the Highwall Access Road.
- A network of 11 and 66 kilovolt transmission lines distribute power internally to the complex and service a number of uses within the broader complex.
- A 132 kilovolt transmission line bisects the eastern portion of the site and runs in a north/south alignment to the east of the Isaac River, (as shown on **Figure 5.1-9**) that centrally bisects MLA70421.
- A 66 kilovolt transmission line begins at the Moranbah North Power Station and runs in a southerly direction, connecting the power station with the national grid.

5.1.5.2 Water Pipelines and Dams

The EIS study area is intersected by three water pipelines shown on **Figure 5.1-9**. These include three pipelines, as follows:

- the Sunwater-owned Burdekin water pipeline which bisects the western portion of the EIS study area in a north/south alignment;
- the Sunwater-owned Eungella Water Pipeline Company pipeline from Eungella to Moranbah also passes to the west of the EIS study area, following a similar alignment to the Burdekin pipeline; and
- the BMA-owned Eungella-Peak Downs pipeline which currently bisects the EIS study area in a north/south alignment.

The Burdekin pipeline, pipes approximately 16,800 million litres of water per year, 220 kilometres from Gorge Weir on the Burdekin River to Moranbah. This pipeline ensures a reliable and adequate water supply to the Bowen Basin from the Burdekin dam and associated storages.

The BMA Eungella-Peak Downs pipeline transfers water from the Eungella dam to the GRB mine complex and Peak Downs Mine.

BMA owned and operated raw water, mine water and tailings storages are also present within the EIS study area. The size, extent and purpose of these dams are detailed within **Section 7.2.3**. There are also a small number of minor farm dams.

5.1.5.3 Gas Pipelines

Two PPL traverse the EIS study area:

- PPL89 (granted 2003) held by North Queensland Pipeline No 1 Pty Ltd which runs to the west of the EIS study area; and
- PPL83 (non-current) held by Stanwell Corporation Limited which has yet to be developed, but which runs through the east of the EIS study area.

PPL89 connects Arrow Bowen Basin production facility north of Moranbah to Townsville. PPL83 is a designated gas pipeline corridor; however this pipeline has not been developed.

5.1.6 Transport Infrastructure

Mine and local roads, a stock route and several rail lines either cross or service the existing mine and the footprint of the future RHM. The location of the transport infrastructure is shown on **Figure 5.1-9**. Details of land use and land tenure are provided below. A description of the wider transport network and a traffic impact assessment are provided in **Section 14** and **Appendix N**.

5.1.6.1 Roads

Goonyella Road and Riverside Access Road provide access to the south and western portions of the EIS study area and travel in a north to south alignment. The Goonyella Road is designated as a private road held by the CQCA JV under the terms of a state held Term Lease 233448 (4/GV174). The Moranbah Access Road on Term Lease 233448 (3/SP109690) originates at Moranbah and terminates at the GRB mine complex.

Pasha Road runs in an east-west alignment between the western boundary of the EIS study area and Riverside Access Road.

Red Hill Road is a council controlled road which extends approximately 35 kilometres north from its intersection with Goonyella Road to its intersection with Suttor Developmental Road. Between Goonyella Road and Broadmeadow Mine Access Road, Red Hill Road is an undivided, sealed, two lane road. From the Broadmeadow Mine Access Road north to the Suttor Developmental Road, Red Hill Road is unsealed.

Currently BMA maintains the section of road beside the diversion and for approximately one kilometre upstream, to where the road turns sharply eastward. BMA carries out periodic maintenance consisting of re-grading and repairing the sealing of the road, primarily after the wet season. To the north of the bend, the road is an unsealed gravel road with Isaac Regional Council responsible for its maintenance.

Mabbin Road runs in an east-west direction along the northern EIS study area boundary while avoiding the disturbed areas of the GRB mine complex and North Goonyella mining operations.

5.1.6.2 Stock Routes

Responsibility for the Queensland Stock Route Network is shared between the relevant local government and the Department of Natural Resources and Mines (NRM), with local government being responsible for its day-to-day management, and NRM, as the custodian of the land, providing support, guidance and strategic directions for management.

The project impacts on the Moranbah-Glendon stock-route (U831), which bisects the EIS study area in a south-west/north-east alignment, as shown on **Figure 5.1-9**. This stock route is being realigned (under a separate approvals process) to ensure integrity of the stock route network.

Investigations have revealed this stock route is currently unused. No watering points, bores, windmills and holding yards that belong to the state have been identified within these sections of stock route.

5.1.6.3 Railways

The Goonyella Branch Railway, Goonyella train load-out and Riverside train load-out are all situated within the EIS study area, west of the existing mining operations.

The existing railway lines are currently utilised by the GRB mine complex and surrounding operations to transport coal product to the Hay Point, Dalrymple Bay and Abbot Point Coal Terminals for shipment to international markets.

Further details on the railway network and load-out facilities servicing the project are contained in **Section 14**.

5.1.7 Statutory Land Use Planning

The proposed mining activity is located within ML1763 and MLA70421 granted under the MR Act. In Queensland all aspects of development of a mining activity for which an environmental authority (EA) (mining activity) applies are exempt from the *Sustainable Planning Act 2009* (SP Act) and therefore are exempt from assessment under the local authority planning scheme in accordance with:

- Schedule 4 Table 5 of the Sustainable Planning Regulation 2009 (SP Regulation) where mining and petroleum activities (as defined under the MR Act) are determined to be development that cannot be declared to be development of a particular type and are therefore exempt from assessment from a planning scheme; and
- Section 319 of the MR Act, which states, 'the Planning Act does not apply to development authorised under this Act'.

Despite these exemptions, an assessment has been undertaken of State, regional and local planning provisions pertaining to the proposed mining activity as required by the terms of reference (TOR). This has been undertaken to determine compliance with the local and regional planning instruments including SPPs in order to gain an understanding of the local planning considerations, identify land use planning issues and ensure the project is consistent with the local government's intention for the area.

There are some activities related to the project which are potentially located off tenure (e.g. upgrades to roads, power and water) and therefore subject to statutory land use planning provisions.

BMA will submit development applications to the applicable agency for any off-lease activities. The development applications will be supported by this EIS and other information required to be provided in order to make the applicable development application 'properly made'.

5.1.7.1 Sustainable Planning Act 2009

The principal land use planning legislation in Queensland is the SP Act. The SP Act seeks to achieve sustainable planning outcomes through:

- managing the process by which development takes place;
- managing the effects of development on the environment; and
- continuing the coordination and integration of local, regional and state planning.

The SP Act emphasises the coordination and integration of planning at the three levels at which it occurs in Queensland, namely:

- local (government) planning;
- regional planning; and
- state planning.

Coordination of planning refers to the linking of planning activities within differing levels of government and the linking of different aspects of planning such as natural resource planning, land use planning and infrastructure planning. Integration refers to the combination and rationalisation of planning outcomes and presenting them in an integrated and logical fashion.

Under the SP Act, state land use planning policy is implemented though state planning instruments, comprising:

- state planning regulatory provisions (such as supporting the regional planning process and providing for infrastructure charge mechanisms);
- SPPs;
- regional plans (including The Sustainable Futures Framework for Queensland Mining Towns, and Mackay, Isaac and Whitsunday Regional Plan that includes the project); and
- standard planning scheme provisions.

5.1.7.2 State Planning Regulatory Provisions

The State Planning Regulatory Provisions (SPRP) are planning instruments that the planning minister can introduce as required for specific issues and are generally used to:

- implement a regional plan;
- implement structure plans for master planned areas;
- allow the planning minister to respond to environmental, cultural, economic or social issues in local areas by affecting the operation of planning schemes; and
- apply state infrastructure charges within master planned areas.

There are no SPRPs that directly relate to the proposed project.

5.1.7.3 State Planning Policies

A number of SPPs and associated guidelines have been developed and support the implementation of the provisions of SP Act. SPPs hold statutory weight and establish state government requirements regarding planning and development matters.

Furthermore, the Queensland Government is currently developing a new single SPP to replace the various current SPPs. The ‘draft SPP’ is intended to set out policies on matters of state interest relating to planning and development and is a key framework of the government's broader commitment to planning reform.

Relevant current SPPs and details of the draft single SPP are as follows.

State Planning Policy 1/03 Mitigating the Adverse Impacts of Flood, Bushfire and Landslide

SPP 1/03 aims to mitigate the adverse impacts of flood, bushfire and landslide for assessable development. This SPP applies generally throughout Queensland, however, the bushfire and landslide outcomes apply only to local governments listed in the SPP.

The former Belyando Shire within the Isaac Regional Council is exempt from the bushfire and landslide outcomes due to the low risk of either of these events (DLGP 2010). However, the bushfire and landslide provisions of the SPP do apply to areas of the former Nebo Shire, which includes a small section along the eastern edge of the EIS study area. **Figure 5.1-10** illustrates the pre-2008 local government boundaries.

There is potential for flooding within the EIS study area, particularly within the Isaac River floodplain. Flood modelling has been undertaken to identify areas that may flood and also potential for exacerbation of flooding as a result of the project. Flood immunity and mitigation measures for the control and management of flood waters have been incorporated into the project's design and are discussed in **Section 7.3.4**.

There is potential for bushfires to occur in the area and management strategies have been developed for the project (**Section 20**). The portion of the EIS study area within the former Nebo Shire is identified as being predominantly low bushfire risk with some areas of medium risk towards the north-east (Nebo Shire Plan 2008).

Based on the above, it can be concluded that adequate design and mitigation measures have been incorporated to address flood, bushfire and landslide potential and that the project is consistent with SPP 1/03.

SPP 2/07 Protection of Extractive Resources

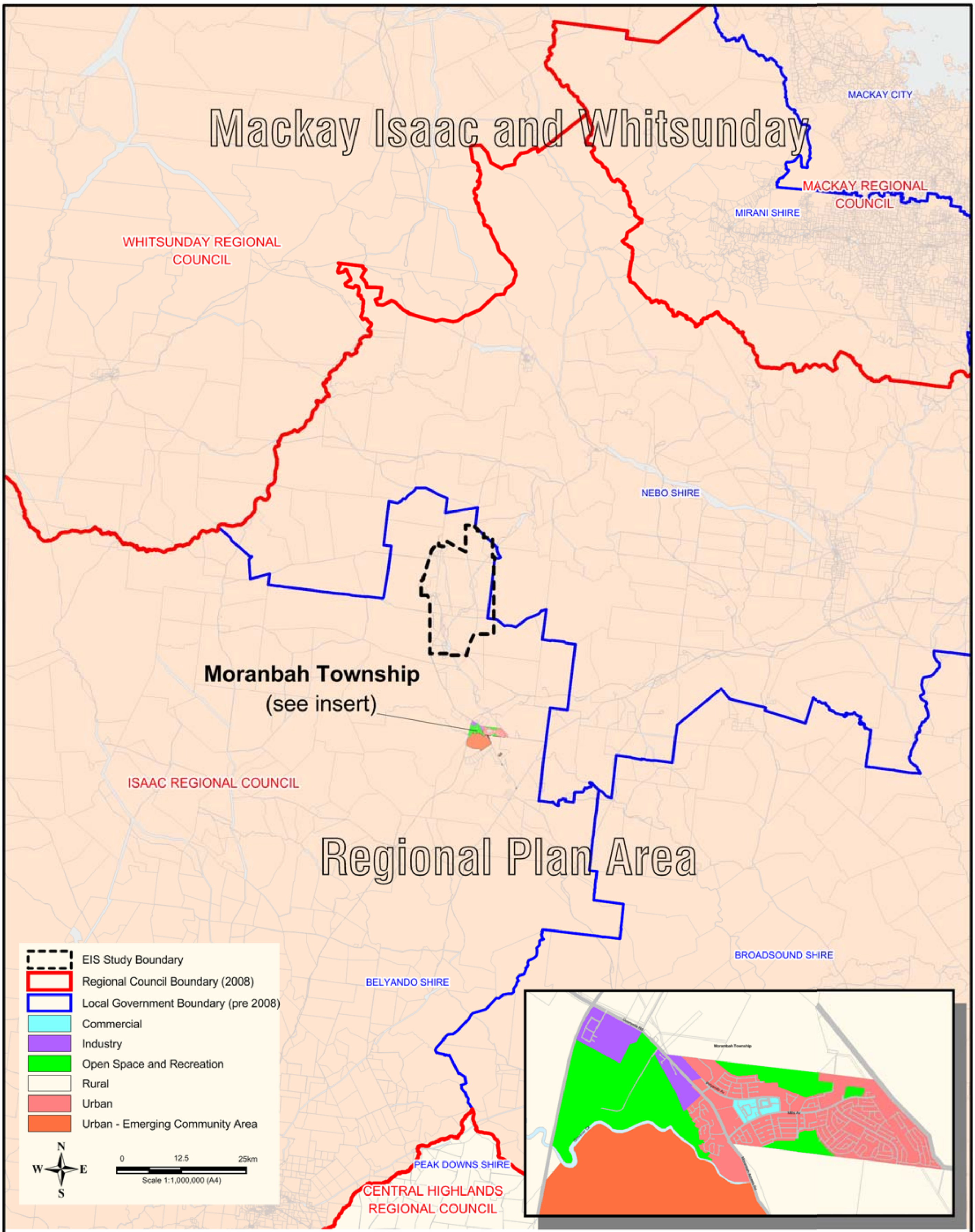
SPP 2/07 identifies extractive resources of state or regional significance where extractive industry development is critical to the future growth of the region. The SPP aims to protect these resources from development that might prevent or constrain current or future extraction when the need for utilisation of the resource arises. Extractive resources include sand, gravel, quarry rock, clay and soil which are used in concrete, asphalt, road bases and a range of other aggregate products (DME 2007).

There are no key resource areas or potential key resource areas identified under SPP 2/07 located in or near the EIS study area (DME 2007).

State Planning Policy 4/11 Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments

SPP 4/11 – Protecting Wetlands of High Ecological Significance (HES) in Great Barrier Reef Catchments aims to ensure that development in or adjacent to wetlands of high ecological significance in Great Barrier Reef catchments is planned, designed, constructed and operated to minimise or prevent the loss or degradation of the wetlands and their values or enhance these values. This SPP provides development assessment controls and administration frameworks for the assessment of proposed development impacting upon referrable wetlands.

The SPP applies to wetland protection areas in the Great Barrier Reef catchments, defined on the map of referable wetlands within the SPP. The EIS study area is located within the Great Barrier Reef catchments as identified by the SPP.



Source: Planning Scheme for Belyando Shire Ver: July 2008

Source: © Mapinfo Australia Pty Ltd and PSMA Australia Ltd., © Copyright Commonwealth of Australia (Geoscience Australia) 2006 , © Copyright The State of Queensland (Department of Natural Resources and Water) 2008, © The State of Queensland (Department of Mines and Energy) 2006-2008, © The State of Queensland (Department of Environment and Resource Management) 2010, Bing Maps © Microsoft Corporation and its data suppliers, Images from Client Oct 2011

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ENVIRONMENTAL IMPACT STATEMENT

LOCAL GOVERNMENT BOUNDARIES AND ZONING

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LAND RESOURCES - LAND USE AND TENURE

Figure: **5.1-10**

File No: **42627136-g-1022.wor** Drawn: **VH** Approved: **CT** Date: **11-06-2013** Rev.**A** A4

Searches conducted identified a number of wetlands within the wetland management areas of the EIS study area. However, no HES wetlands within the wetland protection areas are identified within or downstream of the EIS study area. Therefore, the project does not trigger assessment against SPP 4/11. While there is no overarching consideration that must be given to the requirements of the SPP, the EIS study area is located within the Great Barrier Reef Catchment and will involve soil disturbance. The hydrological impacts associated with the proposed soil disturbances are discussed further in **Section 7** and outlines adequate design and mitigation measures to minimise off site impacts. The project is considered consistent with SPP 4/11.

Draft State Planning Policy

The draft SPP sets out policies on matters of state interest in relation to planning and development, and provides a key framework for the government's broader commitment to planning reform. Once the single SPP is completed and adopted (following consultation), it will replace the 12 existing state planning policies to present one comprehensive policy that represents all the state's interests in planning matters.

The SPP is intended to provide tools to empower and support local governments to make planning decisions for their community and to implement state interests in a way that best suits their community needs.

The draft SPP identifies the state interests relevant to the SPP for the following themes:

- housing and liveable;
- economic growth;
- environment and heritage;
- hazards and safety; and
- transport and infrastructure.

The draft SPP recognises that the resources industry is a key driver of the Queensland economy and also acknowledges that mining and petroleum activities are not regulated under the SP Act. In doing so, the draft SPP identifies that the location of mineral and petroleum resource deposits and the issues and opportunities generated by resources development must be appropriately considered in land use planning.

The draft SPP identifies that the state has an interest in ensuring that mining and extractive resources are considered in land use planning for a number of reasons, including the economic benefits of resource development to Queensland and the conflict the mining and resource sector can cause with other land uses. This interest acknowledges that development decisions will require the careful balancing of competing interests and the importance of maximising the opportunities for coexistence between resource extraction and other development types where possible.

5.1.7.4 Coal Plan 2030

Coal Plan 2030 provides a medium to long term plan for the provision of infrastructure required to meet the needs of the Queensland coal industry over the next 20 years. The plan:

- examines coal demand and production forecasts;
- identifies individual and regional coal infrastructure requirements; and

- estimates staging of infrastructure provision across regions.

The plan has undergone an extensive consultation process with government departments, infrastructure owners and operators, individual coal mining companies and peak industry bodies (DIP 2010).

It is considered that the project is generally supportive of the plan by virtue of providing a key component of the projected growth of the Queensland coal industry.

5.1.7.5 Regional Planning Instruments

Mackay, Isaac and Whitsunday Regional Plan

The Mackay, Isaac and Whitsunday Regional Plan (MIWRP) was issued in February 2012 and replaces the non-statutory Whitsunday Hinterland and Mackay Regional Plan. The MIWRP was developed under the SP Act and is supported by the Mackay, Isaac and Whitsunday State Planning Regulatory Provisions 2012.

The plan will guide future planning decisions for the region over the next two decades. It provides a framework to guide the long term sustainability of the region's communities, strengthen its economy, inform the delivery of social services and infrastructure, and protect its environment.

The plan recognises that the resources sector operates within specific legislation and supports the development of mining projects within the region. The plan also identifies that the Bowen Basin as Australia's largest coal deposit and one of the nation's largest coal producers, with coal mining being the major industry in the region and the largest employer.

The plan establishes a vision and direction for the region to 2031. It provides certainty about where the region is heading and provides a framework to respond to challenges and opportunities that may arise. The regional plan outlines ten desired regional outcomes, supported by a range of policies and programs:

- sustainability, climate change and natural hazards;
- regional landscapes;
- environment;
- natural resource management;
- strong communities;
- strong economy;
- managing growth;
- urban form;
- infrastructure; and
- transport.

The following principles contained within the Mackay, Isaac and Whitsunday Regional Plan are considered relevant in the assessment of this project and are set out in **Table 5.1-3** below.

Table 5.1-3 Mackay, Isaac and Whitsunday Principles

Principle	Compatibility Assessment	Location in EIS where addressed
Sustainability		
Decision-making supports ecologically sustainable	The project promotes ecologically sustainable development through the EIS process, potential environmental and social impacts have been identified and mitigation measures proposed to address these impacts. The EIS provides an assessment of the project against the National Strategy for Ecological Sustainable Development.	**Section 2**
Climate Change		
The generation of greenhouse gases is reduced through land-use planning and development design, and long-term climate change impacts are considered in planning decisions.	The EIS provides a preliminary greenhouse gas emissions inventory, emissions calculations and abatement strategy. The EIS also provides an assessment of climate change which predicts envisaged impacts and measures to ameliorate those impacts.	**Section 12**
Natural Hazards		
The resilience of communities, development, essential infrastructure, natural environments and economic sectors to recognised hazards, including the anticipated effects of climate change, is increased.	The project will not contribute to or exacerbate the effects of natural hazards on communities. The project has put in place measures to minimise dependence on public emergency services.	**Section 20**
Regional Landscape Values		
Manage and enhance the values of the regional landscape to optimise their ability to contribute to the region's liveability, lifestyle, health and economy.	The project aims to mitigate its impact on the values of the regional landscape. Methodologies for the rehabilitation / re-vegetation will use the most appropriate species for the landscape elements. Such methodologies will include habitat matching of species to ensure rehabilitation success. Clearing of vegetation will be minimised where possible to maintain habitat connectivity and provide a movement corridor for small, terrestrial fauna species. A pest and weed management plan will be prepared to control and address the threat of pests and weeds.	**Section 9** and **Section 5.5**
Regional Landscape Areas		
Optimise multiple community benefits through coordinated planning, management and investment in regional landscape areas.	The project is located in a regional landscape and rural production area. As mining is recognised as an important use in the MIWRP, mining of this land is not inconsistent with the land use category. The proposed post mine land use is grazing in a mosaic of pasture and bushland. Biodiversity networks will be maintained or restored.	**Section 9** and **Section 5.5**
Green Space Network		
An integrated green space network caters for a range of community and environmental needs.	Although the regional green space network has not yet been fully mapped for the region, the project is not anticipated to have a significant impact on the regional green space network as the subject land does not allow for public access and does not have any particular features that might suit recreational or other "green space" uses.	**Section 9** and **Section 5.5**

Principle	Compatibility Assessment	Location in EIS where addressed
Biodiversity		
The region's natural assets, biodiversity values and ecological services are protected, managed and enhanced to improve their resilience to the anticipated effects of climate change and other threats.	Ecological assessments have been conducted for the project. The key feature of the site is a wildlife movement corridor along the Isaac River which will be retained and restored as part of the site rehabilitation plan. Clearing of vegetation will be minimised where possible to maintain habitat connectivity and provide a movement corridor for small, terrestrial fauna species. A pest and weed management plan has been prepared to control and address the threat of pests and weeds.	**Section 9**, **Section 10** and **Section 5.5**
Water Quality, Waterway Health and Wetlands		
The ecological health, environmental values and water quality of coastal, surface, ground waters and wetlands are protected.	Surface and ground water quality monitoring and modelling has been undertaken during the EIS. Surface and groundwater resources that are influenced by the project will be managed in accordance with the requirements of the legislative framework, with management requirements detailed in **Sections 7** and **8**.	**Section 7**, **Section 8** and **Section 10**
Coastal Environment		
Coastal resources are managed while protecting human life and property from the hazards of natural fluctuations in coastal processes.	Due to the geographical location of the project, the proposed activities are not anticipated to adversely impact on the coastal districts of the region.	**Section 7**
Air Quality and Noise		
The environment is protected to maintain the health and wellbeing of the community and the natural environment through effective management of air quality and noise.	The project is located away from urban areas in a predominantly rural setting. Detailed acoustic and air quality impact assessment has assessed existing environmental values and likely impacts and identified that the project is not expected to degrade air quality and noise at a local or regional level.	**Section 11** and **Section 13**
Natural Resource Management		
The management and use of natural resources enhance community, economic and landscape values.	The project will be developed in accordance with legislative requirements. The project will allow access to a coal resource. The proposed post mine land use is grazing in a mosaic of pasture and bushland. Minimal loss of land suitable for grazing is predicted.	**Section 3** and **Section 5.5**
Ecosystem-Dependant Economic Resources		
Ecosystems are sustainably managed, ensuring their cultural, social, economic and environmental services and values are protected.	Ecological and other assessments conducted for the project have not identified any particular ecosystem values that are critical in terms of economic and community values. Methodologies for the rehabilitation / re-vegetation will use the most appropriate species for the landscape elements. Clearing of vegetation will be minimised where possible to maintain habitat connectivity and provide a movement corridor for small, terrestrial fauna species. A pest and weed management plan has been prepared to control and address the threat of pests and weeds.	**Section 18** and **Section 19**

Principle	Compatibility Assessment	Location in EIS where addressed
Mineral and Extractive Industries		
Mineral, petroleum and extractive resources are managed for current and future use, and their extraction, processing, transport and downstream value-adding continue to contribute to the economy.	The proposed project will develop a known and valued mineral resource. The mine will have a long life bringing benefit to the region over the long term.	**Section 3** and **Section 19**
Regional Water Supply Planning		
Water, as a valuable and finite regional resource, is planned and managed on a total water cycle basis.	The project will be partially self-sufficient in relation to water, and will utilise existing allocations held by BMA, thus not requiring access to additional water.	**Section 3**
Total Water Cycle Management		
Water is recognised as a valuable and finite resource which is managed on a total water cycle basis.	Water produced by and required for the project will be managed through an integrated mine water management system that focuses on maximising self-sufficiency for water use.	**Section 3** and **Section 7**
Social Planning		
Social planning is incorporated into planning processes to manage and respond to changing communities, and support community wellbeing and quality of life.	BMA has undertaken a social impact assessment as part of the EIS to identify the existing social environment and quantify the potential impacts of the project components and to establish appropriate mitigation strategies. A Social Impact Assessment (SIA) has been developed and outlines strategies for management of potential social impacts (**Appendix P**).	**Section 18**
Address Social and Locational Disadvantage		
Social and locational disadvantage in communities is recognised and addressed.	BMA has undertaken a social impact assessment as part of the EIS to identify the existing social environment and quantify the potential impacts of the project and to establish appropriate mitigation strategies. An SIA has been developed as part of the project and includes strategies to manage potential social impacts (**Appendix P**).	**Section 18**
Healthy and Safe Communities		
Quality of life is enhanced by offering healthy and safe environments that promote active living and healthy lifestyles, and provide accessible health services.	BMA has prepared a social impact assessment for the project (**Section 18**). This includes assessment of community health and safety issues, and strategies to address any potential adverse impacts.	**Section 18**
Community Engagement, Capacity and Identity		
Strong, connected and functional communities exist as a result of grassroots community development, engagement and participation, and maintaining and improving a community's sense of shared identity.	The project incorporates public consultation activities to promote community and stakeholder awareness which will assist in the communication and identification of potential synergies between the project and local economic activities. BMA has in place community networks which meet regularly in relation to BMA activities and operations.	**Section 17** and **Section 18**

Principle	Compatibility Assessment	Location in EIS where addressed
Strengthen Resource Communities		
The long-term viability of resource communities is sustained by enhancing liveability, providing diverse housing and employment options and accommodating the needs of the resource sector.	BMA has prepared a social impact assessment for the project (**Section 18**). This includes assessment of potential impacts on Moranbah and also proposed strategies to strengthen this resource community.	**Section 5.1** and **Section 18**
Engaging Aboriginal and Torres Strait Islander People		
Traditional owners and elders are actively engaged in planning and development processes, and their connectivity with country is understood, considered and respected.	The project has entered into native title agreements with traditional owners and will also prepare CHMPs in consultation with relevant Aboriginal parties.	**Section 16** and **Section 17**
Aboriginal and Torres Strait Islander Social and Economic Equity		
Aboriginal and Torres Strait Islander people have equitable access to opportunities that promote a high standard of living, good economic prospects and general wellbeing.	BMA has in place several programs in relation to training and employment of indigenous people.	**Section 16** and **Section 17**
Economic Leadership and Coordination		
Strong economic leadership attracts, coordinates and drives regional economic development, innovation and investment.	The project will support long term economic growth in the region.	**Section 19**
Integrated Economic, Land-Use and Infrastructure Planning		
Suitable land, infrastructure and facilities are available and managed to enable sustainable economic and employment growth in the region.	The Broadmeadow extension does not require additional infrastructure. Additional site infrastructure will be required to service the RHM underground expansion option and will be developed as part of the GRM incremental expansion.	**Section 5.1**
Resilient and Sustainable Economy		
The economy grows through increasing levels of human-capital, knowledge-capital and natural-capital and is resilient to external factors through multiple strong industry sectors that provide diverse employment opportunities.	The project will support long term economic growth in the region through sustaining and creating jobs and increased diversification of the regional economy. There is potential for BMA to provide educational incentives for the GRM incremental expansion and the RHM underground expansion option through apprenticeships and traineeships, as well as general skills development. The proposed project will develop a known and valued mineral resource. The mine will have a long life bringing benefit to the region over the long term.	**Section 18** and **Section 19**

Principle	Compatibility Assessment	Location in EIS where addressed
Primary Industries		
Maintain existing and expand sustainable and economically viable primary industries, and diversify opportunities in the region.	The proposed post mining land use is grazing. A small loss of grazing land capability will occur as a result of the project; however this is not expected to have any measurable impact on stocking rates or agricultural productivity.	**Section 5.1** and **Section 5.3**
Resource Sector		
Manage mining and extractive resources to maximise economic opportunities and other community benefits, while minimising negative environmental and social impacts for present and future generations.	This EIS presents a comprehensive assessment of the environmental and social impacts and economic and community benefits associated with each of the project elements. The EIS will set out management requirements in relation to minimising adverse impacts and maximising benefits of the project.	**Section 3, Section 18** and **Section 19**
Tourism		
Continue to develop the region's distinctive and sustainable tourist destinations, which offer a diverse range of activities and unique experiences to attract domestic and international visitors.	The project is not expected to contribute or detract from regional tourism. There are no known tourist attractions nearby to the project. Consideration of mine impacts on the scenic amenity (i.e. visual aspects of the project as viewed by passing traffic, including tourists) has been compiled in **Section 5.2**.	**Section 3**
Efficient Use of Land		
Land and infrastructure are used efficiently, taking into account costs of servicing, projected demand on/from existing urban infrastructure and employment.	The project does not require any expansion of existing urban infrastructure to service its needs.	**Section 3**
Planning for Growth		
Development authorities and identified growth areas are secured for delivering medium and long-term growth opportunities, and catering for projected demand requires comprehensive planning and infrastructure delivery.	The project is not located in any development areas or identified growth areas, and due to its remote location, is not likely to preclude such areas in the future.	**Section 5.1**
Rural Residential Development		
Rural residential development is planned to ensure efficient delivery of services and infrastructure, preventing further fragmentation of agricultural land, and avoiding loss of areas with biodiversity and landscape values.	The project does not involve rural residential development, nor is there any rural residential development in close proximity to the project.	**Section 5.1**

Principle	Compatibility Assessment	Location in EIS where addressed
Housing Choice and Affordability		
Housing meets the needs of the community, considering all lifecycle stages, varying demands, and economic circumstances.	Mining of the Broadmeadow extension will be undertaken by the existing BRM workforce. The GRM incremental expansion and the RHM underground expansion option are to rely on remote workforce arrangements for staff and will utilise an accommodation village on the mining lease to house staff engaged by BMA. BMA has developed an SIA which includes provisions in relation to housing and accommodation. BMA is separately undertaking housing development within Moranbah in association with its existing Bowen Basin operations.	**Section 5.1** and **Section 18**
Urban Form		
The form of the region's cities and towns responds to local climate, character and identity, and supports compact, accessible, active and healthy communities.	The project will not directly impact on the urban form of the region's cities and towns.	**Section 5.1**
Heritage, Arts and Cultural Development		
The region's unique heritage places and experiences are identified, protected and valued, with further opportunities for arts and cultural development provided.	Aboriginal and non-Indigenous cultural heritage (NICH) values for the area and wider region have been identified in the EIS, as have management measures to address any potential impacts.	**Section 16**
Centres		
Regional centres and towns are the focal point for the provision of retail, commercial and community services, economic growth and diversity.	The project will not directly impact on the urban form of the region's cities and towns.	**Section 5.1**
Rural Communities		
Rural communities benefit from growth and are serviced by appropriate levels of infrastructure and support services.	A SIA has been developed which contains a number of strategies in relation to impacts and opportunities for rural communities potentially affected by the project.	**Section 18**
Infrastructure Planning		
Efficient, well-planned infrastructure supports population growth, economic opportunities and service provision in a sustainable manner.	The GRM incremental expansion and the RHM underground expansion option have the potential to increase access to a number of infrastructure services that are being developed in the region.	**Section 5.1**
Protecting Key Sites and Corridors		
Current and future infrastructure sites and corridors are identified, protected and managed.	The GRM incremental expansion and the RHM underground expansion option are not anticipated to impact on any key sites or corridors for planning infrastructure provision.	**Section 5.1**

Principle	Compatibility Assessment	Location in EIS where addressed
Energy		
Energy is reliably provided to support growth in an economically and ecologically sustainable manner.	The project has access to grid power.	**Section 3**
Information and Communication Technology		
All communities in the region are provided with modern, reliable, accessible and affordable information and communication services.	The project will not affect the provision of information and communication technology to local communities.	**Section 3**
Waste and Recycling		
The region's waste is minimised, re-used or recycled, and promotes energy recovery.	An assessment of waste generation and minimisation opportunities has been undertaken and is presented in **Section 15**. Measures to track waste generation and identify further opportunities for waste minimisation are included in the EIS.	**Section 15**
Sewerage		
The provision and management of sewage treatment infrastructure is planned, timed and managed, and is protected from encroachment by incompatible development.	Onsite sewage treatment facilities will be provided for the project.	**Section 3**
Social Infrastructure		
Social infrastructure is planned and located, accessible, adaptable and responsive to demographic change.	There are no direct impacts on social infrastructure arising from the project. The draft SIA contains a range of measures to address potential indirect impacts on social infrastructure associated with the GRM incremental expansion and the RHM underground expansion option.	**Section 18**
Integrated Transport and Land Use		
Provide highly connected transport networks to facilitate strong links within and between communities and activity centres to enable high levels of accessibility, route and mode choice.	Potential impacts on state and local road networks have been assessed and no significant impacts have been identified (**Section 14**). The project will need to discuss proportionate contributions for local intersection and road upgrades undertaken by the Isaac Regional Council.	**Section 5.1** and **Section 14**
Efficient, Accessible and Safe Transport		
An efficient, sustainable and integrated transport system exists for the region that is safe and accessible.	The GRM incremental expansion and the RHM underground expansion option will have only minor impacts on the efficiency of the local transport network. Any impacts can be addressed through intersection and road upgrades by the relevant authority. Impacts on road access and safe transport are not anticipated.	**Section 14**
Freight		
The efficient and effective movement of freight supports regional growth.	Product coal from the project will be transported to port using existing rail facilities although a new rail line turn-around loop will be required. BMA will utilise existing rail networks. As (and when) production increases export may also occur through alternate facilities to the Hay Point, Dalrymple Bay and Abbott Point Coal Terminals.	**Section 14**

Northern Economic Triangle

The Northern Economic Triangle (NET) was established by the Queensland Government in 2007 as a plan to promote sustainable economic, social and community growth through the development of mining, mineral processing and industrial development between Mount Isa, Townsville and Bowen.

Even though the project is outside of the taskforce area, the project does support the NET and its strategies, which are as follows:

- supporting stronger regional linkages;
- enhancing mining and mineral processing; and
- enhancing industrial development.

Sustainable Futures Framework for Queensland Mining Towns

The Sustainable Futures Framework for Queensland Mining Towns (DLGPSR 2007) was initiated by the Queensland Government to provide an overview of the existing situation within mining towns in the Bowen and Surat Basins. The aim of the framework is to develop strategies to resolve serious growth management issues (particularly mining, residential and community land use issues) that are having an adverse impact on some of these mining towns.

The key objectives of the framework are:

- to protect the social, economic and environmental values and economic growth of Queensland's mining communities, through collaboration between state and local governments, the mining industry and the community; and
- to build a productive mining industry built on sustainable, vibrant Queensland communities.

BMA is working with the Isaac Regional Council to ensure the needs of the local community are met through the provision of housing and infrastructure developments in the region. The EIS has assessed the impact of the GRM incremental expansion and the RHM underground expansion option on the community, community services and accommodation for the construction and permanent workforces as contained in **Section 18**. The SIA contains proposed mitigation strategies to address potential issues and impacts.

5.1.7.6 Local Planning Instruments

The project is wholly located with the Isaac Regional Council area. The Isaac Regional Council was formed after the amalgamation of the Belyando, Broadsound and Nebo Shires in March 2008.

The majority of the project is within the Belyando Shire area; however a small section protrudes into the Nebo Shire area (approximately 395 hectares on Lot 3 on GV504 along the eastern boundary of the EIS study area) as shown on **Figure 5.1-10**. The lands within the EIS study area are zoned for 'rural use' under both planning schemes.

A compatibility assessment of the project to the Belyando Shire and Nebo Shire Planning Schemes was undertaken even though the project is a mining project located on a mining tenement.

The EIS study area is located within Rural Zones in both planning schemes.

Under the Belyando planning scheme the Rural Zone Code establishes the key assessment criteria under which land uses are assessed for compatibility with the desired outcomes for the Rural Zone.

The outcomes of the Rural Zone Code include the following:

> *(1) The Rural "Zone" retains its viability as an area of primary production and natural resource use, including mining.*
>
> *(2) "Rural activities" and mining are appropriately located within the Rural "Zone" and are not prejudiced by inappropriate development.*

Under the Nebo planning scheme the Rural Locality Code establishes the key assessment criteria under which land uses are assessed for compatibility with the desired outcomes for the Rural Zone. The outcomes of the Rural Locality Code include the following:

> *(n) Extractive industry and coal mining operations, with associated haul routes, are effectively separated from, and protected from encroachment by, any sensitive uses, in particular residential uses*
>
> *(r) Uses and works are compatible and complementary with other uses and works, and meet the needs of the local community*
>
> *(s) Uses and works minimise the potential adverse impacts of flood, bushfire and landslide on people, property, economic activity and the environment*

The project is considered to be consistent with the outcomes sought for the Rural Zone under the Belyando and Nebo planning schemes.

Additional details on the compatibility of the project with the desired environmental outcomes of both planning schemes are included in **Appendix F1**, **Table 6** and **Table 7**.

Although the project is generally exempt from assessment under local government planning schemes, it should be noted that the local government planning scheme provisions will apply for any aspect of the project that is not subject to s319 of the MR Act or Schedule 4 of the SP Regulation.

Some construction and operational aspects of the project within the mining lease will require certification or approval from Isaac Regional Council under the SP Act. These include:

- some aspects of operational works;
- building works; and
- plumbing and drainage works.

At this stage, BMA does not envisage any off-lease development requirements for the project. If off-lease infrastructure or other facilities are required, BMA will submit development applications to the Isaac Regional Council for any off-lease activities requiring council approval, such as quarries, roads, power, and water.

Moranbah Urban Development Area Draft Structure Plan

On 30 July 2010, the Moranbah Urban Development Area (UDA) was declared. The Urban Land Development Authority (ULDA) is working with the Isaac Regional Council and State government agencies to prepare a development scheme for the Moranbah UDA and secure long-term growth areas for the town. Development in the UDA is controlled by the ULDA, and more specifically the provisions of the Moranbah UDA Draft Structure Plan 2010 and the Moranbah Interim Land Use Plan.

The UDA is discussed further in the social impact assessment undertaken for the project (**Section 18** and **Appendix P**).

5.1.8 Land Use Impacts and Mitigation Methods

5.1.8.1 Biophysical Impacts and Mitigation Methods

The project components will have varying levels of impacts on the biophysical values of the lands within the EIS study area. The degree of impact will differ depending on the type of activity proposed for various parts of the EIS study area and for land uses surrounding the EIS study area, the separation distances from the site-based activities.

Biophysical impacts have been assessed in various studies undertaken for this EIS, including:

- impacts on terrestrial ecosystems – **Section 9**;
- impacts on aquatic ecosystems – **Section 10**;
- impacts on water resources and hydrology – **Section 7**;
- impacts on soils and agricultural lands – **Section 5.3** and **Section 5.4**; and
- impacts on the land surface and drainage patterns due to subsidence – **Section 5.3** and **Section 7.3.7**.

Mitigation measures are proposed in these sections to address impacts.

Ultimately, rehabilitation of the lands within the EIS study area will return a stable landform capable of supporting land uses similar to those prior to disturbance, primarily grazing land and bushland. To achieve this, the nominated post-mine land use for the EIS study area will be a mosaic of bushland and grassland. This is further discussed in **Section 5.5**.

5.1.8.2 Mining and Resource Extraction Impacts and Mitigation Methods

The impacts to existing mining and resource extraction activities will be addressed through a Plan of Operations. However, there are a number of potential impacts which may result from the establishment of new activities. These are:

- contaminated land;
- incidental mine gas (IMG) and process water management;
- subsidence; and
- accommodation.

Non-mining related land uses will not be allowed during the mining activity for safety reasons.

Contaminated Land

Potential exists for land to become contaminated from mining and the activities essential to the operation of the mine. Areas with elevated levels of contaminants will need to be managed using methods discussed in **Section 5.4**.

Identified contaminated sites will be identified in the EIS and in management plans for each operation. Identified sites will also be recorded in the environmental management and contaminated land registers as appropriate, held by the Department of Environment and Heritage Protection (EHP). Contaminated land has the potential to impact on the interim and long term land uses able to be accommodated by the affected areas. Management of these areas post project life will be undertaken to allow the proposed post mining land use of grazing.

Surface Facilities and Infrastructure

On completion of the mining activity, all above-ground components of the IMG management infrastructure will have been removed and disturbed areas reinstated with pasture grass and in some locations, bushland. Given the proposed future land use of grazing, it is not proposed to remove buried pipelines except where these may become exposed by landform changes associated with subsidence. All pipelines will however be emptied and made safe in the event that the pipelines are inadvertently disturbed in future. The presence of these pipelines will not preclude grazing land use. Should another post-mining land use be identified in future that is not compatible with the presence of these decommissioned pipelines, it would be possible to remove the pipelines.

The rehabilitation of these lands is discussed further in **Section 5.5**.

Subsidence

As detailed in **Section 5.3.3**, the underground mining activities will result in subsidence.

Impacts generally associated with subsidence are:

- hydraulic impacts and changes to water flow patterns and overland flow paths;
- land surface cracking or compression;
- water quality impacts such as:
  - in-channel ponding;
  - ponding of overland flow; and
  - increases in sediment load;
- impacts on flora such as:
  - root shearing; and
  - changes to soil structure and moisture levels;
- impacts on fauna such as:
  - loss of habitat through impacts on flora communities.

The areas subject to underground mining are expected to revert back to their original use being grazing on grassland and native bushland after the removal of surface facilities and infrastructure.

The assessment of these land use options post mining is further explored in **Section 5.3.3**.

Accommodation Village

As detailed in **Section 3**, the proposed RHM underground expansion option includes an accommodation village. The location of the Red Hill accommodation village is shown on **Figure 5.1-9**.

Potential land use impacts resulting from the construction and location of the Red Hill accommodation village will include impacts to amenity, increased traffic, loss of bushland/grassland and increased hardstand, open spaces and landscaped areas.

The establishment of the village may preclude some other land uses from being established on adjacent non-mining lease areas to the east of the village location over its lifetime. However, as this is grazing land and is isolated from any public roads, pressure for non-grazing land uses is unlikely.

Further, the Red Hill accommodation village has the potential to accommodate up to 3,000 additional construction and operational personal being sited within the nominated south eastern area of MLA70421. The increased worker population required for the project will result in increases in traffic and vehicular movements. This will include both material transport and the moving of workers in and out of the site.

Further details surrounding the impacts resulting from the construction and operation of the Red Hill accommodation village are contained in **Section 5.2**, **Section 9**, **Section 10**, **Section 13**, **Section 14**, and **Section 18**.

5.1.8.3 Impacts on Agricultural Land Use and Values

The project has the potential to impact on existing land use suitability, GQAL and SCL through:

- direct loss of agricultural land;
- land degradation;
- contamination of lands underlying the project; and
- dust and noise which may affect stock.

Potential impacts on land suitability and mitigation measures are discussed in **Section 5.3** and where an assessment of the potential for the project to impact on GQAL and SCL was undertaken using the *Planning Guidelines – The Identification of Good Quality Agricultural Land* (DPI 1993) and *Protecting Queensland's strategic cropping land: A policy framework* (DERM 2010) as guidance and found that the policy requirements are met. The results of the land suitability assessment are discussed further in **Section 5.3**.

In this section the focus is on the statutory recognition given to agricultural resources. In this regard the potential impacts of the project are assessed under the provisions of the relevant local government planning scheme and the statutory provisions relating to the protection of SCL, although local government planning schemes are not formally applicable to mining activities. An assessment against these provisions is required in accordance with the terms of reference for the assessment of impacts of the project.

The project is located within the boundaries of the Isaac Regional Council. The Isaac Regional Council, through its planning scheme, classifies Agricultural Land Classes A, B and C1 as GQAL. The EIS study area contains 7,970 hectares of land as defined within its planning scheme as GQAL. The extent of GQAL as indicated in its planning scheme is shown in **Section 5.5.3** on **Figure 5.3.3–5**.

The project is expected to encroach on areas designated as GQAL (C1 and C2) that is currently used for grazing. However, given the already disturbed nature of the landscape the loss of productive land is considered to be relatively minor.

Further details regarding the loss of GQAL are contained within **Appendix F2**.

The other measure of impact on agriculturally valued land is the requirement to protect areas of SCL. The criterion for validating and assessing SCL is detailed within **Section 5.3.3**.

Areas of land which may contain potential SCL have been mapped in the north-eastern portion of the EIS study area. **Figure 5.3-14** in **Section 5.5.3** shows the presence of trigger mapped SCL in the north-eastern area of the site. This portion of the EIS study area containing mapped areas of SCL is not expected to be disturbed by any project activities.

Further details regarding the extent of lands which may contain SCL are contained in **Appendix F2**.

Other impacts on the agricultural land uses are the potential effects of noise and dust on livestock. Noise impacts are not expected to be discernible outside the EIS study area. Dust impacts associated with the project are also predicted to be negligible outside the EIS study area.

5.1.8.4 Impacts on Residential and Other Sensitive Land Uses

Field investigations undertaken in March 2011 revealed that the only land uses that may be considered sensitive land uses and that may be impacted by the project are homesteads and rural residences.

As identified in **Section 5.1.4.4**, there are a number of homesteads that may be indirectly impacted by the project due to their respective proximity to the proposed construction and mining activities. These properties are detailed in **Appendix F1**, **Table 1** and shown on **Figure 5.1-8**.

Properties detailed in **Appendix F1**, **Table 1** and shown on **Figure 5.1-8** may be impacted by:

- dust and other windblown particulate contaminants (refer to **Section 11**);
- noise and acoustic intrusion (refer to **Section 13**);
- reductions in visual amenity (refer to **Section 5.2**);
- increased vehicular traffic and associated impacts on amenity (refer to **Section 14**); and
- light spillage (refer to **Section 5.2**).

Studies undertaken for the EIS have indicated that, with mitigation measures in place, the proposed project will have low or negligible impact on the amenity of adjacent landholders and the listed sensitive receivers.

Where land is directly or indirectly impacted by the proposed mining operations, BMA proposes to negotiate purchases or compensation agreements with the landholders.

5.1.8.5 Urban Development Impacts and Mitigation Methods

The project is not expected to have a direct land use impact on any urban land uses of a commercial, industrial or residential nature in Moranbah. However, concerns have been raised by stakeholders regarding flow-on effects of the GRM incremental expansion and the RHM underground expansion option which may increase pressure for some land uses and services within the town.

Social impacts and associated pressures on social/community infrastructure are discussed within **Section 18** and a social impact assessment has been developed to describe potential impacts and develop potential strategies for addressing these impacts.

5.1.9 Utilities and Services Impacts and Mitigation Methods

5.1.9.1 Power Impacts and Mitigation Methods

The EIS study area is traversed by 132 and 66 kilovolt lines serving BMA operations. Both transmission lines may be impacted by subsidence associated with the proposed project. It is possible that both powerlines may need to be relocated as mining progresses depending on exact location with respect to pillars and subsidence areas.

If required, a new alignment will be determined in consultation with the infrastructure owner/operator prior to subsidence effects occurring. BMA may also consult with other infrastructure service providers to identify whether there are any opportunities for coordination in relation to new linear infrastructure corridors.

5.1.9.2 Water Pipelines and Dams Impacts and Mitigation Methods

The existing mining operation is supported by existing water pipelines as discussed in **Section 5.1.5.2**. The construction and operation of the GRM incremental expansion and the RHM will necessitate the installation of purpose built take off lines from these water pipelines.

The alignments of the Burdekin water pipeline and the Eungella Water Pipeline Company water pipeline are to the west of the proposed activities and are not expected to be impacted by the expansion to the activities proposed.

The Eungella – Peak Downs water pipeline crosses the subsidence footprint for the RHM underground footprint and may be impacted by subsidence associated with underground mining (refer to **Section 3.10** and **Figure 5.1-9**). It is expected that the pipeline can remain in the existing alignment with ongoing management during subsidence. As the pipeline is owned and operated by BMA, if the pipeline needs to be relocated, BMA will manage this process internally.

5.1.9.3 Gas Pipelines Impacts and Mitigation Methods

The existing project is serviced by several gas pipelines known as the PPL89 and the PPL83 as shown on **Figure 5.1-9**.

The alignment of the PPL89 pipeline is not currently expected to be impacted by the project.

The alignment of PPL83 along the eastern portion of the EIS study area follows the 132 kilovolt high voltage corridor. PPL83 is a designated gas pipeline corridor; however this pipeline has not been developed. As with the location of the existing high voltage corridor (132 kilovolt), the alignment of PPL83 may need to be altered to allow for the expanded project footprint and to avoid any areas that will be subject to subsidence in the future. If required by the leaseholder, the corridor can be realigned to the east of its current alignment to avoid these areas.

If required, a new alignment will be determined in consultation with the infrastructure owner/operator prior to subsidence effects occurring. BMA may also consult with other infrastructure service providers at the time to identify whether there are any opportunities for coordination in relation to new linear infrastructure corridors.

5.1.10 Transport Infrastructure Impacts and Mitigation Methods

5.1.10.1 Roads

The Broadmeadow extension will not increase transport infrastructure requirements associated with the existing BRM operations as the existing BRM workforce will be utilised and no additional mine infrastructure is required to service the project.

A transport impact assessment (TIA) detailing the expected traffic generation potential and associated impacts on the road network for the GRM incremental expansion and the RHM underground expansion option is contained within **Section 14**.

No roads that make up part of the state controlled road network are to be impacted by the project.

Red Hill Road is a local road that will be impacted by the future RHM. A compensation arrangement is in place where BMA may undertake mining activities on the road reserve provided an alternate alignment is first developed to a standard acceptable to council and dedicated as a road in accordance with the *Land Act 1994*.

The Isaac Regional Council retains control of the road and is responsible for its maintenance. The realignment will continue to provide connectivity to the existing road network. These realignments do not form part of this project and will be dealt with beneath another approval process.

Ongoing management of subsidence effects on Red Hill Road will be carried out by BMA as required. These may include sealing of cracks, re-grading the road surface and managing drainage.

5.1.10.2 Stock Routes

Changes to the current alignment of Red Hill Stock Route will be required as a result of the works associated with the proposed new railway pit on GRM.

The NRM require that any proposed activities do not negatively impede the integrity of the stock route network and that all elements of the network remain intact, even if they have been unused for a number of years.

BMA has already undertaken consultation with the landholder and NRM to discuss an appropriate alignment for the stock route. The stock route alignment will need ongoing management as mining progresses in an easterly direction.

5.1.10.3 Railways

Mining activities proposed to occur within the EIS study area will be designed to accommodate the existing rail network. No changes to the design and overall layout of the existing rail infrastructure are expected as a result of the project.

A new train load-out is proposed as part of the GRM incremental expansion and is to be located on the Riverside rail loop adjacent to the existing train load-out, to load coal from the proposed Red Hill coal handling and preparation plant (CHPP).

BHP Billiton continues to assess the best rail infrastructure solutions to accommodate its future growth from its Bowen Basin assets. The timing of any potential port development beyond the current expansion of the Hay Point Terminal (HPX3) will be linked to the Company's future growth plans.

5.2 Scenic Amenity and Lighting

5.2.1 Description of Environmental Values

5.2.1.1 Introduction

This section of the EIS presents an assessment of possible impacts on landscape character and scenic amenity in the vicinity of the project. The assessment involved a field inspection in 2011, together with a comprehensive desktop analysis.

The visual assessment includes a description of the existing landscape character of the EIS study area and surrounds. The result of this assessment provides the environmental values against which the potential incremental visual impacts associated with the proposed project are then assessed.

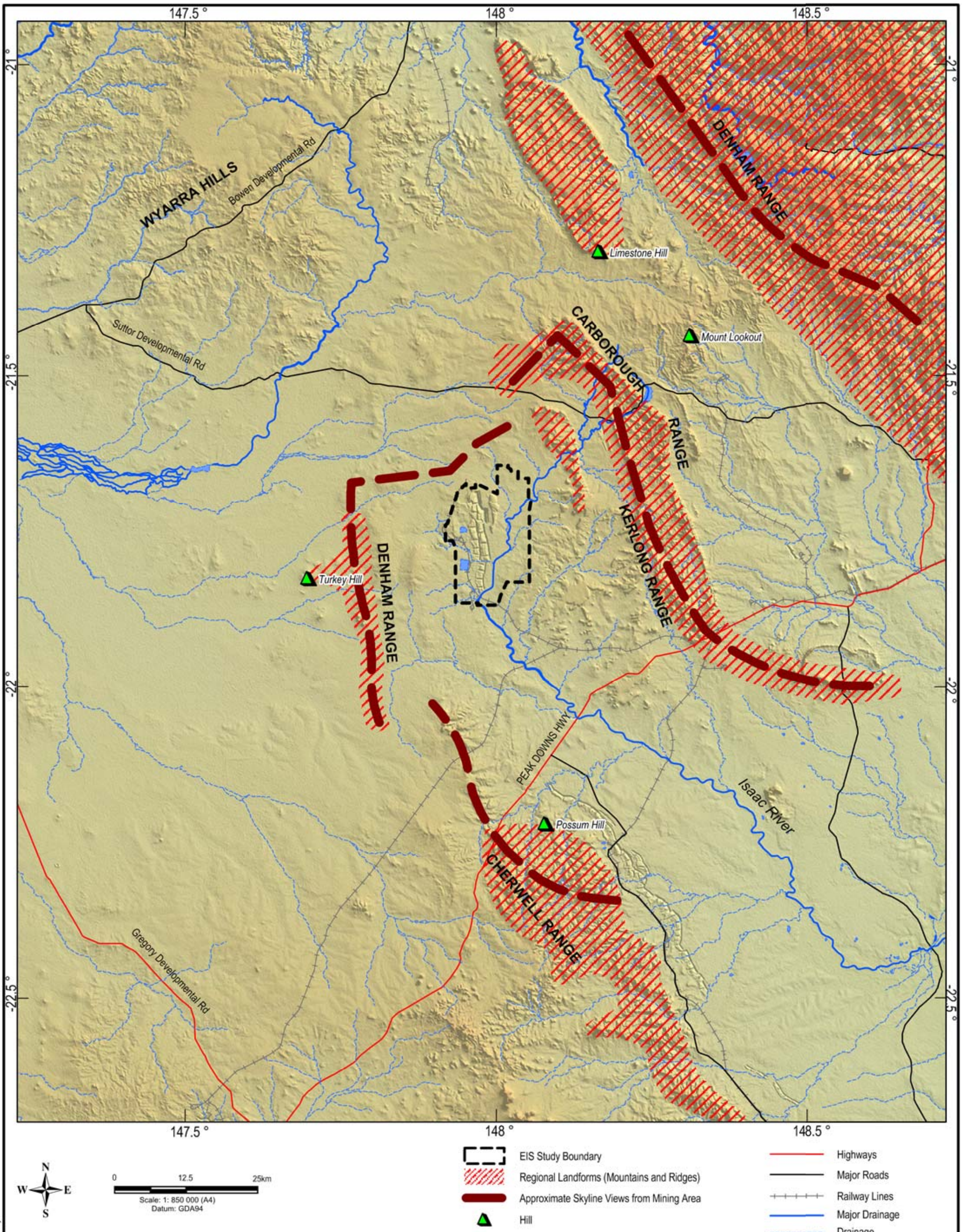
5.2.1.2 Regional Landscape Context

The EIS study area is located within the Brigalow Belt, an area that is complex in terms of land uses and ecological systems. The Brigalow Belt is divided into two bioregions that are both characterised by the occurrence of *Acacia harpophylla* (brigalow) growing as forest or woodland on clay soils. Prior to European settlement, brigalow communities were estimated to have covered approximately 7 million hectares. However, about 90 per cent of the original extent of brigalow has been cleared or severely degraded, and it is now listed under national legislation as an endangered ecological community. Remnant vegetation in the region includes eucalypt forest and woodland, grassland, dry rainforest, cypress pine woodland and riparian communities (DSEWPaC 2011).

Since World War II, the Brigalow Belt bioregions have been transformed into major agricultural and pastoral areas through broad scale clearing as part of extensive land development in the 1960s. While most of the lowland landscapes, and those formed on shale, have been extensively cleared, the more rugged topography associated with the sandstone and metamorphic ranges remains relatively undisturbed. Changes to fire regimes and the introduction of invasive exotic species, such as *Pennisetum ciliare* (buffel grass) have further contributed to the changed landscape character throughout the Brigalow Belt.

The landscape of the Bowen Basin is typically characterised by gently undulating landforms across broad valleys associated with sedimentary rock formations that are bordered by a system of more prominent hills and mountain ranges. The semi-arid climate that prevails over most of the Bowen Basin generally results in the predominance of grassland with a sparse cover of tree and shrub vegetation on areas between the rivers and creeks, which usually support woodland vegetation.

Open-cut coal mining is a visually common feature in the Bowen Basin. The existing GRB mine complex and the proposed project are located within a broad valley that is drained by the Isaac River. The valley is defined to the west by the Denham Range and to the east by the Carborough Range and Kerlong Range. The southern end of the valley broadens out on to a wide flood plain. The regional context of RHM is illustrated in **Figure 5.2–1**.



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BMA
BHP Billiton Mitsubishi Alliance

RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

REGIONAL LANDSCAPE CONTEXT

URS

LAND RESOURCES - SCENIC AMENITY & LIGHTING

Figure: **5.2-1**

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5.2.1.3 Local Landscape Context

Mining Operations

The most visually apparent changes to the landscape character in the vicinity of the EIS study area have resulted from mining operations, particularly the creation of new overburden landforms associated with the GRM and the adjacent North Goonyella Mine. The visual prominence of these landforms results from the combination of their large scale and elevation above the relatively flat surrounding topography. This visual prominence is increased by the contrast in colour and texture between the slopes of bare overburden and the flat areas of savannah woodland that commonly form the foreground, to views of the overburden landforms. While portions of the overburden have been revegetated, new un-vegetated overburden slopes continue to be created by current mining operations. Visibility of the overburden stockpiles from some viewpoints is restricted by vegetation in the foreground (see **Figure 5.2-2**).

Figure 5.2-2 View from Red Hill Road Showing Visual Screening by Vegetation

Other visually prominent infrastructure elements associated with current mining operations include CHPP, railway lines, roads, vehicle maintenance facilities and high voltage powerlines. While these elements contrast in visual character with the grass and woodland of the landscape in which they are located, their visual prominence is limited by the relatively narrow corridors in which they are located or the much larger scale of adjoining overburden landforms.

Industrial facilities associated with current mining operations are located alongside the western and south-eastern edge of the current mining area. However, they do not form a significant visual component of the landscape character as they are generally not visible from public roads or homesteads in the vicinity of the EIS study area.

Agricultural Activities

Prior to mining operations, agricultural land uses and activities resulted in major changes to the landscape character throughout the EIS study area. In particular, the clearing of trees and shrubs to establish grassland for grazing has changed the landscape character across a large proportion of the Isaac River valley. Removal of vegetation has opened up many long distance views that would not have existed prior to pastoral activities. In areas where the intensity of grazing has been reduced or removed completely, natural regeneration of native trees and shrubs is taking place. If this vegetation continues to grow over time, it will change the landscape character of the area and reduce the availability of long distance views.

Landform

The topography of the Isaac River valley in the vicinity of the EIS study area varies from approximately 250 metres Australian Height Datum (AHD) elevation along the Isaac River east of the EIS study area to approximately 450 metres AHD elevation along portions of the Denham Range that define the western edge of the valley. The relatively steep slopes associated with the Denham Range contrast with the extensive flat areas across the base of the river corridor where gradients are generally less than 1:100.

To the north of the EIS study area a low broad ridge defines the northern extent of the Isaac River catchment.

The low hills located to the east of the EIS study area are strongly undulating with a well-developed system of drainage lines.

Vegetation

A substantial portion of the proposed underground footprint has been cleared for grazing, with patches of remnant vegetation located along the Isaac River and areas to the east, as described in **Section 9.1.3.1** of this EIS.

While the northern portion of the EIS study area is predominantly grassland, there are patches of remnant vegetation and regrowth of shrubs and trees. The open visual character of this grassland, combined with the undulating landform, generally provides a visually open landscape character with extensive views to the west defined by overburden landforms associated with past and current open-cut mining operations.

Roads

State highways and major roads do not form a significant element in the local landscape context as there are none in the vicinity of the project. Goonyella Road is the most significant at a local level because it is the primary vehicle access to the GRB mine complex. Red Hill Road is important at a local level as it provides access between Moranbah and recreation facilities and national parks to the north as well as to properties in the vicinity of the project.

Existing woodland vegetation growing along some sections of public roads in the vicinity of the EIS study area provides visual screening at a local scale. However, there are extensive sections of pubic road that are adjoined by grassland that does not provide visual screening. Consequently, some current mining operations are visible at long and mid distances along some sections of public roads.

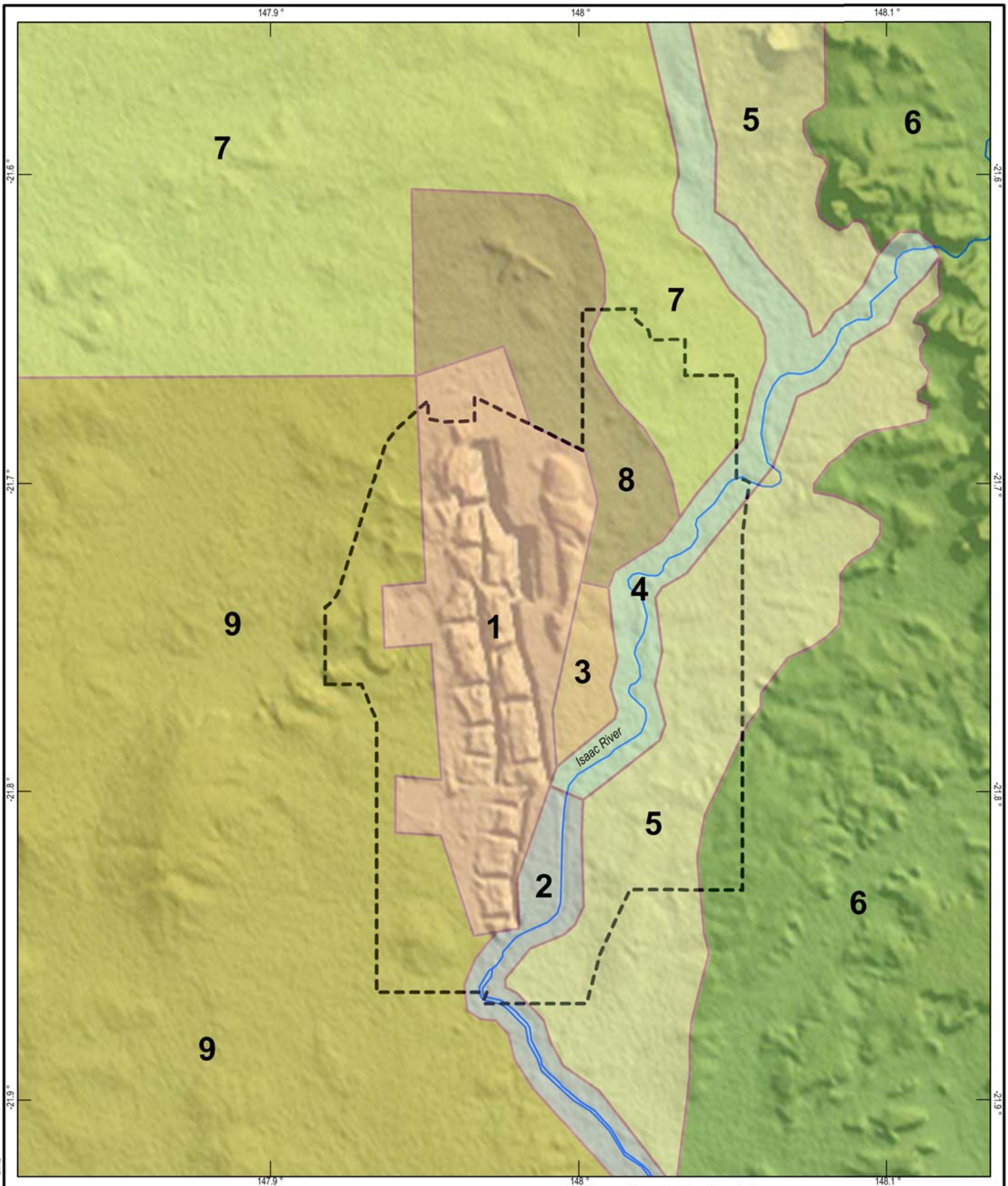
5.2.1.4 Landscape Character Zones

An assessment has been undertaken in order to describe the current landscape visual character of the EIS study area and surrounding areas.

A series of landscape character zones (LCZ) were identified and described. These LCZ represent areas that are relatively consistent in terms of their combination of landform, vegetation and land use, and, hence, produce a distinctive visual character. They are shown in **Figure 5.2-3** and listed below.

- LCZ 1 – existing GRM operations;
- LCZ 2 – existing Isaac River diversion;
- LCZ 3 – Broad plain east of GRM;
- LCZ 4 – Isaac River riparian corridor;
- LCZ 5 – Broad plains east of Isaac River;
- LCZ 6 – Carborough Range, foot hills and slopes;
- LCZ 7 – undulating landforms north of Goonyella Creek;
- LCZ 8 – Goonyella Creek corridor; and
- LCZ 9 – sub-catchment south-west of GRM.

The boundaries of the LCZ were confirmed during field checks, during which the landscape character of each LCZ was recorded and photographed. Each LCZ is described and illustrated in **Figures 5.2–4** to **5.2–12** on the following pages.



Landscape Character Zone Description

LCZ 1 existing GRM operations	LCZ 6 Carborough Range, foot hills and slopes
LCZ 2 existing Isaac River diversion	LCZ 7 undulating landforms north of Goonyella Creek
LCZ 3 Broad plain east of GRM	LCZ 8 Goonyella Creek corridor
LCZ 4 Isaac River riparian corridor	LCZ 9 sub-catchment south-west of GRM
LCZ 5 Broad plains east of Isaac River	

N W E S

0 2.5 5km

Scale: 1: 180 000 (A4)
Datum: GDA94

EIS Study Boundary
Landscape Character Zone Boundary
9 Landscape Character Zone
Major Drainage

BME

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

LANDSCAPE CHARACTER ZONES OF PROJECT SITE

URS

LAND RESOURCES - SCENIC AMENITY & LIGHTING

Figure: **5.2-3**

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Landscape Character Zone 1 (LCZ 1) – Existing GRM Operations (Figure 5.2-4)

Key characteristics include:

- Large scale overburden stockpiles dominate the visual character throughout this LCZ, with CHPP and coal stockpiles forming distinctive visual components in some areas.
- The landscape character is changing in areas where current mining operations are taking place, which involves vegetation clearing, placement of overburden in new landforms, re-grading and re-vegetation as part of the site rehabilitation process.
- Mining operations within the void, which are shown in **Figure 5.2-4**, are not visible to the general public from roads or other areas surrounding the mine.

Figure 5.2-4 View of Current GRM Mining Operations

Landscape Character Zone 2 (LCZ 2) – Existing Isaac River Diversion (Figure 5.2-5)

Key characteristics include:

- Realignment of a section of the Isaac River has created a linear diversion channel, with constructed levee banks that appear as in the landscape.
- Vegetation within the diversion channel is primarily grassland with some scattered shrubs. Remnant riparian woodland growing on undisturbed ground adjoins the diversion channel.
- Views from the section of Red Hill Road running parallel to the diversion channel include the GRM overburden landform to the west and the levee bank of the diversion channel to the east.

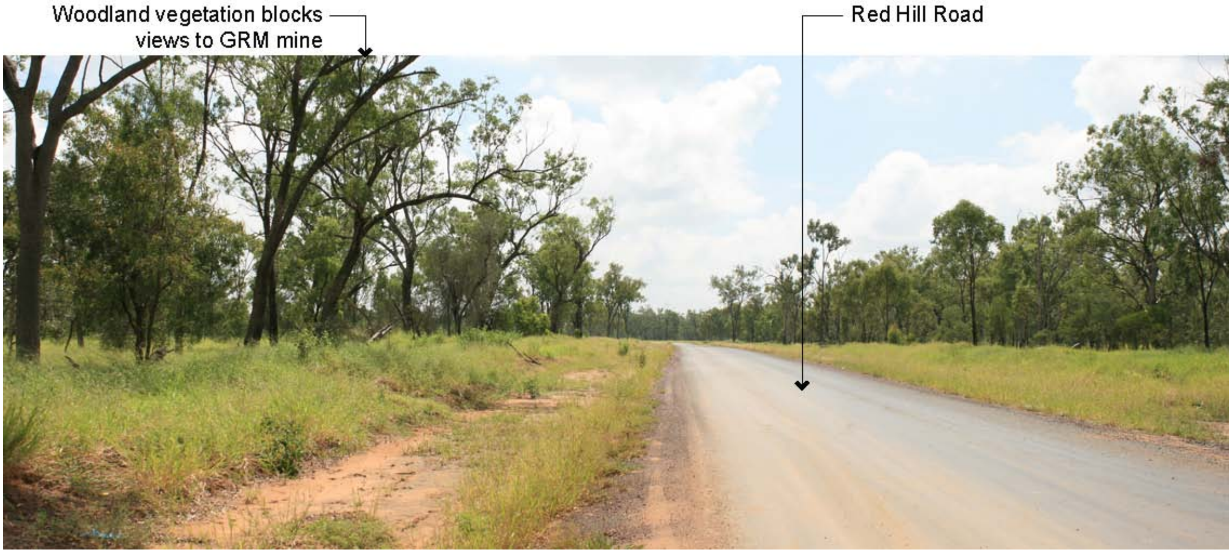
Figure 5.2-5 View from Red Hill Road Crossing of the Isaac River Diversion

Landscape Character Zone 3 (LCZ 3) – Broad Plain East of GRM (Figure 5.2-6)

Key characteristics include:

- relatively flat landform with weakly defined drainage system;
- extensive cover of savannah woodland together with large areas of grassland; and
- occasional glimpses of the eastern slopes of the GRM overburden landform, although most views are screened by woodland vegetation adjoining the road.

Figure 5.2-6 View Looking North along Red Hill Road



Landscape Character Zone 4 (LCZ 4) – Isaac River Riparian Corridor (Figure 5.2-7)

Key characteristics include:

- Significant variation in landform that is created at local scale by natural embankments associated with the Isaac River and its tributaries.
- Views within this LCZ are generally limited to mid-distance by tree/shrub vegetation with views along the river further limited by sections of embankment in some locations.

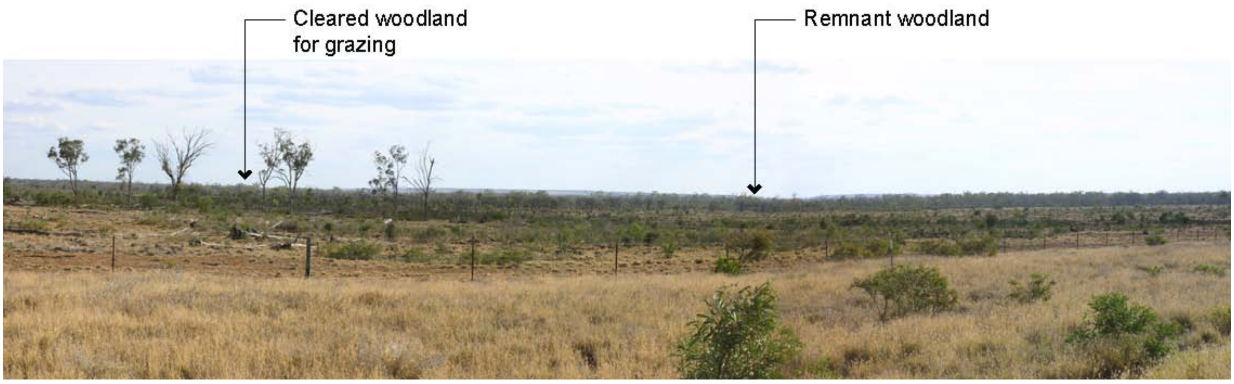
Figure 5.2-7 View from Red Hill Road to Riparian Woodland on Isaac River Floodplain

Landscape Character Zone 5 (LCZ 5) – Broad Plains East of Isaac River (Figure 5.2-8)

Key characteristics include:

- gently undulating landform with extensive area of savannah woodland and cleared grassland; and
- long distance views beyond the LCZ, resulting from vegetation clearing for grazing.

Figure 5.2-8 View South-West from Suttor Developmental Road Across LCZ 5

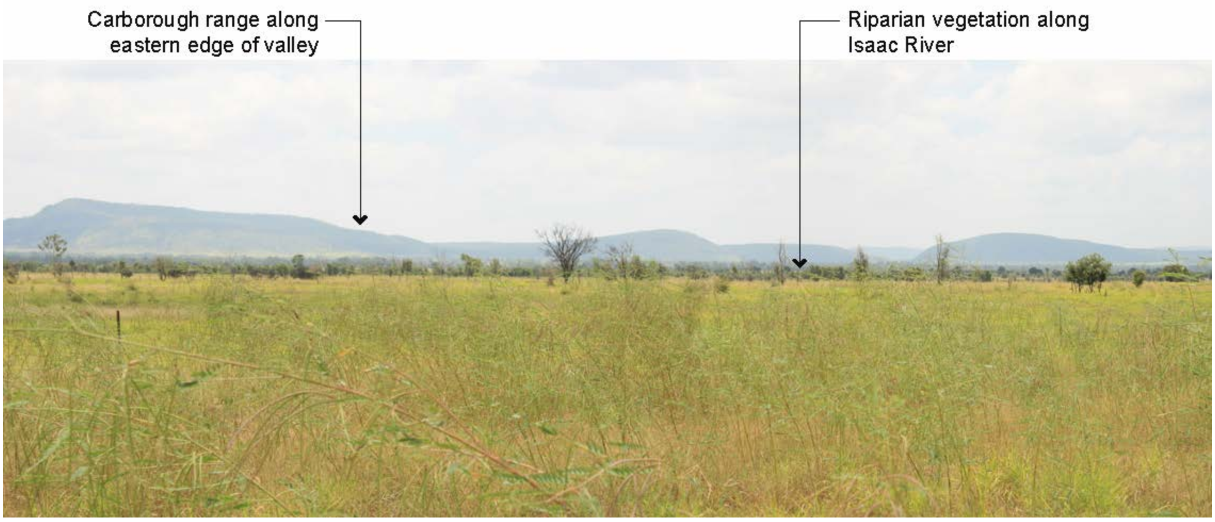


Landscape Character Zone 6 (LCZ 6) – Carborough Range Foot Hills and Slopes (Figure 5.2-9)

Key characteristics include:

- visually prominent mountain range together with hills and ridges that form the eastern edge of the wide Isaac River valley;
- extensive savannah woodland cover together with areas of grassland; and
- long distance views to and from the mountain range.

Figure 5.2-9 View North East from Red Hill Road Across Isaac River Valley to Carborough Range



Landscape Character Zone 7 (LCZ 7) – Undulating Landforms North of Goonyella Creek (Figure 5.2-10)

Key characteristics include:

- extensive savannah woodland cover and rock outcrops in some locations; and
- long distance views from Red Hill Road across the grassland and scattered trees, which have resulted from clearing for grazing.

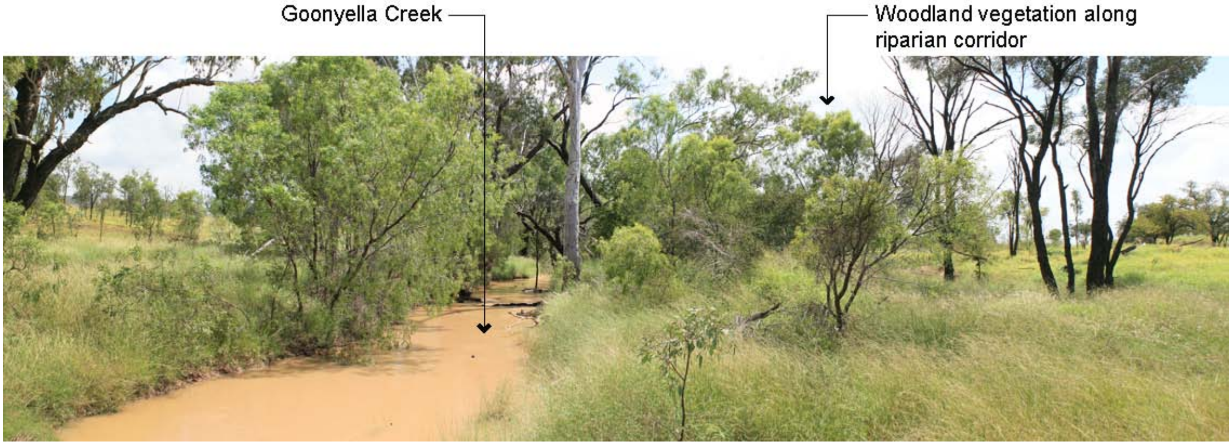
Figure 5.2-10 Long Distance View to South-West over LCZ 7

Landscape Character Zone 8 (LCZ 8) – Goonyella Creek Corridor (Figure 5.2-11)

Key characteristics include:

- broad valley associated with Goonyella Creek, which flows south-east into the Isaac River;
- extensive savannah woodland and grassland along sections of Goonyella Creek; and
- views generally screened by vegetation but in some locations the view includes GRM and North Goonyella Mine overburden landforms.

Figure 5.2-11 View to North along Goonyella Creek Riparian Corridor

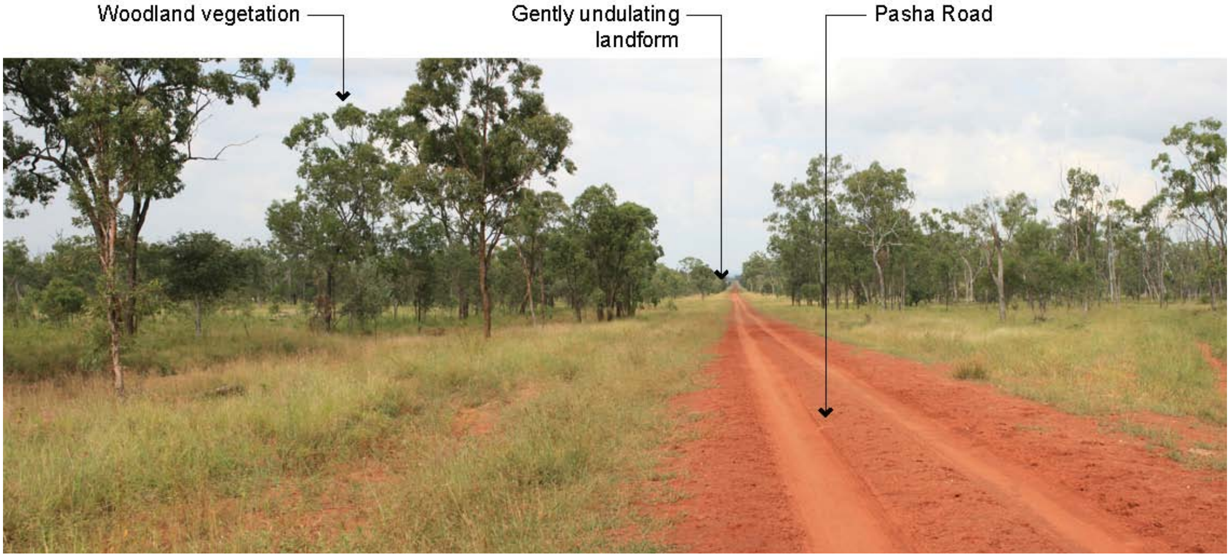


Landscape Character Zone 9 (LCZ 9) – Eureka Sub-catchment Southwest of GRM (Figure 5.2-12)

Key characteristics include:

- moderately undulating landform in the Eureka Creek sub-catchment, which drains to the Isaac River south of GRM; and
- predominantly savannah woodland vegetation, which generally screens views but glimpses of the overburden landforms at the GRM and North Goonyella Mines occur in some locations.

Figure 5.2-12 View to East towards GRM



5.2.1.5 Landscape Scenic Quality

An assessment of landscape scenic quality of the EIS study area and surrounds was carried out using a methodology adapted from that used by the United States Bureau of Land Management (BLM) (1984). Definitions of the rating criteria used in the assessment have been modified to make them relevant to the project. For example, reference to 'steep canyons, mesas, buttes, cinder cones, and drumlins' in the landform component and 'cascading white water' in the water component of the BLM (1984) document, have been removed because they are not relevant to the EIS study area.

The scenic quality assessment tool used in this assessment is defined in **Table 5.2-1**. An overall rating for the EIS study area was generated by combining rating scores for each individual rating criteria listed in the table.

Table 5.2-1 Scenic Quality Assessment Tool

Component	Rating Criteria & Scores		
Landform	High vertical relief as expressed mountain peaks, massive rock outcrops or severe surface variation or highly eroded formations including major dune systems; or detailed features, dominant and exceptionally striking.	Steep valleys, ridgelines, volcanic cones; or interesting erosion patterns or variety in size and shape of landforms; or detailed features which are interesting though not dominant or exceptional.	Low rolling hills, foothills or flat valley bottoms or few or no interesting landscape features.
	5	3	1
Vegetation	A variety of vegetative types that have interesting and distinctive forms, textures and patterns.	Some variety of vegetation, but only one or two major types.	Little or no variety or contrast in vegetation.
	5	3	1
Water	Clear and clean appealing, still or cascading white water; any of which are a dominant visual element in the landscape.	Flowing or still, but not a dominant visual element in the landscape.	Absent or if present then not noticeable.
	5	3	0
Colour	Rich colour combinations, variety or vivid colour; all pleasing contrast in the soil, rock, vegetation or water.	Some intensity in variety of colours and contrast of soil, rock and vegetation, but not a dominant scenic element.	Subtle colour variations, contrast or interest; generally mute tones.
	5	3	1
Influence of adjacent scenery	Adjacent scenery greatly enhances visual quality of the landscape area.	Adjacent scenery moderately enhances overall visual quality of the landscape area.	Adjacent scenery has little or no influence on overall visual quality of the landscape area.
	5	3	0
Scarcity	One-of-a-kind or unusually memorable, or very rare within the region. Regular opportunities to view exceptional fauna and flora.	Distinctive, though somewhat similar to other landscape areas within the region.	Interesting within its setting, but fairly common within the region.
	5+	3	1
Cultural modifications	Modifications add favourably to visual variety while maintaining visual harmony.	Modifications add little or nothing to visual variety of the area but do not introduce discordant elements.	Modifications add variety, but are discordant.
	2	0	- 4

Source: BLM 1984

The maximum potential rating that can be achieved is 32. This score would only apply to a landscape that was assessed as meeting all of the criteria in the left hand column of the rating criteria and scores. The scenic quality ratings, based on the score achieved using the above criteria (BLM 1984), are defined as:

- High (32 - 19);
- Medium (18 - 12); or
- Low (11 or less).

An assessment of the existing scenic quality rating was carried out for the EIS study area by applying the criteria in **Table 5.2-1**. Of the three options in the rating criteria and scores columns in **Table 5.2-1**, the most appropriate for the EIS study area and surrounds was selected. The individual rating numbers were then added to give an overall rating and the results are presented in **Table 5.2-2**.

Table 5.2-2 Scenic Quality Rating

Component	Explanation of Rating	Rating
Landform	Mine overburden landforms are visually interesting and contrast with surrounding flat natural landform.	3
Vegetation	Some vegetation variety includes woodland and grassland.	3
Water	No noticeable water bodies.	0
Colour	Subtle colour variations in vegetation.	1
Influence of adjacent scenery	Adjacent scenery moderately enhances overall visual quality of the landscape area.	3
Scarcity	Interesting within its setting, but fairly common within the region.	1
Cultural modifications	Modifications associated with mining add variety but are discordant until slopes are revegetated by rehabilitation works.	- 4
	Overall rating of EIS study area	**7**

The overall rating of seven indicates that the current scenic quality is in the low scenic quality category.

5.2.1.6 Landscape Significance of the EIS Study Area

The arid grassland and scattered woodland landscape character of the EIS study area is typical of a large proportion of the Bowen Basin. Due to the predominance of this landscape character throughout the Bowen Basin, the EIS study area is considered to be of relatively low significance as it is not located within a landscape classified as being of state-wide, national or international significance.

Previous and current open-cut mining operations involving disposal of overburden material at GRB mine complex have created a major new landform. The shape, scale and colours associated with this new landform combine to make it a visually prominent component of the landscape character of the area.

5.2.1.7 View Situations Descriptions

An inspection of the EIS study area identified two general categories of viewing situations where viewers will be able to see the proposed RHM footprint or associated infrastructure and facilities; these include views from public roads and from individual homesteads. Viewing locations are identified on **Figure 5.2-14** and described and illustrated in the following sections.

5.2.1.8 View Situations Assessment - Roads

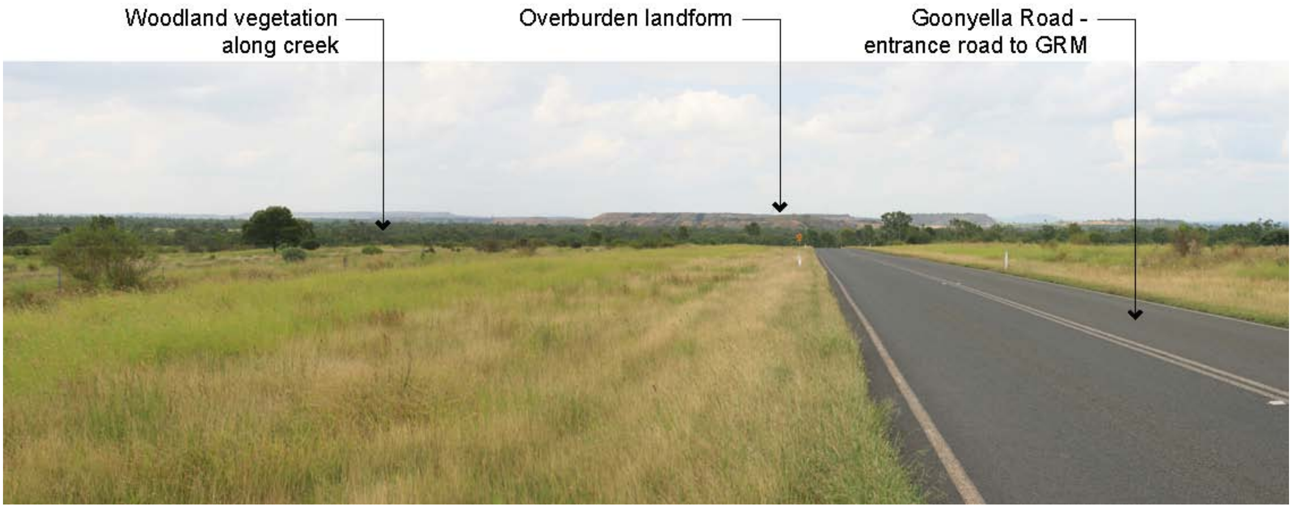
Road 1 (R1) – Goonyella Road south of GRM (Figure 5.2-13)

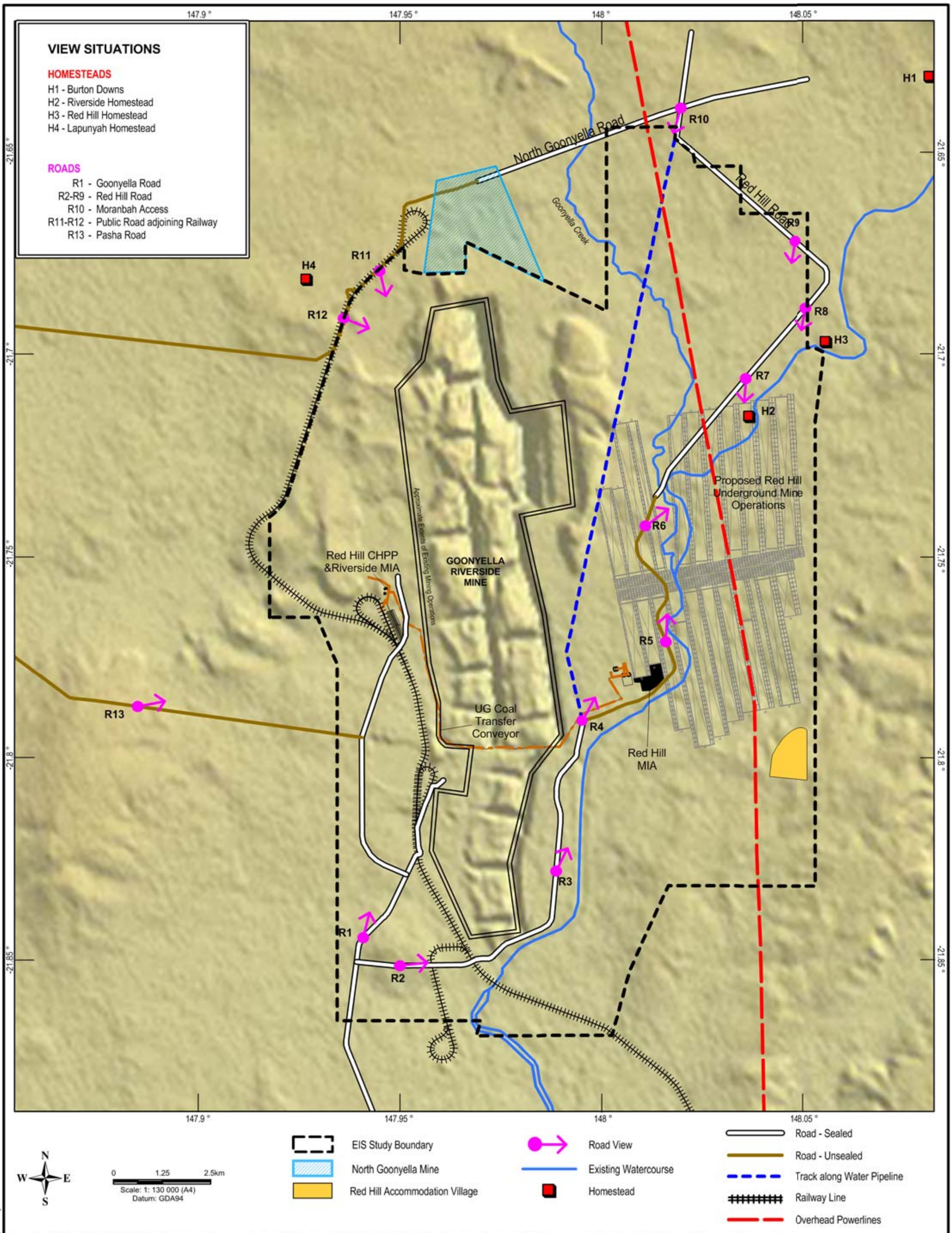
Existing views include:

- open views to north, west and south from hill-top section of the Goonyella Road; and
- views to north include visually prominent overburden landforms associated with the GRM operations.

The majority of traffic using this road is associated with the existing mine operations.

Figure 5.2-13 View North from Goonyella Road (R1)





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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

VIEW SITUATIONS

URS

LAND RESOURCES - SCENIC AMENITY & LIGHTING

Figure: **5.2-14**

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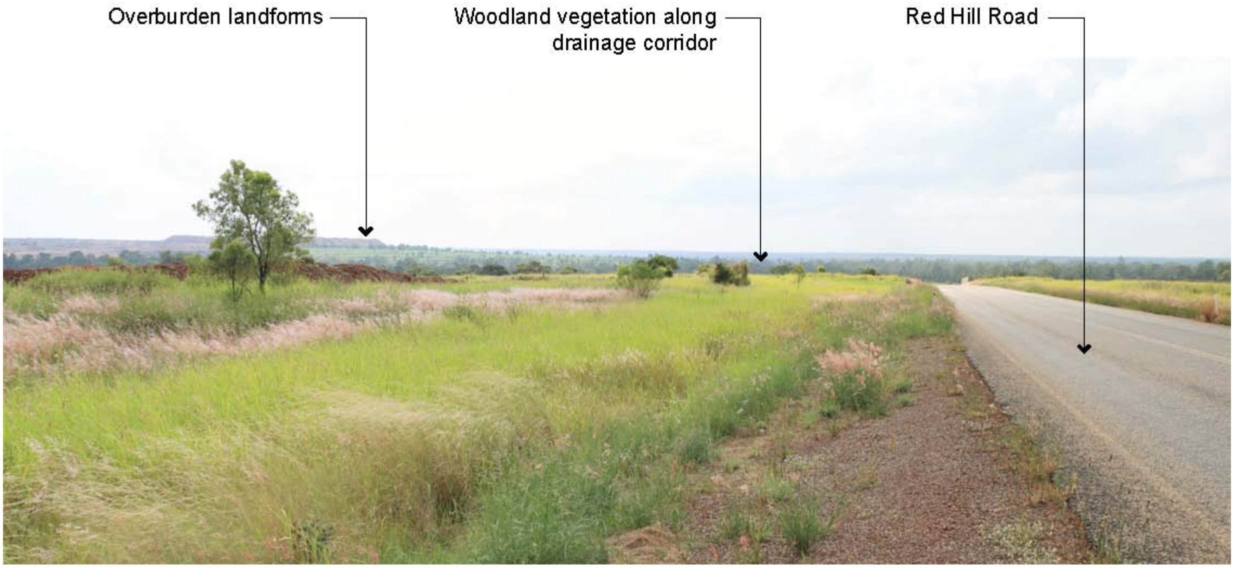
Road 2 (R2) – Red Hill Road South of GRM (Figure 5.2-15)

Existing views include:

- long distance views along the road extend over the Isaac River riparian corridor to mountains on the horizon; and
- overburden landforms are visible on the skyline to the north-east.

This sealed section of Red Hill Road provides access to the eastern side of the GRB mine complex, the proposed EIS study area and rural properties.

Figure 5.2-15 View East from Red Hill Road (R2)



Road 3 (R3) – Red Hill Road near South-East Corner of GRM (Figure 5.2-16)

Existing views include:

- long distance views are confined within the road corridor, and potential views towards the existing GRB mine complex operations and proposed EIS study area are currently blocked by woodland vegetation; and
- low traffic volumes include mine workers, rural property owners and tourists.

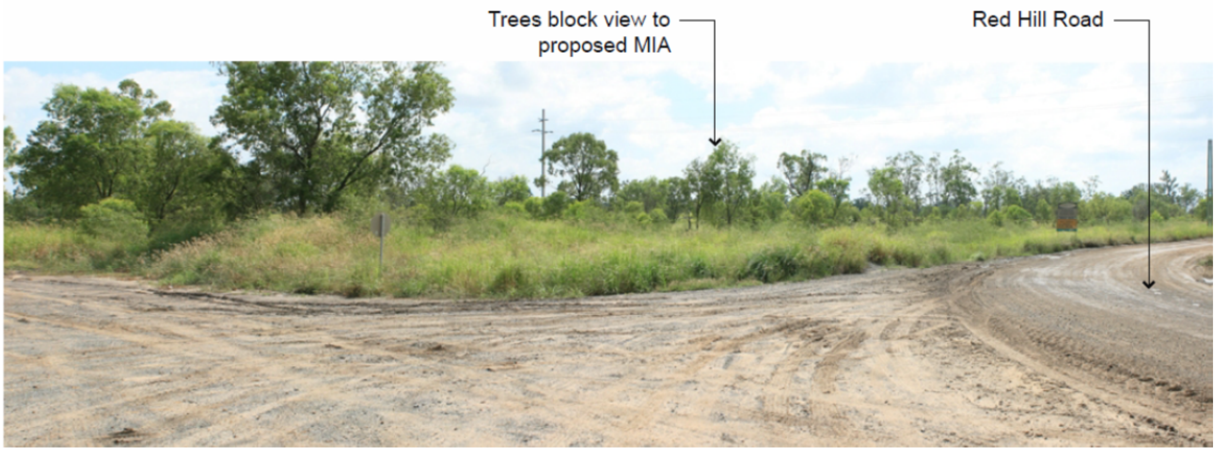
Figure 5.2-16 View North East from Red Hill Road (R3)

Road 4 (R4) – Red Hill Road near entrance to Broadmeadow Mine Industrial Area (Figure 5.2-17)

Existing views include:

- views from this bend in Red Hill Road extend to the tops of existing GRM overburden landforms to the north with views to Broadmeadow mine industrial area (MIA) blocked by roadside embankment; and
- views to the proposed MIA are currently largely blocked by vegetation.

Figure 5.2-17 View North East from Red Hill Road at Broadmeadow MIA Entrance (R4)



Road 5 (R5) – Red Hill Road west of Isaac River (Figure 5.2-18)

Existing views include:

- woodland vegetation adjoining Red Hill Road partially blocks most views towards the existing GRB mine complex operations; and
- views from Red Hill Road to the proposed RHM underground footprint occur where clearing has been carried out for grazing.

Figure 5.2-18 View North across EIS Study Area from Red Hill Road (R5)

Road 6 (R6) – Red Hill Road south of Goonyella Creek Crossing (Figure 5.2-19)

Existing views include:

- views from Red Hill Road extend across a mixture of grassland and woodland on the EIS study area.

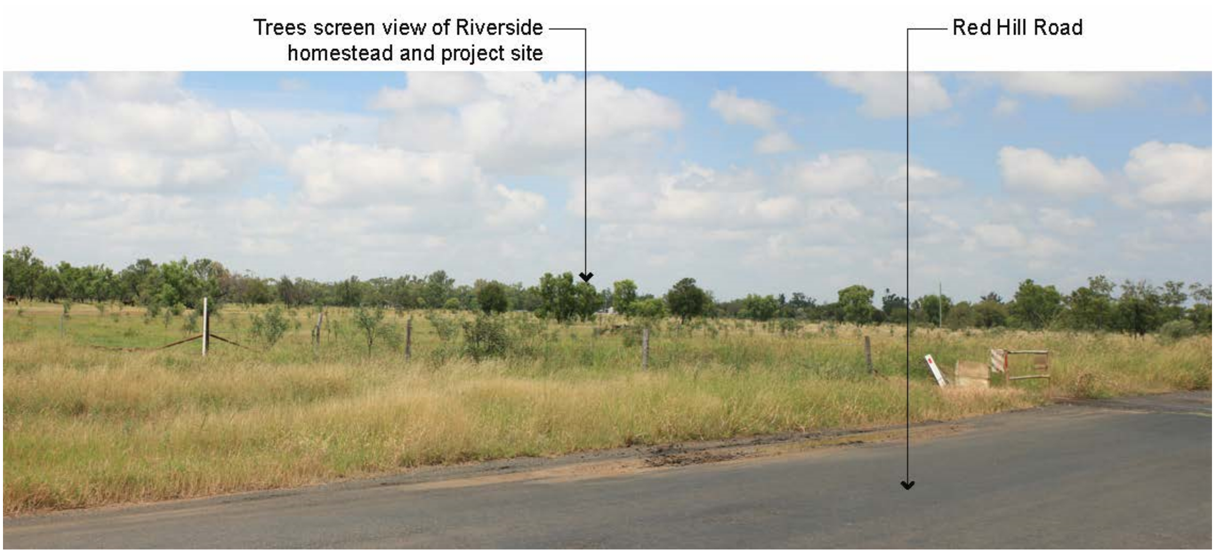
Figure 5.2-19 View North-East across EIS Study Area from Red Hill Road (R6)

Road 7 (R7) – Red Hill Road near Riverside Homestead Entrance (Figure 5.2-20)

Existing views include:

- views from this section of road are generally open in character due to the predominance of grassland with scattered shrubs and small trees; and
- views towards the EIS study area and proposed underground mine footprint are currently blocked by woodland vegetation in mid-distance.

Figure 5.2-20 View South from Red Hill Road near Riverside Homestead (R7)



Road 8 (R8) – Red Hill Road near Entrance to Red Hill Homestead (Figure 5.2-21)

Existing views include:

- views from this section of road are generally short to middle distance with shrubs and trees screening long distance views; and
- potential views to the EIS study area are currently blocked by vegetation and landform.

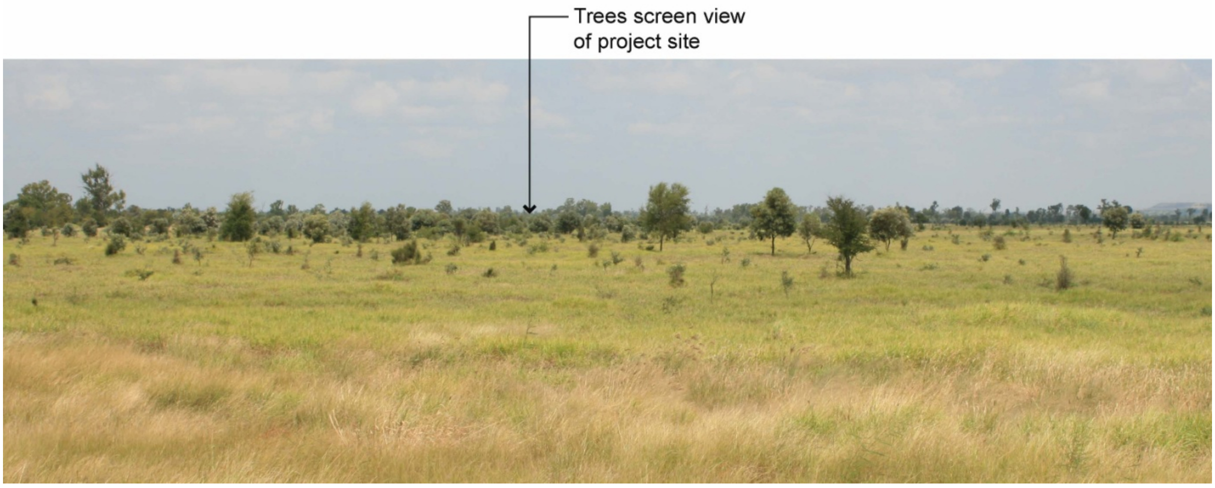
Figure 5.2-21 View South from Red Hill Road near Red Hill Homestead (R8)

Road 9 (R9) – Red Hill Road North of Red Hill Homestead (Figure 5.2-22)

Existing views include:

- views from this section of road are generally open and long distance extending across grassland with scattered shrubs and small trees;
- glimpses of upper portions of the GRM overburden landforms are visible on the horizon; and
- potential views to the EIS study area are currently blocked by vegetation and landform.

Figure 5.2-22 View South from Red Hill Road towards the EIS Study Area (R9)

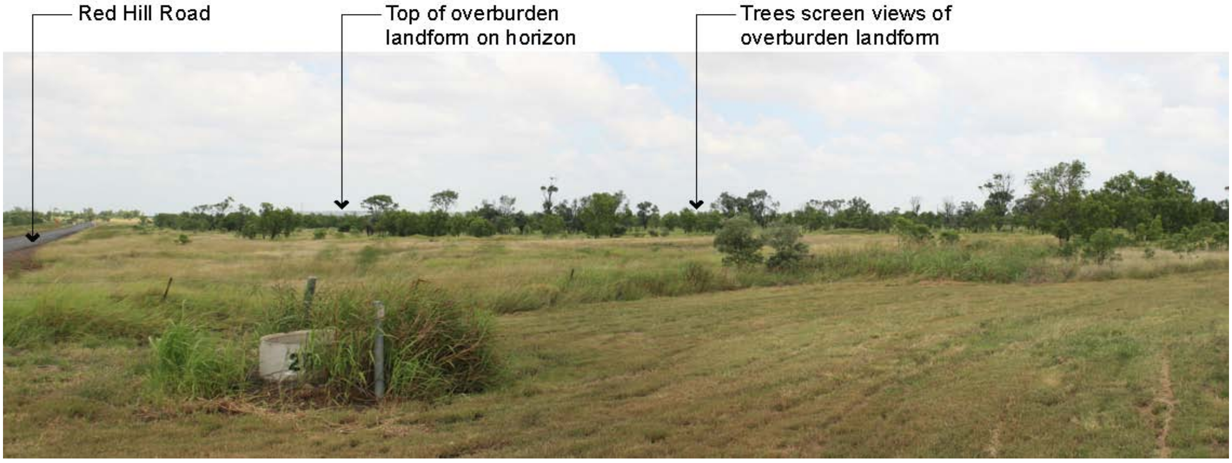


Road 10 (R10) – Red Hill Road and North Goonyella Mine Access Road intersection (Figure 5.2-23)

Existing views include:

- some long distance views but trees in the mid distance generally provide visual screening;
- glimpses of the upper portions of the GRM overburden landforms can be seen through gaps between tree canopies; and
- potential views to the EIS study area are currently blocked by vegetation and landform.

Figure 5.2-23 View South from the Intersection of Red Hill Road and North Goonyella Mine Access Road (R10)

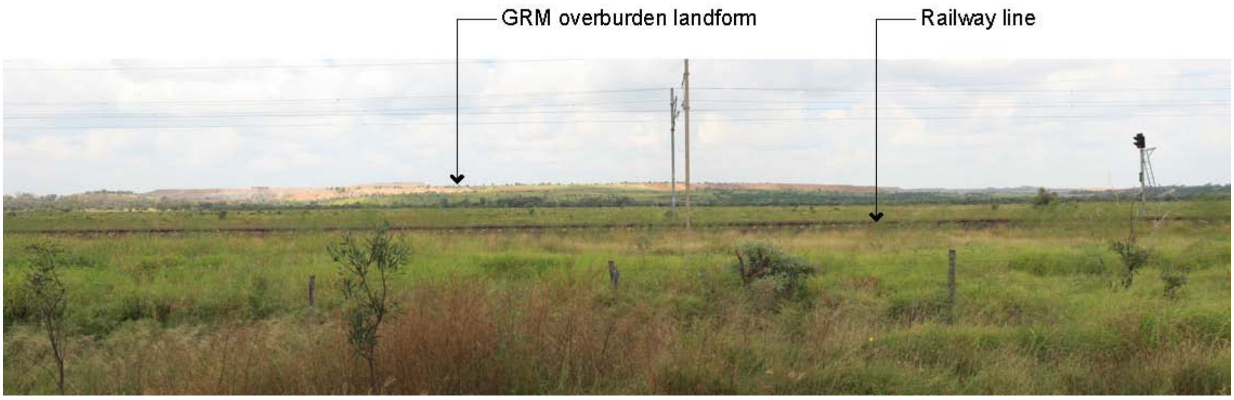


Road 11 (R11) – Public Road alongside Railway Line West of the North Goonyella Mine (Figure 5.2-24)

Existing views include:

- views from this section of unsealed road extend across the railway line in the foreground to the GRM overburden landforms that are visible on the horizon; and
- views to the EIS study area are blocked by the GRM overburden landforms.

Figure 5.2-24 View South across Railway Line to GRM Overburden Landforms (R11)



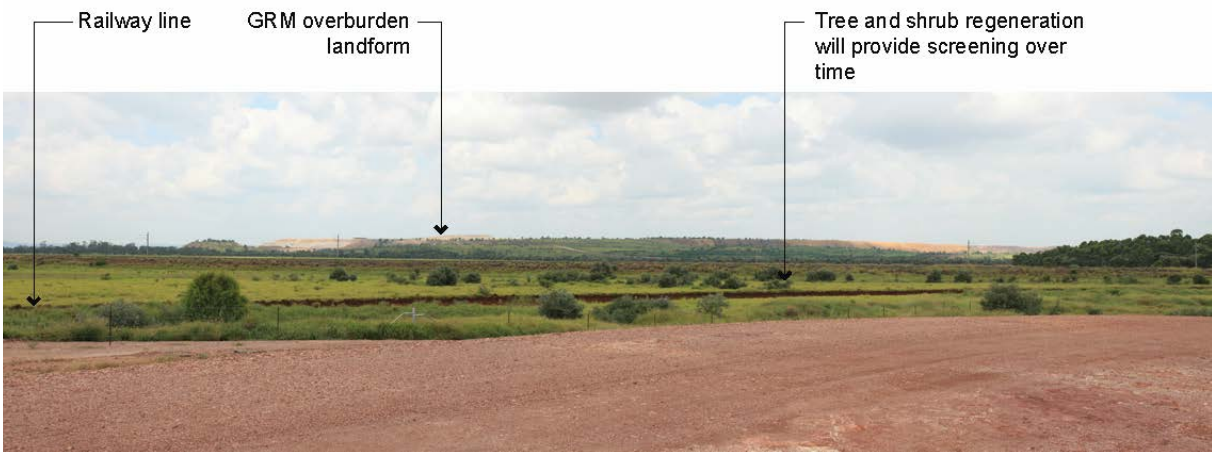
Road 12 (R12) – Public Road near the Entrance to Lapunyah Homestead (Figure 5.2-25)

Existing views include:

- views from this section of unsealed road extend across the railway line in the foreground to the overburden landforms associated with the current GRM mining operations; and
- potential views to the EIS study area are blocked by the GRM overburden landforms.

The number of motorists travelling along this road is very low.

Figure 5.2-25 View East towards the Project Overburden Landform (R12)



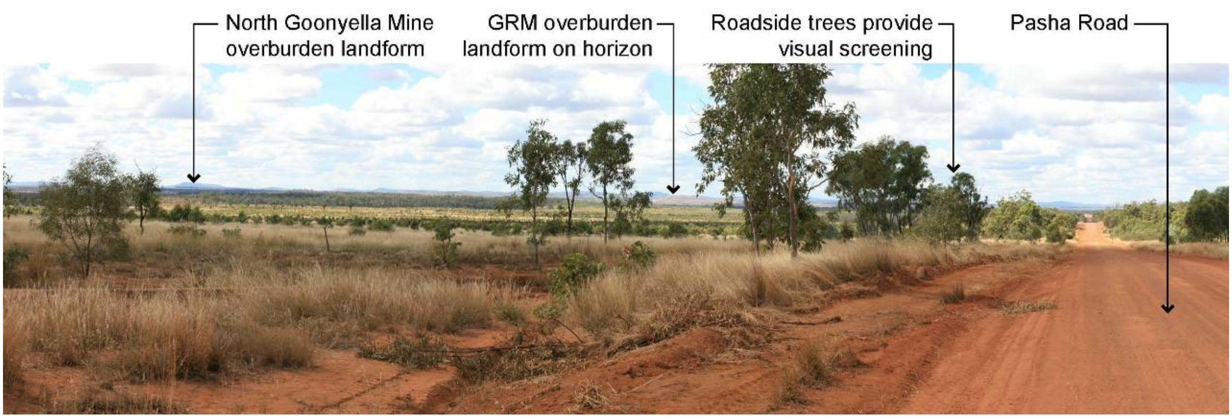
Road 13 (R13) – Pasha Road West of GRM (Figure 5.2-26)

Existing views include:

- views to the east from this section of unsealed public road extend across a broad valley in the mid distance to the GRM overburden landform on the horizon; and
- potential view to EIS study area blocked by roadside vegetation and the GRM overburden landforms.

It is noted (**Section 14**) that the number of motorists travelling on this road is very low.

Figure 5.2-26 View East from Pasha Road towards GRM and North Goonyella Mine (R13)



5.2.1.9 View Situation Assessment – Homesteads

Homestead 1 (H1) – Burton Downs Homestead (Figure 5.2-27)

Existing views include:

- potential views from the homestead towards the GRM and the EIS study area are screened by trees and buildings.

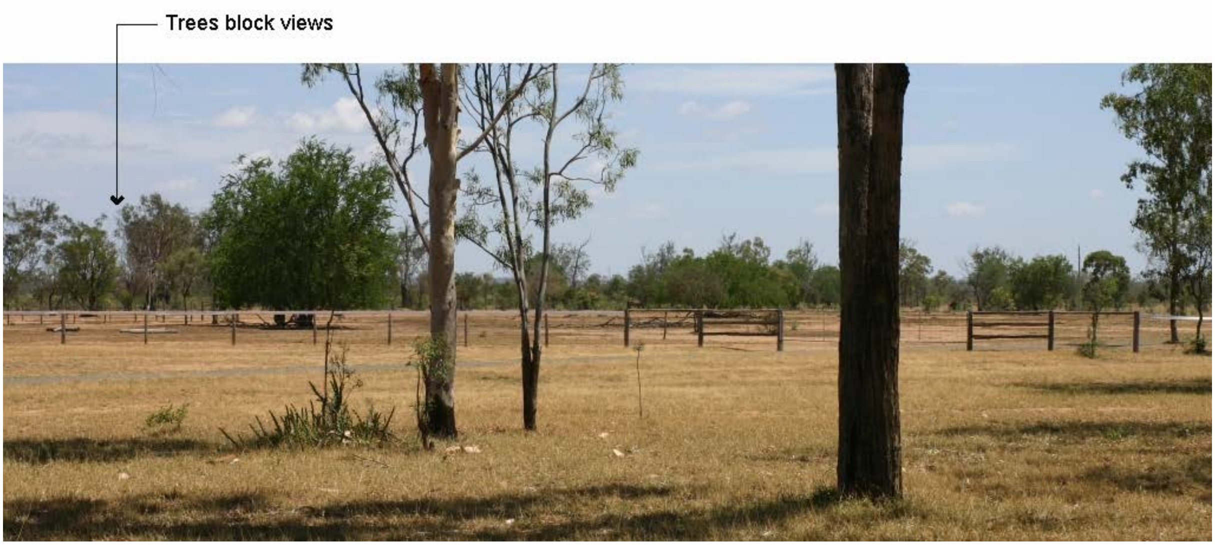
Figure 5.2-27 View from Burton Downs Homestead towards GRM and the EIS Study Area (H1)

Homestead 2 (H2) – Riverside Homestead (Figure 5.2-28)

Existing views include:

- views from the homestead towards the GRM are screened by vegetation; and
- small portions of the tops of the GRM overburden landforms are visible on the skyline between tree canopies.

Figure 5.2-28 View from Riverside Homestead towards Northern End of EIS Study Area (H2)

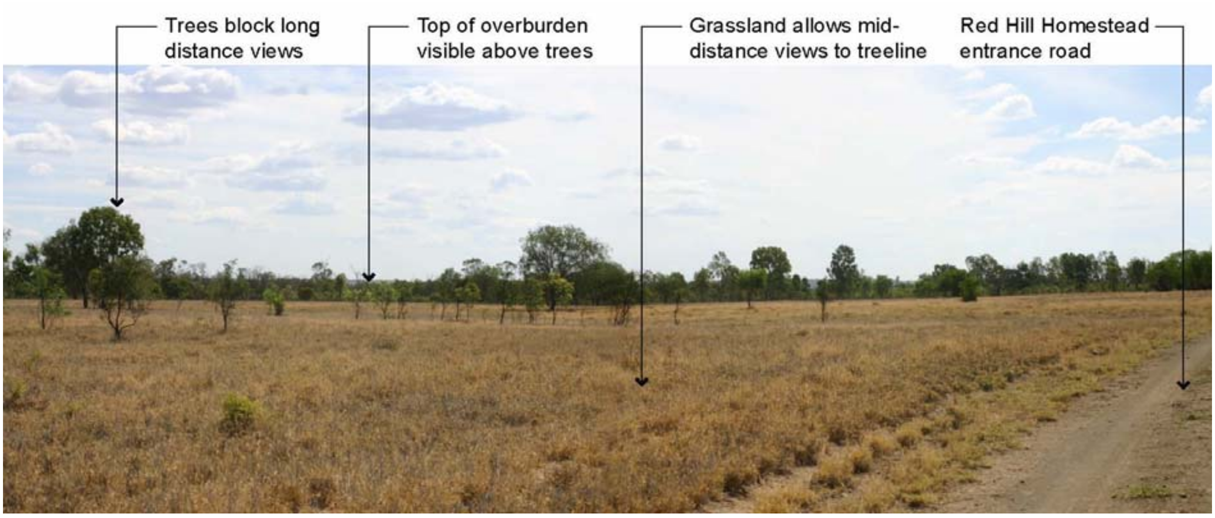


Homestead 3 (H3) – Red Hill Homestead Entrance Road (Figure 5.2-29)

Existing views include:

- glimpses through gaps in the tree canopies to GRM overburden landforms; and
- potential views of the GRM and the EIS study area are blocked by trees and shrubs.

Figure 5.2-29 View from near Entrance to Red Hill Homestead (H3)



Homestead 4 (H4) – Public Road Adjoining Lapunyah Homestead (Figure 5.2-30)

Existing views include:

- potential views along the public road in front of the Lapunyah Homestead towards GRM and the EIS study area beyond are blocked by woodland vegetation; and
- glimpses of the North Goonyella Mine overburden landforms through gaps between the trees.

Figure 5.2-30 View from near Lapunyah Homestead towards GRM and the EIS Study Area (H4)

5.2.2 Potential Impacts from Proposed Project

5.2.2.1 Visual Components of Proposed Project

The majority of visual impact associated with the project relates to the GRM incremental expansion and the RHM underground expansion option. The Broadmeadow extension of panels 14, 15, and 16, into MLA70421 will display surface impacts associated with subsidence and gas drainage infrastructure, however the visual impacts will be low given the location of the proposed extensions and limited surface infrastructure being proposed.

The visual components of the GRM incremental expansion and the RHM underground expansion option include the following:

- a network of bores and associated surface infrastructure over the underground mine footprint to enable extraction of IMG and management of goaf methane;
- a ventilation system for the underground workings;
- a new MIA (**Figure 5.2-32**);
- a CHPP adjacent to the Riverside MIA − the Red Hill CHPP will consist of two 1,200 tonne per hour (tph) modules with the capability to install a third 1,200 tph module;
- a conveyor system linking RHM to the Red Hill CHPP;
- associated coal handling infrastructure and stockpiles;
- a new conveyor linking product coal stockpiles to a new rail load out facility;
- a bridge across the Isaac River located above the main headings;
- a new accommodation village for the construction and operational workforces with capacity up to 3,000 workers (**Figure 5.2-33**);
- a new 66 kilovolt line (five kilometres) to the Riverside MIA;
- a new 66 kilovolt / 11 kilovolt sub-station at the Riverside MIA to feed directly to the mine reticulation system and the Red Hill CHPP;
- relocation of the existing 66 kilovolt line which currently runs north-south across the proposed RHM site;
- relocation of the existing 132 kilovolt substation north of the proposed RHM site;
- construction of a new train load-out to be located on the Riverside rail loop, adjacent to the existing train load-out; and
- a potential new flood protection levee approximately five metres high would be constructed along the western side of the section of Red Hill Road adjoining the proposed RHM MIA as required for flood mitigation.

Figure 5.2-31 View from Red Hill Road across Proposed Underground Mine Footprint

Figure 5.2-32 View from Red Hill Road towards Proposed MIA

Figure 5.2-33 View towards Proposed Red Hill Accommodation Village

Subsidence is predicted to occur as a result of the proposed underground mining operations. The long-term implications for the landscape character of the area are addressed as part of this assessment of visual amenity.

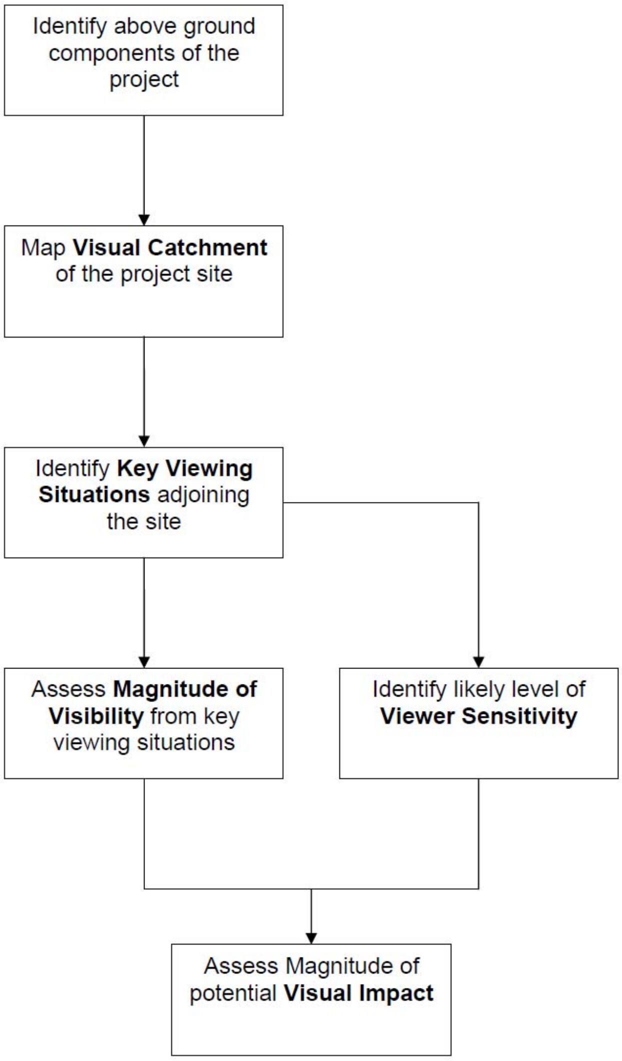
The future RHM mine will not generate any significant additional overburden material. Coal rejects and dewatered tailings from the future RHM and the Broadmeadow extension will be disposed of in existing waste dumps at the GRB mine complex. Consequently, significant new overburden and mine waste landforms will not be created.

A large component of the infrastructure required for the proposed project has already been developed for the current GRB mine complex. This infrastructure includes industrial areas, power transmission lines, rail infrastructure, rejects emplacements, roads (both service and haul), sediment dams, water supply dams and water supply pipelines. However, a number of new infrastructure elements will be required, as listed above.

5.2.2.2 Assessment Methodology

The methodology developed to assess the extent to which the proposed operations and infrastructure have the potential to impact the visual amenity of surrounding areas is illustrated in **Figure 5.2-34**.

Figure 5.2-34 Visual Assessment Methodology



The methodology used has involved identification of the extent to which the proposed mining operations and infrastructure would be visible (magnitude of visibility) and the sensitivity of viewers who would potentially see the changes resulting from the mining operations (viewer sensitivity). These two components were then combined to determine the magnitude of potential visual Impact of the proposed mining operations.

5.2.2.3 Visibility (Viewshed) Assessment

The approximate extent to which the above ground components of the GRM incremental expansion and the RHM may be visible is referred to as the potential viewshed and is indicated on **Figure 5.2-35**. It should be noted that this is an approximate area in which the above ground components may be partly or wholly visible. Visibility at a particular location within the potential viewshed may be partly or fully blocked by vegetation, structures or local landforms located close to the viewer.

The extent to which various components of the proposed GRM incremental expansion and the RHM underground expansion option will be visible within the potential viewshed will vary. For example, those above ground components of the gas management system adjoining Red Hill Road will be more visible than the new Red Hill MIA, which will be located more than 2.5 kilometres from Red Hill Road against a backdrop of existing mining activities.

The key view situations that are described in **Section 5.2.2.4** are also shown on **Figure 5.2-35** together with the potential viewshed. The potential visual impact of the proposed GRM incremental expansion and the RHM underground expansion option on viewers at these key view situations has been assessed and the results presented in the following sections.

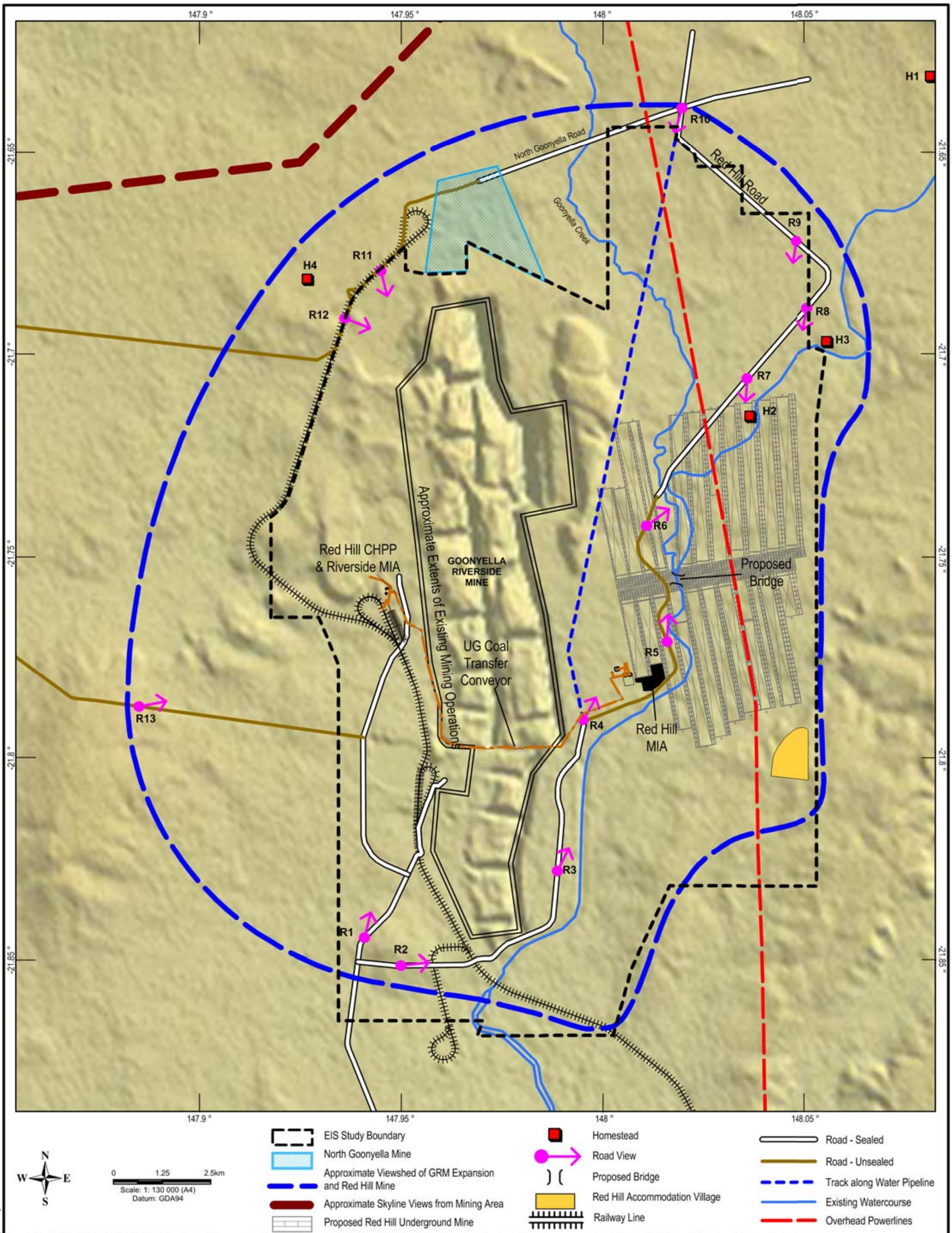
5.2.2.4 Visual Impact Assessment Criteria

The criteria used to determine the potential magnitude of visibility (i.e. the extent to which components of the project are visible) of the above ground components of the proposed GRM incremental expansion and the RHM are defined in **Table 5.2–3**.

View Situation

Table 5.2-3 View Situation Assessment Criteria

Criteria	Definition
View Distance	
Long Medium Short Very short	>5 km 1-5 km 200 - 1,000 m <200 m
Period of View	
Long term Medium term Short term	>2 hours 1 minute to 2 hours <1 minute
Number of Viewers	
High Medium Low Very low	>5,000 people per day 1,000 – 5,000 people per day 100 – 1,000 people per day <100 people per day



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

POTENTIAL VIEWSHED OF PROPOSED RED HILL MINE OPERATIONS

URS

LAND RESOURCES - SCENIC AMENITY & LIGHTING

Figure: **5.2-35**

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5.2.2.5 Visual Impact Assessment – Viewer Locations

In order to determine number of viewers from public roads, a peak hour traffic volume survey was undertaken in May 2013 for the two public roads listed in the table above are summarised in **Table 5.2-4**.

Table 5.2-4 Traffic Counts

Road (Location)	Am Peak Hour Two-Way Vehicle Volume	AM Heavy Vehicle %	PM Peak Hour Two-Way Vehicle Volume	PM Heavy Vehicle %
Goonyella Road	445	8%	358	5%
Red Hill Road	151	7%	123	4%

The magnitude of visibility resulting from various combinations of the above criteria are presented in **Table 5.2-5**. Under each of the four categories of view distance three categories of period of view is listed (i.e. long, medium, short periods of view). In each column the magnitude of visibility resulting from the particular combination of number of viewers, period of view and view distance is listed. The categories of negligible (N), low (L), medium (M) or high (H) are defined below.

Table 5.2-5 Magnitude of Visibility Matrix

View Distance		Long Distance			Medium Distance			Short Distance			Very Short Distance		
Period of View[1]		L	M	S	L	M	S	L	M	S	L	M	S
		Magnitude of Visibility[2]											
Number of Viewers	High	M	L	L	H	M	M	H	H	M	H	H	H
	Medium	L	L	N	M	M	L	H	M	M	H	H	M
	Low	L	N	N	M	L	L	M	M	L	H	M	M
	Very Low	N	N	N	L	N	N	L	L	L	M	L	L

Note 1: L = Long, M = Medium and S = Short
Note 2: N = Negligible, L = Low, M = Medium and H = High

Magnitude of Visibility

The four categories of magnitude of visibility of view are defined below.

Negligible (N) – very minor loss or alteration to one or more key elements/features/characteristics of the baseline visual character (i.e. pre-development landscape or view) and/or introduction of elements that are not uncharacteristic to the existing landscape (i.e. approximating the ‘no change’ situation).

Low (L) – minor loss of/or alterations to one or more key elements/features/characteristics of the baseline visual character (i.e. pre-development landscape or view) and/or introduction of elements that are not uncharacteristic of the existing landscape.

Medium (M) – partial loss of/or alteration to one or more key elements/features/characteristics of the baseline visual character (i.e. pre-development landscape or view) and/or introduction of elements that may be prominent but not considered to be substantially uncharacteristic of the existing landscape.

High (H) – total loss of key elements/features/characteristics of the baseline visual character (i.e. pre-development landscape or view) and/or introduction of elements considered to be totally uncharacteristic of the existing landscape.

Viewer Sensitivity

Viewer sensitivity is defined as the extent to which a viewer is able and/or willing to accept changes to the existing view that would result from the mine development, without perceiving it as an adverse impact on the quality of the current view. Viewer sensitivity is influenced by a combination of:

- location and context of the view (e.g. residences, workplaces, recreation/open space areas, public roads/highways);
- expectations and activities of the viewer (e.g. resident relaxing at home, worker engaged in work activities, motorists driving or as passenger, people participating in recreation/sporting activities reliant on the natural environment); and
- importance of the view (e.g. significance as a regional scenic resource, referenced in tourist maps/guides, numbers of people deliberately seeking the view, reference to the view in literature).

Those with the highest levels of viewer sensitivity are likely to include:

- residents with views affected by the proposed mining operations;
- users of public open space where their attention is focused on visual landscape values, such as scenic lookouts and natural landscape areas with attractive views; and
- communities in which the proposed mining operations would result in changes to the landscape setting of views that are valued by the community.

Those with the lowest viewer sensitivity are likely to be:

- workers who are focused on work activities;
- motorists whose attention is focused on driving; and
- people who are actively engaged in outdoor sporting activities.

The two main categories of potential viewers relevant to the project are motorists travelling on public roads and residents in homesteads located in the vicinity of the proposed above ground components. While residents are generally considered to have a high viewer sensitivity, the visual assessment has determined that the proposed above ground components of the project will not be visible from any homesteads due to the screening of views by existing vegetation and/or existing overburden landforms. Motorists travelling on public roads are generally likely to have a low level of viewer sensitivity.

The criteria defined in **Table 5.2-6** were applied to each view situation to determine the magnitude of visibility of the proposed new overburden landform.

Table 5.2-6 Magnitude of Visibility of Proposed Mining

View Situation	View Distance (approx. distance to MIA)	Viewer sensitivity	Approx. Period of View	Relative No. of Viewers	Magnitude of Visibility
Roads					
R1 – Goonyella Road entrance to GRM	Long 9.5 km	GRM and project related traffic, local residents and visitors to properties.	Medium	Very Low	Negligible
R2 – Red Hill Road south of GRM	Long 10 km	GRM and project related traffic, local residents and visitors to properties and recreation facilities to the north.	Medium	Very Low	Negligible
R3 – Red Hill Road adjoining south-east corner of GRM	Long 6 km	Local residents and visitors to properties and recreation facilities to the north.	Medium	Low	Negligible
R4 – Red Hill Road at northern end of Isaac River diversion	Short 1 km	Local residents and visitors to properties and recreation facilities to the north.	Medium	Low	Medium
R5 – Red Hill Road west of Isaac River	Short 1 km	Local residents and visitors to properties and recreation facilities to the north.	Medium	Low	Medium
R6 – Red Hill Road north of Goonyella Ck. Crossing	Medium 4 km	Local residents and visitors to properties and recreation facilities to the north.	Medium	Low	Low
R7 - Red Hill Road near Riverside Homestead northern entrance	Long 10 km	Local residents and visitors to properties and recreation facilities to the north.	Medium	Low	Negligible
R8 – Red Hill Road near entrance to Red Hill Homestead	Long 12 km	Local residents and visitors to properties and recreation facilities to the north.	Medium	Low	Negligible
R9 – Red Hill Road north of Red Hill Homestead	Long 13 km	Local residents and visitors to properties and recreation facilities to the north.	Medium	Low	Negligible
R10 – Red Hill Road and North Goonyella Mine Access Road intersection	Long 16 km	North Goonyella Mine related traffic, local residents and visitors to properties and recreation facilities to the north.	Medium	Low	Negligible
R11 – Public road alongside railway line west of the North Goonyella Mine	Long 14 km	Local residents and visitors to properties.	Medium	Low	Negligible

View Situation	View Distance (approx. distance to MIA)	Viewer sensitivity	Approx. Period of View	Relative No. of Viewers	Magnitude of Visibility
R12 – Public road parallel to railway line west of GRM	Long 13 km	Local residents and visitors to properties.	Medium	Low	Negligible
R13 – Pasha Road west of proposed Holding Paddock Dam	Long 13 km	Local residents and visitors to properties.	Medium	Very Low	Negligible
Homesteads					
H1 – Burton Downs Homestead	Long 17 km	Local residents and visitors to properties.	Not visible	Very Low	Negligible
H2 – Riverside Homestead	Long 7.5 km	Local residents and visitors to properties.	Not visible	Very Low	Negligible
H3 – Red Hill Homestead	Long 10 km	Local residents, works and visitors to properties.	Not visible	Very Low	Negligible
H4 – Public road at Lapunyah Homestead	Long 14 km	Local residents and visitors to properties.	Not visible	Very Low	Negligible

The above ground infrastructure associated with the project will create the primary change to the visual landscape. The magnitude of potential visual impact predicted to result from these components has been determined by combining the magnitude of visibility with the level of viewer sensitivity in accordance with methodology presented on **Figure 5.2-34** and the matrix in **Table 5.2-7**.

Table 5.2-7 Visual Impact Magnitude Matrix

Magnitude of Visibility	Viewer Sensitivity		
	Low	**Medium**	**High**
High	Moderate	Moderate/High	High
Medium	Low/Moderate	Moderate	Moderate /High
Low	Low	Low/Moderate	Moderate
Negligible	Negligible	Negligible/Low	Low

The various levels of 'visual impact magnitude' applied in the assessment process are defined below. These definitions have been adapted from those presented in *Guidelines for Landscape and Visual Impact Assessment* prepared by The Landscape Institute and Institute of Environmental Management and Assessment in the UK (Landscape Institute 2002).

Negligible visual impact - only a very small part of the development would be discernible and/or it would be located at such a distance that it would be scarcely or not visible at all from any significant viewing locations.

Low visual impact - the development would constitute only a minor component of the wider view and might be missed by the casual observer; awareness of the development would not have a marked effect on the overall quality of the view and/or viewer sensitivity is low.

Moderate visual impact - the development may form a visible and recognisable new element within the overall scene and may be readily noticed by an observer.

High visual impact - the development would form a significant and immediately apparent part of the view that would affect and change its overall character (the change may be positive or negative).

Each of the view situations identified during the field inspection are shown on **Figure 5.2-35** and listed in **Table 5.2-8**. The assessed magnitude of visibility, and viewer sensitivity, are also listed in **Table 5.2-8** together with the visual impact magnitude that was determined in accordance with **Table 5.2-7**.

Table 5.2-8 Visual Impact Assessment for View Situations

View Situation	View Situation	Magnitude of View Change	Viewer Sensitivity	Visual Impact Magnitude	Comments
Roads					
R1 – Goonyella Road entrance to GRM	North	Negligible	Low	**Negligible**	Potential view of GRM incremental expansion and the RHM infrastructure will generally be blocked by current GRM overburden landform and woodland vegetation.
R2 – Red Hill Road south of GRM	East	Negligible	Low	**Negligible**	Potential views of Red Hill MIA will be blocked by current GRM landform.
R3 – Red Hill Road adjoining south-east corner of GRM	North	Negligible	Low	**Negligible**	Potential views of Red Hill MIA will be blocked by woodland vegetation.
R4 – Red Hill Road at northern end of Isaac River diversion	East	Medium	Low	**Low/Moderate**	Potential views of Red Hill MIA will generally be blocked by woodland vegetation and proposed levee alongside Red Hill Road.

View Situation	View Situation	Magnitude of View Change	Viewer Sensitivity	Visual Impact Magnitude	Comments
R5 – Red Hill Road west of Isaac River	West	Medium	Low	**Low/Moderate**	Potential view of Red Hill MIA will generally be blocked by woodland vegetation but a number of gas management well heads to the west of Red Hill Road will be visible to motorists.
R6 – Red Hill Road north of Goonyella Ck. crossing	North East	Low	Low	**Low**	Potential view of Red Hill MIA will be blocked by woodland vegetation but a number of gas management well heads will be visible to motorists travelling along Red Hill Road.
R7 – Red Hill Road near Riverside Homestead northern entrance	East	Negligible	Low	**Negligible**	The Red Hill MIA facilities will not be visible from this location. Views to gas management well heads will be screened by existing vegetation.
R8 – Red Hill Road near entrance to Red Hill Homestead	South	Negligible	Low	**Negligible**	The above ground infrastructure will not be visible from this location.
R9 – Red Hill Road north of Red Hill Homestead	South	Negligible	Low	**Negligible**	The above ground infrastructure will not be visible from this location.
R10 – Red Hill Road and North Goonyella Mine Access Road intersection	South	Negligible	Low	**Negligible**	The above ground infrastructure will not be visible from this location.
R11 – Public road alongside railway line west of the North Goonyella Mine	East	Negligible	Low	**Negligible**	The above ground infrastructure will not be visible from this location.
R12 – Public road parallel to railway line west of GRM	East	Negligible	Low	**Negligible**	The above ground infrastructure will not be visible from this location.
R13 – Pasha Road west of GRM	East	Negligible	Low	**Negligible**	The above ground infrastructure will not be visible from this location.

View Situation	View Situation	Magnitude of View Change	Viewer Sensitivity	Visual Impact Magnitude	Comments
Homesteads					
H1 – Burton Downs Homestead	West	Negligible	High	**Negligible**	The above ground infrastructure will not be visible from the house.
H2 – Riverside Homestead	West	Negligible	High	**Negligible**	The above ground infrastructure will not be visible from the house.
H3 – Red Hill Homestead entrance road	West	Negligible	High	**Negligible**	The above ground infrastructure will not be visible from the house.
H4 – Public road at Lapunyah Homestead	East	Negligible	High	**Negligible**	The above ground infrastructure will not be visible from the house.

5.2.2.6 Visual Impact Assessment – Above Ground Components

The proposed project elements will involve development or upgrading of above ground infrastructure. This will include a gas management system for both the future RHM and the Broadmeadow extension, and coal handling facilities, rail infrastructure, vehicle maintenance, administration buildings, powerlines, the Red Hill accommodation village, a bridge over the Isaac River and a possible water pipeline diversion associated with the RHM underground expansion option. Each of these infrastructure elements are discussed in relation to their visibility and potential visual impact.

New Red Hill CHPP at Riverside MIA

The new CHPP will be constructed in the vicinity of the existing Riverside CHPP at Riverside MIA on the western side of the GRM overburden landforms. It will only be visible to people working or visiting the MIA, and will be seen in the context of the existing Riverside CHPP. From a distance, it will not be discernible from other structures associated with the existing mining activities. Consequently, the visual impact is predicted to be negligible (see **Figure 5.2-36**).

Figure 5.2-36 View of Riverside MIA and CHPP from Adjoining Reject Landform

Red Hill MIA

The proposed Red Hill MIA will be located approximately 100 metres from Red Hill Road at the closest point. However, a proposed levee is to be constructed between Red Hill Road and the MIA, which will generally be running parallel to the road. The height of the proposed levee will be approximately five metres, or as otherwise required for flood mitigation and would be expected to screen views of most infrastructure components. The potential visual impact is predicted to be low.

Raw Coal Stockpiles

The two raw coal stockpiles associated with the proposed transfer conveyor and located at the Red Hill MIA are expected to be approximately 40 metres high. They will be located approximately 250 metres from the nearest section of Red Hill Road and separated from it by the proposed levee and any retained remnant woodland vegetation. Potential views are expected to be limited to glimpses of the tops of the coal stockpiles and conveyor. The visible structures will be similar to other structures associated with the existing mine operations and, hence, no new types of structures will be introduced. The potential visual impact on motorists travelling along Red Hill Road is therefore predicted to be low.

Coal Transfer Conveyor

A conveyor system will transfer coal from the raw coal stockpiles at the Red Hill MIA to the proposed Red Hill CHPP at the Riverside MIA from where it will be loaded on to trains. The coal transfer conveyor will be approximately two metres wide and about one metre high supported on a structure typically 1.5 metres above the ground. Transfer stations approximately five metres high will be located at intermediate points along the conveyor system. The conveyor alignment largely passes through already developed areas and the conveyor will be seen against a background of mining infrastructure and overburden stockpiles.

The proposed levee to be constructed alongside Red Hill Road will block views of the conveyor, which will not be visible from any homesteads. However, the conveyor will be visible to a very limited extent where it crosses Red Hill Road. The visual impact is predicted to generally be negligible.

Powerlines

While locations of new powerlines have not been finalised, it is expected that sections of new powerlines to be constructed as part of the project include:

- 66 kilovolt, potentially alongside the realigned section of Red Hill Road stock route to supply power to the mine and Red Hill accommodation village; and
- 66 kilovolt to provide additional power for the new infrastructure to be developed at the Riverside MIA.

The section of power line that will adjoin Red Hill Road will be seen in the context of an existing power line and the visual impact is predicted to be low.

A new section of power line that will run alongside the realigned Red Hill Road stock route will not be visible from Red Hill Road, except where it crosses near the Red Hill MIA (see **Figure 5.2-37**). The level of visual impact is predicted to be low.

Figure 5.2-37 Typical Powerlines Associated with GRM

Electrical Sub-stations

A 132 kilovolt sub-station is to potentially be relocated alongside the existing 132 kilovolt power line north of the proposed RHM underground expansion option footprint. As a result, the sub-station may be located approximately 500 metres from Red Hill Road and partly screened from view by roadside vegetation. The visual impact on motorists travelling along Red Hill Road is predicted to be negligible.

A new 66 kilovolt sub-station is to be constructed alongside Riverside Access Road at the southern end of the new section of 66 kilovolt power line. The sub-station, which is relatively small in size, will be set back from the road and the visual impact on motorists travelling to and from the Goonyella and Riverside MIAs is predicted to be Low.

Red Hill Accommodation Village

A new accommodation village will be constructed on a site approximately 3.7 kilometres from Red Hill Road. This site is separated from Red Hill Road by the Isaac River corridor and potential views will be screened by riparian vegetation that is to be retained along the river corridor, so will not be visible from Red Hill Road or from any homesteads. The potential visual impact has therefore been assessed as negligible.

Bridge across Isaac River

A bridge is to be constructed across the Isaac River above the main drive of the RHM underground expansion option, which will carry water pipelines and gas pipelines associated with the IMG management system. The proposed retention of existing vegetation along the Isaac River corridor is expected to partially visually screen the bridge from motorists travelling along Red Hill Road. Motorists may see glimpses of the bridge, however, the potential visual impact has been assessed as negligible.

Lighting

Lighting impacts associated with the project will be limited to the above ground components of the proposed Red Hill MIA, accommodation village and CHPP. Such lighting would be similar to that associated with the current mining operations. Given the proximity of the MIA and CHPP to the existing mining operations the visual impact of lighting associated with the MIA and CHPP is expected to be minimal. Potential views from the adjoining section of Red Hill Road will generally be screened by the proposed levee and remnant roadside vegetation that is expected to remain. Night time traffic on Red Hill Road is generally low. The potential visual impact of lighting at the MIA and CHPP is therefore predicted to be low.

Lighting from the accommodation camp may be visible as glimpses through trees to motorists travelling on Red Hill Road; however intensity of these lights will be low and not expected to be highly visible. Additionally, night time traffic on Red Hill Road is generally low. The potential visual impact has therefore been assessed as low.

Incidental Mine Gas Management System

The project will require extensive surface infrastructure to drain and manage IMG to enable the safe and efficient operation of the underground mine. IMG management will involve a series of wells to remove gas prior to underground mining (gas pre-drainage) and a second set of wells will be installed to remove goaf gas from those portions of the underground mine from which coal has been removed.

The IMG management system will consist of a network of gas drainage infrastructure comprising gas pipes, water pipes, tracks and wells as described in **Section 3.8.2**. Once mining has occurred, goaf gas drainage wells will also be required as discussed in **Section 3.8.4**.

Above ground components will consist of pumps, vents and pipes, with typical facilities as illustrated by **Figure 5.2-38**.

Some of the gas wells, as well as associated pipeline and access track corridors will be visible from the 10 kilometre section of Red Hill Road that will run above the RHM underground expansion option footprint. The visible installations are predicted to have a moderate visual impact on motorists travelling along Red Hill Road.

Figure 5.2-38 Typical Gas Extraction Infrastructure

Flaring of gas may be required during initial well installation using flares similar to that shown in **Figure 5.2-39**. Flares may also be needed for short term use if some kind of emergency situation prevents gas being piped away for utilisation.

Figure 5.2-39 Typical Gas Extraction Infrastructure with Flaring

Gas flaring will be quite visible at night at those flare stacks located near Red Hill Road. However, the night time traffic flow along this section of Red Hill Road is low. The short term nature of flaring and the generally low visual sensitivity of motorists is expected to result in only a moderate visual impact.

A drill rig and associated equipment including a derrick, top drive, high pressure pumps, iron roughneck, mud handling systems, electrical generator, pipe racking and related support equipment including tool skids, offices and crib facilities will be utilised for gas well installation. A photograph of a typical drilling rig is presented in **Figure 5.2-40**. Due to the height of the drilling rig, it is likely to be visible to people travelling on Red Hill Road.

Figure 5.2-40 Typical Access Track and Drill Rig on Hardstand Pad

Ongoing maintenance operations will involve four-wheel drive vehicle access to individual well sites on a regular basis to observe site conditions. Maintenance at each well site will be carried out as required and will involve mobilisation of a 'workover' rig and crew to remove and replace 'downhole' equipment.

The potential visual impact resulting from installation and operation of the IMG management wells will primarily affect motorists travelling along Red Hill Road. The length of Red Hill Road passing through the area of wells is approximately 10 kilometres. The number of well sites that are likely to be visible from Red Hill Road will depend on the exact locations of the well heads and the stage of the project but it is likely that a number of well locations, as well as associated linear infrastructure corridors, will be visible from the road. Depending on the number of wells, visual impact could be moderate to high in the initial stages where gas wells are being installed. However, as vegetation is re-established the visual impact is predicted to reduce to low to moderate.

Surface Subsidence

The proposed underground mining process will result in subsidence of the overlying ground surface. The degree of subsidence will vary but is predicted to average between three to five metres with a maximum of six metres. The pattern of surface subsidence will generally reflect the pattern of mining below. This will result in marked localised changes to surface drainage patterns and topography as described by Alluvium (2011). A number of drainage lines will follow the alignment of the underground mining panels and ponds will form in some of the subsidence troughs, as shown in **Section 7.3.7**.

Runoff will collect in subsidence areas, resulting in increased soil moisture along the base of the subsided areas. Vegetation species that typically occur along drainage lines are likely to be favoured by this change in soil moisture, which will produce a change in the species composition. As a result, the landscape character of the area will change over time, although this is expected to be a relatively slow process and, in the longer term, may result in a more visually diverse landscape. However, during this process it is likely that some existing vegetation will die as a result of changes to drainage pattern and surface cracking (exposing or severing roots) along the edges of the subsidence areas.

In those areas where existing vegetation is to be cleared to install the IMG management system the proposed site remediation works are to establish a grassland cover for grazing with riparian woodland vegetation along drainage lines. Species selection for these revegetation works will be able to take account of the predicted pattern of surface subsidence and altered drainage. Refer to **Section 9.6.3** for further details on impacts to species composition and **Section 5.5** for proposed rehabilitation strategies.

While subsidence will change some aspects of the landscape at a local scale, the overall landscape character will continue to reflect a mosaic of grassland and bushland together with some new ponded areas. The likely visual impact of the mine subsidence had been assessed as generally low.

Levee

A flood protection levee may be required for the MIA. If required, the levee would be constructed adjoining the Red Hill MIA and is expected to be visible from some sections of Red Hill Road. While the levee will be visually prominent immediately after construction, due to the contrast in colour between the bare soil of the levee and the adjoining natural vegetation, it will reduce significantly once a vegetation cover is established on the levee embankment surface. The longer term visual impact is predicted to be low. It should also be noted that the levee will create a positive visual benefit by screening views from Red Hill Road to the structures and buildings associated with the Red Hill MIA.

Potential Obstruction of Sunlight

The proposed underground mining operations will not result in the creation of new landforms that could potentially obstruct sunlight. Shadows from the proposed above ground infrastructure elements will not fall on any areas associated with homesteads or public roads or open space recreation areas.

Summary

The above ground components of the project will result in changes to the existing landscape character of the area. However, the various components of mine infrastructure will generally not be visible from Red Hill Road, which is the only significant public road in the vicinity of the proposed RHM. In situations where infrastructure elements may be visible, the long distance of the view will result in the potential visual impact being low or negligible, as outlined in **Table 5.2-9**.

Table 5.2-9 Potential Visual Impacts of Infrastructure Elements

Infrastructure Element	Visual Impact Magnitude	Comment
New Red Hill CHPP at Riverside MIA	Negligible	This new infrastructure element will not be visible from public roads or homesteads.
Red Hill MIA	Low	Structures associated with the Red Hill MIA will not be visible from any homesteads and are not expected to be visible from Red Hill Road.
Raw coal stockpiles located at the Red Hill MIA	Low	The stockpile will not be visible from any homesteads and any views from Red Hill Road will be limited to tops of the stockpiles.
Underground coal transfer Conveyor	Negligible	The conveyor will not be visible to motorists travelling along Red Hill Road or from homesteads, except where the conveyor crosses Red Hill Road, and this visibility will only be for a very short duration.
Power lines	Low/Negligible	The new 132 kV power line to be located along the eastern edge of the mine lease area will not be visible from Red Hill Road or homesteads.
Electrical sub-stations	Negligible	The sub-station will not be visible from any homesteads or from Red Hill Road.
Red Hill accommodation village	Negligible	The Red Hill accommodation village is not expected to be visible from Red Hill Road and will not be visible from any homesteads.
Bridge across Isaac River	Low/Negligible	The bridge structure will generally not be visible to motorists travelling along Red Hill Road due to the retention of vegetation along the Isaac River.
Lighting	Low	Lighting associated with the above ground components of the mine will not generally be visible from public roads or homesteads.
Gas management system	Moderate	Gas venting installations that are visible from Red Hill Road will create a moderate visual impact on motorists travelling along the road. Clearing of existing shrub and tree vegetation to install the wells will impact the visual amenity of the area. However, retention of vegetation along the Isaac River and major creek lines will provide visual screening in some locations.
Surface subsidence	Low	Areas of subsidence and changes to the drainage and vegetation cover in areas adjoining Red Hill Road will be visible to motorists. However, in the longer term a more visually diverse landscape may evolve.
Potential obstruction of sunlight	Negligible	No new landforms will be created with the potential to block sunlight and shadows from infrastructure elements will not fall on homesteads or public roads.

Infrastructure Element	Visual Impact Magnitude	Comment
Proposed levee adjoining the Red Hill MIA	Low	Once a vegetation cover is established on the proposed levee embankment the contrast with surrounding landscape will be minimal. The proposed levee will screen views of the Red Hill MIA form the adjoining section of Red Hill Road.

The most visible infrastructure of the project will be the gas management installations that will be visible from Red Hill Road.

Potential views of the proposed Red Hill MIA from the section of Red Hill Road immediately adjoining it will generally be screened by the proposed five metre high flood levee alongside the road. If any infrastructure elements are visible above the levee they are not expected to be visually prominent.

The overall visual impact of the visible portion of the project has been assessed as generally being low or negligible due to the combination of factors that include:

- The mine-related infrastructure elements that are to be located above ground will generally not be visible from Red Hill Road, which is the only public road in the vicinity of the mine.
- In those situations where mine related elements will be visible they will be seen with a backdrop of large scale overburden landforms associated with the exiting GRB mine complex.
- The most significant visual impact will result from vegetation clearing and installation of the IMG management system which will be visible to motorists travelling along Red Hill Road.

5.2.2.7 Rehabilitation and Closure

Rehabilitation and closure is discussed in **Section 5.4**. Areas disturbed by IMG management infrastructure will be progressively rehabilitated as mining progresses and/or associated gas drainage activities are completed. Similarly, the adaptive management approach to subsidence will mean that vegetation loss will be progressively addressed, particularly along the Isaac River corridor.

On completion of mining, all other above ground components will be removed except where it is agreed that these be left in place for future use by the landholder. Cleared areas will be revegetated with pasture grass or, in selected locations, woodland vegetation will be established.

Although some local changes to topography and drainage will occur as a result of subsidence, the post mining landscape and land use will be similar to the current situation and to surrounding lands that are extensively used for grazing. Consequently the overall long term visual impacts of the proposed development are generally assessed to be low.

5.2.3 Recommendations and Mitigation Commitments

Recommendations to minimise the potential visual impacts of the proposed project are summarised below:

- Retention of existing tree and shrub vegetation alongside Red Hill Road wherever safe to do so, to maximise screening of mining activities (including flaring) from views of passing motorists.
- Establishing a grass cover on the proposed levee to minimise its visual prominence.

- Retention of the riparian corridor of existing vegetation along the Isaac River wherever safe and practicable. This will provide visual screening of a significant proportion of the gas management installations for motorists travelling along the adjoining section of Red Hill Road.
- Progressive rehabilitation of areas disturbed by the IMG management infrastructure including replanting of pasture grasses over infrastructure alignments and excess areas around drilling pads (refer to **Section 5.5.6.7**).
- Design of lighting to limit bright lighting within the direct line of sight of public roads, where practicable.

5.2.4 Conclusion

This visual assessment of the proposed project concludes that it will generally produce a low to negligible visual impact on surrounding areas due to the combination of factors that include:

- Low scenic quality of the landscape in which the EIS study area is located.
- The nature of underground mining operations that will not generate new overburden landforms.
- The proximity of proposed infrastructure to existing similar infrastructure associated with the GRB mine complex.
- The very low number of potential viewers due to the absence of townships, villages, public recreation areas and lookouts within the viewshed of the project.
- The very low number of occupied homesteads in the vicinity of the EIS study area and the absence of views from those homesteads to the proposed mining operations and infrastructure.
- The limited number of public roads in the vicinity of the EIS study area, which include Red Hill Road, Goonyella Road, Riverside Road, Pasha Road and a section of unsealed road alongside the railway line north-west of the GRB mine complex.
- The relatively low traffic flows on public roads in the vicinity of the EIS study area, a substantial proportion of which are associated with mining activities. These traffic flows are expected to increase only moderately during the period of proposed mining operations.
- The visual prominence of existing overburden landforms and infrastructure associated with the current GRM mining operations will form a backdrop to the proposed Red Hill MIA and other infrastructure.
- The generally flat and broad scale landform of the Isaac River valley in which the EIS study area is located, which often results in vegetation in the foreground and mid distance thereby screening long distance views.
- Proposed construction of a flood levee between Red Hill Road and the proposed Red Hill MIA.
- Lighting associated with the project will not be directly visible from homesteads due to the visual screening by trees in the foreground and mid-distance combined with the long distances from the mine site.

5.3 Topography, Geology and Soils

5.3.1 Topography

Topography of the Bowen Basin is dominated by flat to gently undulating landforms across broad valleys. Sedimentary rock formations are bordered by a system of more prominent hills and mountain ranges. The semi-arid climate that prevails over most of the Bowen Basin, and widespread clearing for agricultural uses, generally results in the predominance of grassland with a sparse cover of tree and shrub vegetation on areas between the rivers and creeks. The riparian areas usually support woodland vegetation. Refer to **Section 9.1.3.1** for further details.

The existing GRB mine complex is located within a broad valley through which the Isaac River flows, generally in a southerly direction. The valley is defined to the west by the Denham Range and to the east by the Carborough Range. The southern end of the valley broadens out on to a wide flood plain. The northern portion of the EIS study area is formed by a low broad ridge that defines the northern part of the Isaac River catchment. The low hills located to the east of the Isaac River near the existing mine are strongly undulating with a well-developed system of drainage lines. The regional context of the EIS study area is illustrated in **Figure 1–1**.

The topography of the Isaac River valley near the EIS study area varies from approximately 250 metres elevation along the Isaac River east of the EIS study area to approximately 325 metres elevation along portions of the Denham Range that define the western edge of the valley. The relatively steep slopes associated with the Denham Range contrast with the extensive flat areas across the base of the river corridor, where gradients are generally less than 1:100. Refer to **Figure 5.3-1**, which shows the existing topography.

There are five main creeks within the EIS study area; Goonyella Creek, Eureka Creek, 12 Mile Gully, Fisher Creek and Platypus Creek. These are tributaries of the Isaac River which runs along the east of the current operations within the EIS study area, forming part of the Isaac River catchment. The area to the north-east of the existing mine is drained by Goonyella Creek and the area west of the existing mine is drained by Eureka Creek, as shown in **Figure 5.3-1**.

The EIS study area consists of the following geomorphological land zones of Cainozoic age. For further details refer to **Section 5.3.3.**

- Quaternary Alluvium (Qa); River and Floodplain Deposits; clay, silt, sand, and gravel;
- Tertiary-Quaternary Older Alluvial Deposits (TQa); somewhat dissected high-level alluvial deposits in re-entrant valley floors and footslopes; clay, silt, sand, and gravel;
- Tertiary-Quaternary Residual Soils and Colluvium (TQr); siliceous and ferruginous gravelly residual soils and colluvium; locally occurring as (TQr\Qf) mainly siliceous gravelly alluvial fan deposits (bajadas) or (TQr\f) highly ferruginous (lateritic) residual soils and/or colluvium;
- Tertiary Basalt Flows and Plugs (Tb); basalt;
- Tertiary Suttor Formation (Ts), fluvial and lacustrine sediments; quartz sandstone, clayey sandstone, mudstone, conglomerate and minor interbedded basalt;
- Late Permian Fort Cooper Coal Measures (Pwt); lithic sandstone, conglomerate, mudstone carbonaceous shale, coal, tuff and tuffaceous (cherty) mudstone; and
- Permian (Undivided) Back Creek Group (Pb); marine sandstone, siltstone and shale.

The potential impacts of the project on the landscape character of the EIS study area are described in **Section 5.3.3**. These include potential changes to the broad scale topography and vegetation character of the EIS study area, due to subsidence and vegetation clearing.

5.3.2 Geology

5.3.2.1 Mining and Petroleum Tenure

BMA holds mining lease tenements, MDLs and EPCs over the EIS study area, as discussed in **Section 5.1**. BMA has also made a mining lease application to consolidate the mining tenure over the eastern part of the EIS study area. There are also petroleum exploration interests held by petroleum explorers over the EIS study area as discussed in **Section 5.1**.

5.3.2.2 Regional Geological Setting

Regionally the EIS study area lies on the Collinsville Shelf on the north-western flank of the geological Permo-Triassic Bowen Basin, as shown in **Figure 5.3-2**. The Bowen Basin is a 600 kilometre long linear sedimentary basin that stretches from Collinsville in the north to Rolleston in the south.

The Collinsville Shelf is a stable tectonic environment and is characterised by a thin accumulation of sediments, gentle easterly dips (two to eight degrees) and minor structural deformation. The boundary between the Collinsville Shelf and the adjoining major axis of deposition, the Nebo Synclinorium of the Taroom Trough, is marked by a major thrust fault termed the Burton Range Thrust Fault, which is located approximately 10 kilometres east of the EIS study area.

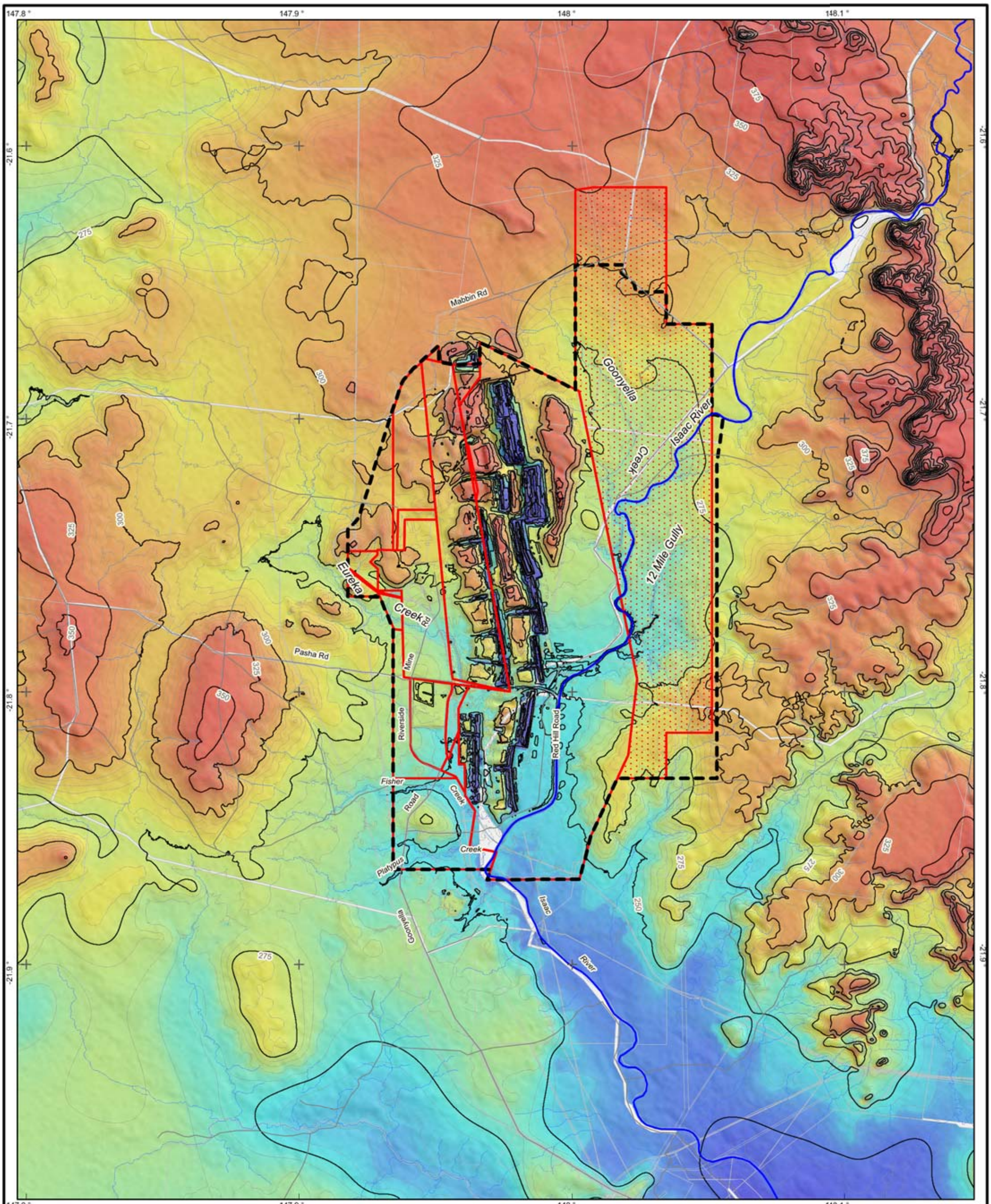
Regionally, the stratigraphic sequence is summarised as follows: the Permo-Triassic sediments of the Bowen Basin are overlain by a veneer of unconsolidated Quaternary alluvium and colluvium, poorly consolidated sediments of the Tertiary Suttor Formation and, in places, remnants of Tertiary basalt flows.

5.3.2.3 Project Specific Geological Setting

The geology surrounding the EIS study area is presented in **Figure 5.3-3a** and **Figure 5.3–3b**, with cross-sections in **Figure 5.3-4**. A summary of the stratigraphic sequence is provided in **Table 5.3-1** and **Figure 5.3–5**.

Stratigraphy

Locally, the Permo-Triassic sequence comprises, in ascending stratigraphic order: the upper part of the late Permian German Creek Formation of the marine influenced Back Creek Group; and the Moranbah Coal Measures, Fort Cooper Coal Measures and Rangal Coal Measures of the late Permian Blackwater Group. All units of the Permo-Triassic sequence dip from west to east at between three and five degrees in the vicinity of the EIS study area. The target coal seams for mining in the EIS study area are contained within the Moranbah Coal Measures.



N W E S

0 2.5 5km

Scale 1:200,000 (A4)

Datum: GDA94

EIS Study Boundary

BMA Tenure/Tenement

Mining Lease Application Boundary (MLA70421)

—200— Contour Major (25m interval)

Contour Minor

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

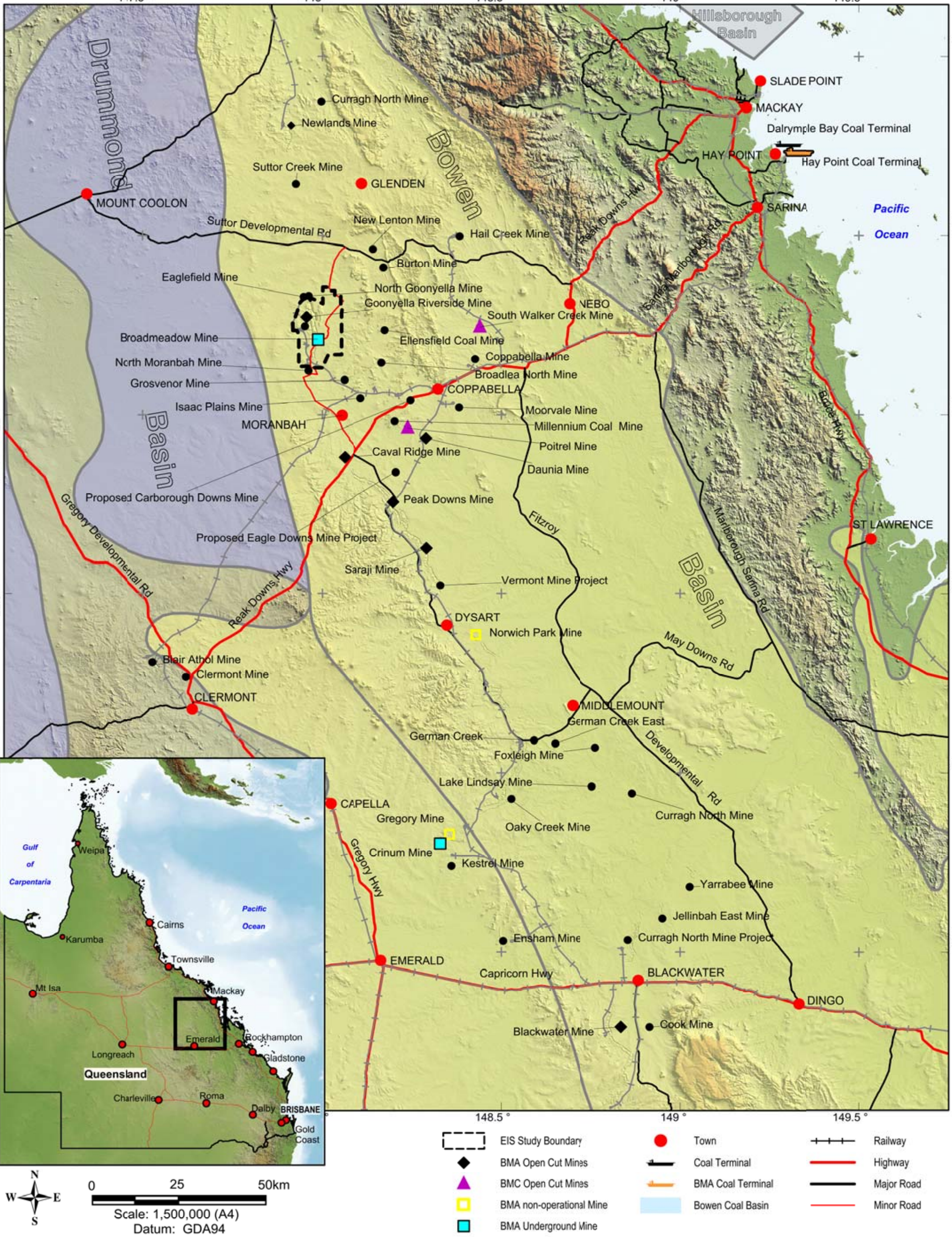
EXISTING TOPOGRAPHY

URS

LAND RESOURCES - TOPOGRAPHY

Figure: **5.3-1**

File No: **42627136-g-1043.wor** Drawn: **VH** Approved: **CT** Date: **17-06-2013** Rev. **A** A4



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ENVIRONMENTAL IMPACT STATEMENT

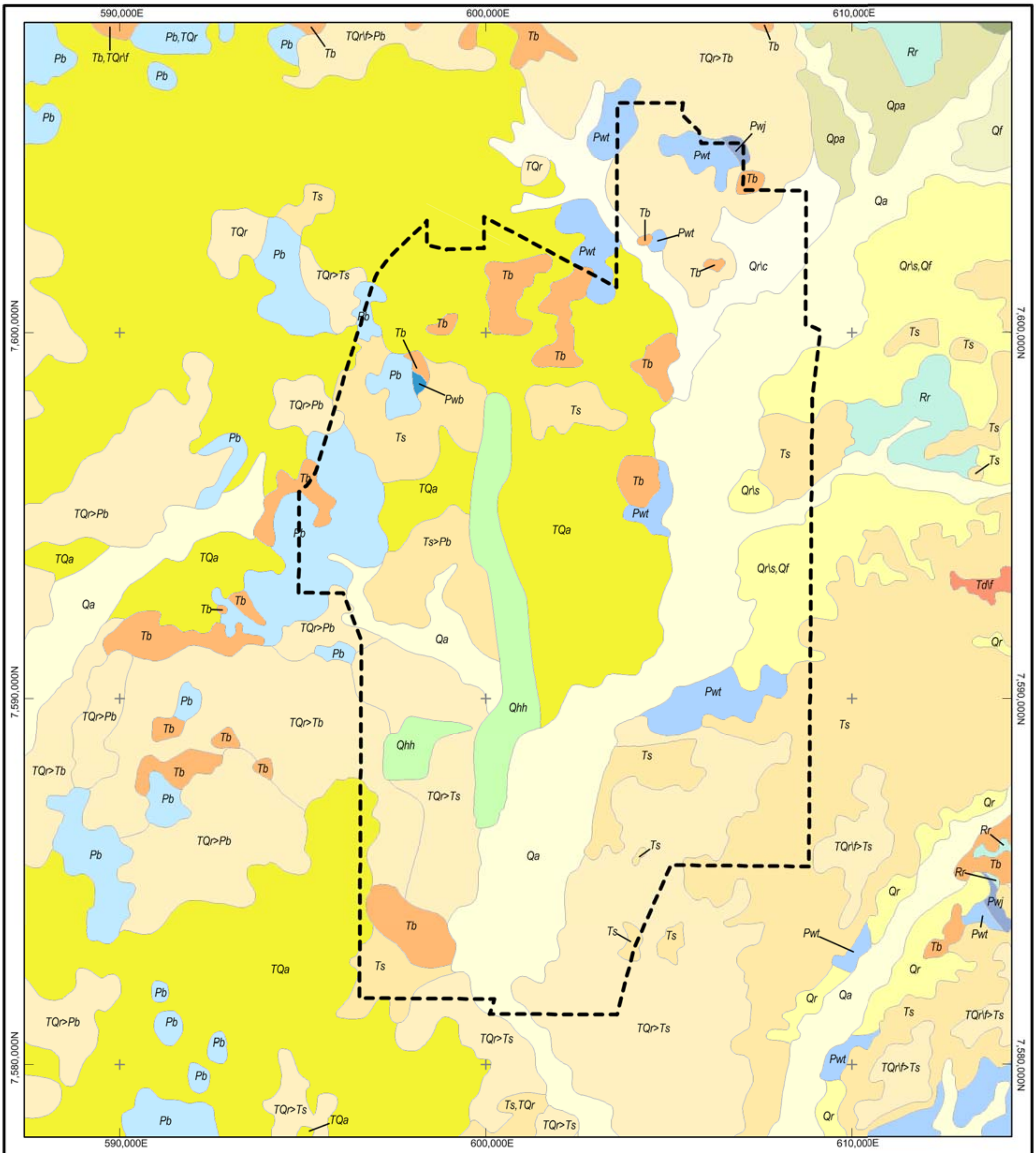
BOWEN BASIN AND THE PROJECT REGIONAL SETTING

URS

LAND RESOURCES - GEOLOGY

Figure: **5.3-2**

File No: **42627136-g-1034c.wor** Drawn: **VH** Approved: **CT** Date: **27-11-2013** Rev.**B** A4



N
W E
S

0 1.25 2.5km
Scale 1:150 000 (A4)
Projection: MGA Zone 55, (GDA94)

EIS Study Boundary

Rr	Rewan Formation
Pb	Back Creek Group
Pwb	Moranbah Coal Measures
Pwt	Fort Cooper Coal Measures
Pwj	Rangal Coal Measures

NOTE:
This Figure 5.3-3a must be viewed in conjunction with Figure 5.3-3b.

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

SURFACE GEOLOGY

URS

LAND RESOURCES - GEOLOGY

Figure: **5.3-3a**

File No: **42627136-g-1035.wor** Drawn: **VH** Approved: **CT** Date: **17-06-2013** Rev. **A** A4

QUATERNARY

Qa	Clay, silt, sand, gravel; floodplain alluvium
Qr\c	Residual soil, colluvium (clay)
Qr	Clay, silt, sand, gravel and soil; colluvial and residual deposits
Qr\s	Residual soil, colluvium (sands)
Qr\s,Qf	Residual soil, colluvium (sands)
Qf	Alluvial fan deposits, bajadas

PLEISTOCENE

Qpa	Clay, silt, sand, gravel; flood plain alluvium on high terraces

HOLOCENE

Qhh	Man-made deposits, mine tailings etc

TRIASSIC

Re	Medium to coarse-grained quartzose to sublabile, micaceous sandstone, siltstone, mudstone and granule to pebble conglomerate
Rr	Lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base)

PERMIAN

Pb,TQr	Marine sandstone, siltstone and shale (principally on western side of basin)

EARLY PERMIAN - LATE PERMIAN

Pb	Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite

LATE PERMIAN

Pwb	Labile sandstone, siltstone, mudstone, coal, conglomerate in the east
Pwj	Calcareous sandstone, calcareous shale, mudstone, coal, concretionary limestone
Pwt	Lithic sandstone, conglomerate, mudstone, carbonaceous shale, coal, tuff, tuffaceous (cherty) mudstone

TERTIARY

Tb	Mostly olivine basalt; some areas of nephelinite, basanite etc
Tb,TQr\f	Basalt flows, rare plugs
Td\f	Duricrusted surfaces/scarps (ferricrete)
Ts	Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt
Ts,TQr	Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt
Ts>Pb	Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt

TERTIARY - QUATERNARY

TQr>Pb	Older residual soils, colluvium
TQr\f>Pb	Older residual soils, colluvium (ferruginous soils)
TQr\f>Ts	Older residual soils, colluvium (ferruginous)
TQr>Tb	Older residual soils, colluvium

LATE TERTIARY - QUATERNARY

TQr>Ts	Clay, silt, sand, gravel and soil; colluvial and residual deposits (generally on older land surfaces)
TQa	Locally red-brown mottled, poorly consolidated sand, silt, clay, minor gravel; high-level alluvial deposits, generally dissected, and related to present stream valleys
TQr	Clay, silt, sand, gravel and soil; colluvial and residual deposits (generally on older land surfaces)

NOTE:
This Figure 5.3-3b must be viewed in conjunction with Figure 5.3-3a.

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ENVIRONMENTAL IMPACT STATEMENT

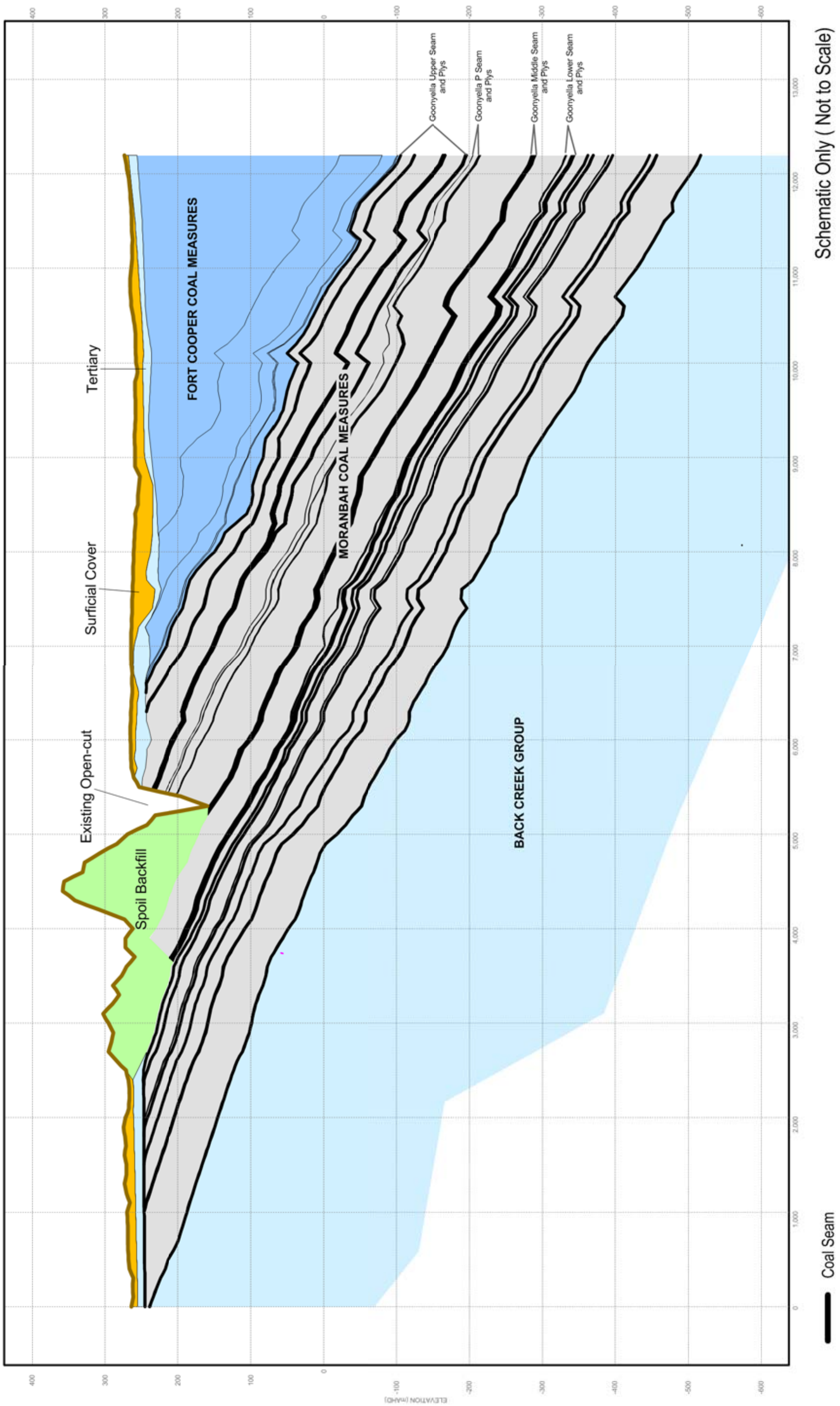
SURFACE GEOLOGY - LEGEND

URS

LAND RESOURCES - GEOLOGY

Figure: **5.3-3b**

File No: **42627136-g-1035.wor** Drawn: **VH** Approved: **CT** Date: **17-06-2013** Rev:**A** A4



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

TYPICAL GEOLOGICAL CROSS SECTION

URS

LAND RESOURCES - GEOLOGY

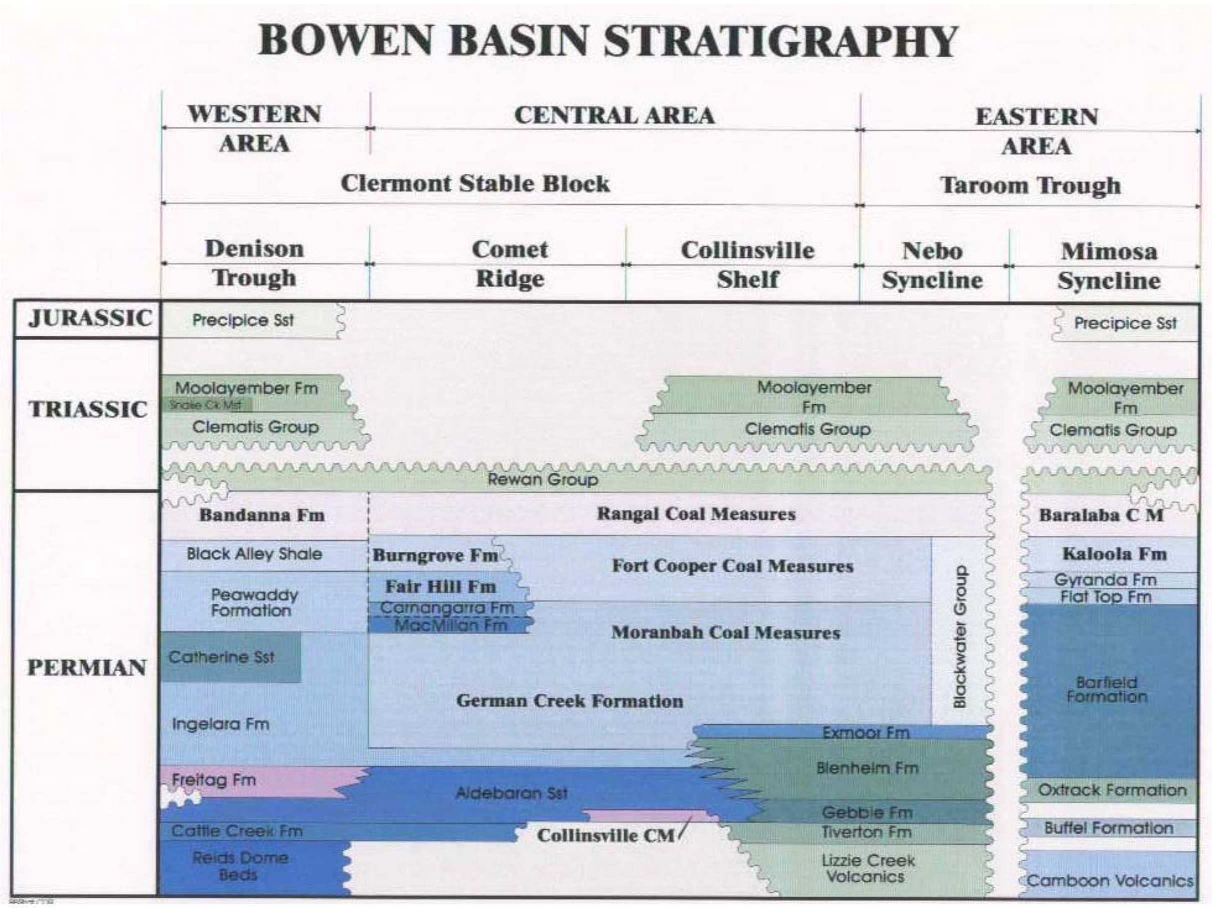
Figure: 5.3-4

File No: 42627136-g-1036.wor | Drawn: VH | Approved: CT | Date: 17-06-2013 | Rev: A | A4

Table 5.3-1 Local Stratigraphic Sequence

Age	Group	Unit	Lithology	Thickness (m)
Quaternary		Alluvial deposits	Residual soils and colluvium units include all blanketing sandy, loamy and clay soils	0 – 30
Tertiary		Suttor Formation	Mainly unconsolidated sand and clay alluvial deposits, minor basalt flows	
Late Permian	Blackwater	Rangal Coal Measures	Grey sandstone and siltstone, with interbedded mudstone, carbonaceous mudstone and coal	70
		Fort Cooper Coal Measures	Lithic grey sandstone, siltstone and mudstone, with thick inferior coal interbedded with carbonaceous mudstone	400
		Moranbah Coal Measures	Labile grey sandstone and siltstone, mudstone, carbonaceous mudstone and coal seams including: Goonyella Upper Seams (GUS); Goonyella Middle Seam (GMS); and Goonyella Lower Seams (GLS).	200 – 300
	Back Creek	German Creek Formation	Predominantly quartzose sandstones, silty sandstone, mudstone, carbonaceous mudstone and coal	Unknown

Figure 5.3-5 Bowen Basin Geological Stratigraphy Sequence



German Creek Formation

The German Creek Formation was deposited in a deltaic environment during the early stage of foreland basin development. It consists of quartzose sandstone, silty sandstone, mudstone, carbonaceous mudstone and coal, and outcrops or sub-crops west of the mining areas (**Figure 5.3-3a** and **Figure 5.3–3b**).

Moranbah Coal Measures

The Moranbah Coal Measures, which contain the target coal seams, conformably overlie the German Creek Formation and are conformably overlain by the Fort Cooper Coal Measures. The Moranbah Coal Measures were deposited in a predominantly fluvial flood plain environment.

The lithology of the Moranbah Coal Measures is generally characterised by interbedded fine-grained lithic sandstone, siltstone, mudstone, claystone, and coal, which is uniform across the entire EIS study area. The Moranbah Coal Measures show regular grading of lithological sequences from sandstone to siltstone and mudstone to coal, then tending back to sandstone, typical of depositional flood plain / river systems.

The Moranbah Coal Measures are characterised by several laterally persistent thick coal seams interspersed with several thin minor seams, which split and coalesce.

Coal occurs in four distinct horizons within the EIS study area:

- Goonyella upper seam (GUS);
- P seam (seam part of the Moranbah Coal Measures);
- Goonyella middle seam (GMS); and
- Goonyella lower seam (GLS).

Coal of a suitable thickness and quality to be mined in the EIS study area is confined to the GUS, GMS, and GLS, which is sub-cropped within the mining area.

In descending stratigraphic order the seam descriptions are depicted in **Figure 5.3-6**, **Figure 5.3-7**, and **Figure 5.3-8** and are briefly described as follows:

- The GUS is complex in its split pattern. In the south the thickest section of the seam is the GU1 (made up of the R, S and T coal splits (known as plys), where a ply is a lithological subdivision of the coal seam). The GU1 splits to form the GU5U (R1 ply) and the GU3X seam (R2, S and T plys). The GU5L (R2 ply) then separates to the east and west leaving the GU3 seam (S and T plys). Beneath these seams and splits is the GU2 seam (U ply) which moves closer to the base of the GU3 seam until it merges to form the GU0. The GU5U continues above the GU0 seam over the northern end of the lease. The GU5L is not persistent after separating from the GU3 seam (**Figure 5.3-6**). The total thickness of the coal plys in the GUS is approximately 5.7 metres.
- The GMS is the most consistent of the major seams in the EIS study area. Over most of the EIS study area the seam is consistently 9 to 10 metres thick and only in the south do thin seams (less than 0.5 metres thick) separate from the main seam. Firstly, the GM2 separates from the top of the GM0 to leave the GM1, and then the GM3 separates off from the base of the seam in the far southern end of the lease to leave the GM4. The average thickness of GM1 is six to seven metres. The GMS ranges in depth from approximately 70 to 90 metres at the highwalls adjacent to the underground area to 300 metres at the eastern lease boundary (**Figure 5.3-7**).

- The GLS in its entirety is known as the GL0. This thick seam occurs over much of the northern part of the EIS study area. It splits to the north firstly into the GL6 and GL7 and then the GL6 splits into the GL4 and GL2. To the south the seam splits into the GL4 and GL1. These two seams again coalesce in the south-western corner of the lease. To the east, close to the eastern edge of the lease, the GL1 splits into the GL2S and GL7S. It is a more variable seam than the GMS both in lithology and quality and is more prone to seam splitting (**Figure 5.3-8**). The total thickness of the coal plys in the GLS is approximately eight metres.

Figure 5.3-6 Goonyella Upper Seam Splits and Plys – Not to Scale

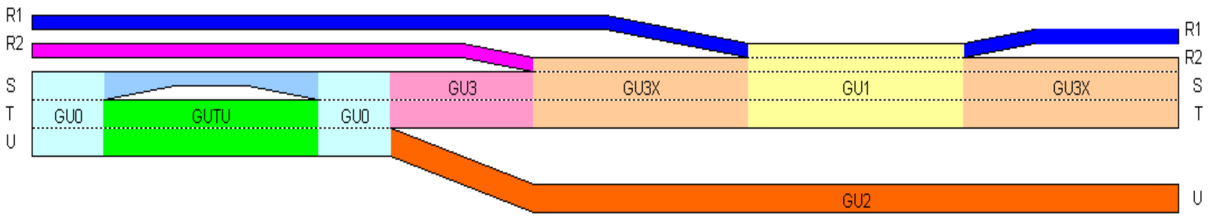


Figure 5.3-7 Goonyella Middle Seam Splits and Plys – Not to Scale

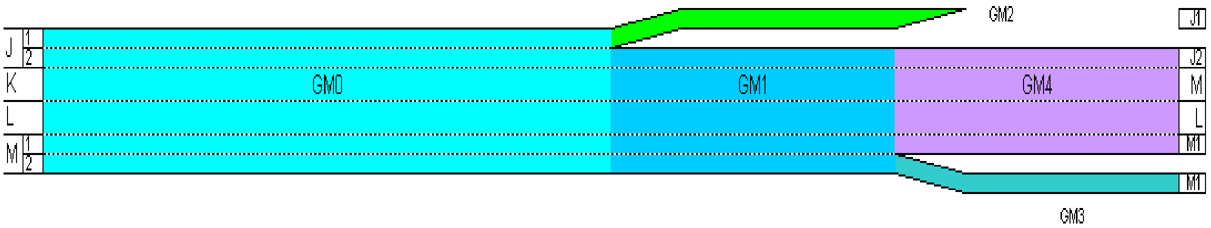
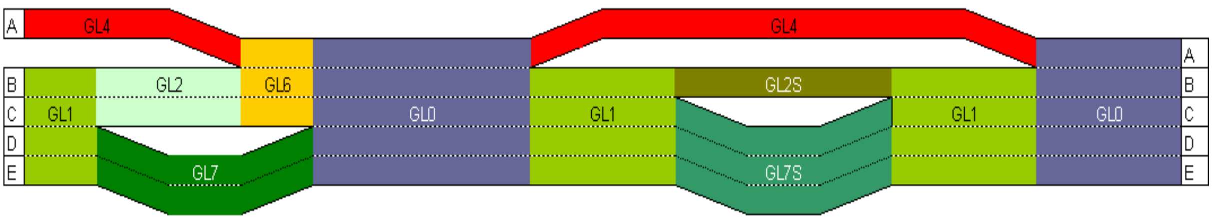


Figure 5.3-8 Goonyella Lower Seam Splits and Plys – Not to Scale



Fort Cooper Coal Measures

The Late Permian Fort Cooper Coal Measures conformably overlie the Moranbah Coal Measures, and are present across the eastern portion of the EIS study area (**Figure 5.3-3a** and **Figure 5.3-4**). The Fort Cooper Coal Measures consist of grey lithic sandstone, siltstone, mudstone, coal, and tuffaceous sediments. A number of coal seams are contained within the Fort Cooper Coal Measures. The seams are typically thick (up to 70 metres in the case of the GF2 seam), highly stone-banded and contain high inherent ash coal and are, therefore, not considered economic for the project.

The lower boundary of the Fort Cooper Coal Measures is taken as the base of the GF0 seam, a thick and widespread sequence of interbedded dull and stony coal, carbonaceous mudstone and tuff. This unit lies approximately 60 to 70 metres above the GUS.

Rangal Coal Measures

The Rangal Coal Measures only outcrop/subcrop in the north-east of the EIS study area (**Figure 5.3-3a**). They comprise light grey, cross-bedded, fine to medium grained sandstone, grey siltstone, mudstone, and coal seams. Cemented sections are common in the sandstone. The transition between the Fort Cooper Coal Measures and the Rangal Coal Measures is generally clearly marked by the Yarrabee Tuff; a basin-wide marker bed comprising weak, brown tuffaceous claystone band.

The conformably overlying Triassic Rewan Group does not occur within the EIS study area.

Tertiary and Quaternary Formations

The EIS study area is covered by a 0.5 to 30 metre thick layer of poorly consolidated Tertiary and Quaternary sediments unconformably overlying an irregular erosion surface of Permian strata. These sediments consist of lenses of river channel gravels and sands separated by sandy silts, sandy clays and clays. The Tertiary silts and clays are densely compacted and hard. Lag deposits of sand and gravel are found directly on the Tertiary/Permian unconformity, and can also be present related to recent Quaternary deposition from the Isaac River.

Geological Structures Mapped on Site

At the end of sediment deposition in the late Triassic, the Bowen Basin was subject to tectonic compression from the eastern side resulting in major thrust faulting. In the Cretaceous to Tertiary, normal faulting occurred due to extension associated with the opening of the Coral Sea, then the Tertiary hot spots resulted in thermal doming and collapse with widespread intrusion and extrusion of basalt dykes, sills and flows.

The tectonics resulted in the Permo-Triassic sequence dipping from west to east at between three and five degrees in the vicinity of the site. Faulting and seam splitting is common, producing localised steepening of the coal seam dips. The area has been influenced by several stages of structural deformation, including an extensional phase resulting in normal faulting and igneous intrusion in the form of sills and dykes, with a final late Cretaceous to early Tertiary compressional phase that resulted in thrusting and reversed re-activation of normal faults and a regional horizontal stress field. Core holes intersecting thrust faults are characterised by repeated coal intervals, increased interburden thicknesses and heavily sheared and jointed non-coal intervals.

Three extensive basalt sills intrude the GMS, GUS and multiple seams within Fort Cooper Formation.

More isolated occurrences of igneous rocks and coked coal appear in various seams above the GMS, but only rarely below. In addition to the sills there are at least two zones of probable dyke swarms. Most of the igneous borehole intersections in these zones occur between seams at various stratigraphical levels and do not correlate across adjacent drill holes. This pattern is consistent with narrow near vertical dykes. Most of the borehole observations occur above the GMS and up into the upper seams, suggesting that the dyke swarms become more intense toward the surface. These potential dyke swarms lie along strikes of normal fault zones mapped in the open pits, suggesting a link between the faults and dykes.

Geomorphology

No significant geomorphological features have been identified within the EIS study area. The Quaternary and Tertiary formations that cover the mining area are dominantly sediments which hold no geomorphological significance. The Tertiary basalt that occurs in the west of the mining area is generally thin and extensively weathered, therefore no surface lava tubes or similar geomorphologically significant volcanic features are known to be present. Exploration drilling through basalt has not encountered voids that could be interpreted as lava tubes or lava caves.

There are no identified limestone or similar carbonate units on site, therefore it is anticipated that no karst or cave systems are present.

Fossil Material

The coal bearing strata present in the EIS study area together with the overlying rock of Permian, Tertiary and Quaternary age are of sedimentary origin. There is a potential for fossils to be present, however, based on experience in other open-cut coal mines in the Bowen Basin, the potential for location of significant fossils is expected to be low. Permian-age rocks of the Bowen Basin and other contemporaneous basins in eastern Australia routinely contain vegetation fossils and microfauna fossils, however, these are not considered to be unique or rare.

5.3.2.4 Geological Factors Relevant to Resource Utilisation

Summary of Exploration Process for Coal

Coal exploration has been intensively carried out in the area around Moranbah since the 1960s. Borehole drilling has historically been the primary exploration tool, because of the shallow target depths, amenable strata for the most part, and easy surface access. Approximately 12,000 drill holes have been completed in connection with exploration and resource assessment for the existing GRB mine complex and potential expansion areas. More recently, as the technique was developed to achieve high quality data, seismic surveys have been conducted in both two-dimensions (2-D) and three-dimensions (3-D) form as an adjunct to drilling.

The primary data acquisition tool is, therefore, vertical surface drilling. Both core and non-core methods are used resulting in several sizes of coal and rock core used for testing.

Non-core drilling is utilised for the following:

- limit of oxidation (LOX) drilling;
- pilot holes (drilled at core sites to provided details for core hole); and
- structural definition (fault delineation and seam splitting – from geophysics).

Core drilling is utilised for the following:

- coal quality sampling and washability (usually 100 or 200 millimetre diameter);
- gas testing (usually 63 millimetre diameter); and
- geotechnical drilling (strata strength testing).

The majority of the boreholes drilled are rotary chip holes with no core recovery. Many of the older series of holes, without down hole geophysics, are susceptible to inaccuracies in depth and thickness, but more recent holes are routinely depth corrected based on the down hole logs.

Geophysics has been used to back up drilling data in a number of ways, including:

- Down hole geophysics to gather additional information from each bore hole and to provide a check and calibration of the lithological logs.
- Seismic surveys (both 2-D and 3-D renderings) to map structure of the seams. 3-D seismic is the preferred method of structural definition especially in areas of potential underground mining.
- Aero-magnetic surveys to delineate intrusions.

The exploration history is summarised in **Table 5.3-2**.

Table 5.3-2 Summary of Mine Site Exploration History

Area	Date	Remarks
Goonyella	1960s	Exploration drilling for Goonyella open-cut mine
	Ongoing	Mine drilling
Riverside	1970s	Exploration drilling for Riverside open-cut mine
East of Eureka Pit	late 1970s – early 1980s	Drilling to investigate potential for bord and pillar underground mine. Abandoned in 1985 in favour of development of the Cleanskin pit.
Ramp 0	1993 – 1996	Drilling for structure, coal quality and geotechnical investigations. Surface and airborne magnetic surveys and 2-D seismic surveys conducted.
The Gap	1998	Drilling for structure, coal quality and geotechnical investigations. Systematic inclusion of the GLS.
BRM	1998 – 1999	Drilling for structure, coal quality, gas content and geotechnical investigations for pre-feasibility study.
	2000	Drilling for exploration audit.
	2003 – 2004	Resource drilling, 3-D seismic surveys for mine development.
	2004 to present	Current mine drilling.
Red Hill	1996 – 2000	General resource, gas, structure, geotechnical and quality drilling, 2-D seismic surveys to fulfil commitments for exploration.
Expansion Projects	2005 to present	Resource, gas, structure, geotechnical, and quality drilling, 2-D and 3-D seismic surveys, for both expansion projects and extension of resource base.

Coal Quality Testing

Drill core is initially sampled as raw ply. The initial raw analysis is validated and assessed, with a National Association of Testing Authorities laboratory conducting washability analysis requirements for a working section. Generally, raw ply are initially weighed and crushed to <12.7 millimetres and analysed for ash content, relative density, volatile matter content, chlorine, crucible swell number (CSN), moisture holding capacity, and inherent moisture. The crushed coal is then washed and gravity separated by flotation. The float fractions are then analysed for ash content, volatile matter content and inherent moisture. The cumulative float sample is analysed for inherent moisture, ash, volatile matter content, total sulphur, CSN, ultimate analysis, carbon dioxide, Gieseler plastometer, dilatation, maceral analysis, ash analysis, Hardgrove Grindability Index (HGI), abrasion index, trace elements (arsenic, cadmium, mercury, lead, selenium, fluoride) and phosphorous.

Coal Characterisation

All mine saleable product is a washed coal that meets various client quality specifications. Presently, two wash plants are in operation, Goonyella and Riverside. To be able to predict product quality from *in situ* quality a number of coal quality tests are undertaken on the bore core (see above). These tests are undertaken on raw coal, sized coal, washed coal or sized and washed coal.

Raw coal analysis is carried out on untreated coal samples and is used to characterise the in situ coal quality. This is important for quantity definition (tonnage). After float and sink analysis has been carried out, selected fractions (both sized and density) are combined to form composite samples that represent as far as possible the likely products that will be produced from the wash plant. Coal quality data are stored in a database on a ply by ply basis, and are used to create coal quality mapfiles for gridding purposes, and a washability database to derive underground working sections.

The mine competes in the mid-volatile hard coking coal market with fluidity, coke strength, phosphorus and ash being the major determinants in the coal production schedule.

Classification of Resources

Coal Resource estimation for BMA projects and mine sites is carried out using BMA standard resource estimation procedures and reported in accordance with the Australasian Joint Ore Reserves Committee code (JORC Code) (2012 Edition). The JORC Code provides minimum standards for public reporting of resources and reserves and coal estimates are supplemented by the Australian Guidelines for Estimating and Reporting of inventory Coal, Coal Resources and Coal Reserves (Australian Coal Guidelines 2003).

Because both tonnage and coal quality must be known to the same level of confidence, BMA standard practice requires valid points of observation to have the following attributes:

- geophysical logging;
- cored and with sample analyses pertinent to the coal product being quoted as resource; and
- at least 95 per cent linear core recovery for the target seam.

Where possible, resource estimates across BMA utilise the results of geostatistical studies, such as Drill Hole Spacing Analysis (DHSA) to define the drillhole spacings for various resource categories: Measured, Indicated and Inferred.

Coal resources for the proposed Red Hill Underground mine plan were derived from the 2011 geological model and classified using the results of DHSA analysis for the target GMS seam. Drillhole spacing employed for the resource classification are 1,000 metres for Measured, 2,000 metres for Indicated and 5,000 metres for Inferred.

Resources were estimated for the area covered by the proposed Red Hill mine plan. The Red Hill mine plan straddles the boundary between ML1763 and MLA70421. An estimate was also made of the GMS resources within Broadmeadow extension panels 14, 15 and 16, where they extend into MLA70421.

Resources within the Broadmeadow extension and RHM are a subset of the Goonyella-Riverside and Broadmeadow Resources, and the Red Hill deposit Resources, reported in BHP Billiton's 2013 Annual

Report. Resources for the RHM underground expansion option have not previously been separately reported. The estimate was made by Steve Wilson, under the supervision of Stella Martinez. Ms Martinez is the Competent Person for coal resources at Red Hill and Goonyella and a full-time employee of BMA; she has sufficient experience relevant to the style of mineralisation and type of deposit under consideration and to the activity which she is undertaking to qualify as a Competent Person as defined in the 2012 Edition of the *Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves*.

Table 5.3-3 summarises the coal resource estimate for the area,

Table 5.3-3 Coal Resource Estimate for the Area

Area	Parameter	Measured	Indicated	Inferred	Total
Red Hill Underground MLA70421	Proportion of total (%)	0	99	1	100
	Average thickness (m)	7.7	8.1	8.4	8.1
	Resources within mine plan (MT)	0.7	160.3	1.7	162.6
GYL Underground ML1763	Proportion of total (%)	12	88	0	100
	Average thickness (m)	8.0	8.4	-	8.4
	Resources within mine plan (MT)	12.2	92.4	-	104.6
Broadmeadow Extension	Proportion of total (%)	0	94	6	100
	Average thickness (m)	-	6.6	6.6	6.6
	Resources within mine plan (MT)	-	8.8	0.6	9.3
Total	Resources within mine plan (MT)	12.8	261.5	2.2	276.6

Notes:
Estimate of coal resources, as at June 2013, within the target GMS for the EIS study area.
Resource estimate within the RHM underground footprint, including the Broadmeadow extension within MLA70421.
Resources reported in this estimate include coal in MLA70421 and ML1763 (Goonyella and BRM) that are covered by the 2013 mining footprint.

Gas Content of Coal

As coal is formed, large quantities of methane rich gas are generated and stored with the coal matrix. The gas content of the coals in the EIS study area has been assessed in a number of studies as summarised in WDS (2011). Gas content of coal of the GMS ranges from approximately 2 to 12 cubic metres per tonne within the footprint of the RHM.

5.3.2.5 Geochemical Information for the Area to be Mined

As part of the EIS process a geochemical characterisation and assessment of waste rock was completed for the EIS study area (refer to **Section 6**). The program focussed on acquiring representative lithological samples of the main overburden, interburden and potential reject material types (sandstone, siltstone, carbonaceous siltstone and mudstone). Geochemical information for the area to be mined is discussed further in **Section 6**.

5.3.2.6 Potential Impacts and Mitigation Measures

Based on the compilation and review of available geology data and mining activities, an impact assessment has been conducted. The evaluation of available geological information indicates the potential for environmental impacts associated with the nature and characteristics of the geological resources, these include:

- ground stability;
- IMG management;
- subsidence due to underground mining;
- resource utilisation;
- resource sterilisation;
- coal seam propensity for spontaneous combustion;
- management of fossils; and
- geological implications for rehabilitation and mine closure planning.

These matters are discussed in more detail below.

Ground Stability

Faulting can have a significant impact on the design of an underground mine and it is important to have a high level of confidence in the location and size of faults in order to reduce this key operational risk. Minor faulting from the larger regional tectonic influences are mapped in most pits within the GRM, in the BRM, and throughout the seams in the EIS study area. Intersections of thrust faults and west-north-west trending strike slip faults are associated with zones of roof instability in the underground mine. Data collected from drilling programs, 2-D and 3-D seismic programs, airborne magnetic studies and geotechnical investigations are assimilated to construct the geological model of the coal deposits and will be used to better define areas of disturbance and so maximise resource utilisation. Where longwall blocks are intersected by a large fault these areas may need to be avoided for mine safety reasons.

Incidental Mine Gas Management

The coal within the longwall blocks proposed for mining has a high methane concentration that is over the outburst threshold in many areas. To ensure that production activities can commence safely, IMG will be drained in advance of longwall mining activities as discussed in **Section 3** of this EIS.

Subsidence

IMC Mining Group (IMC) and SCT Operations (SCT) undertook assessments of subsidence for the proposed RHM and the Broadmeadow extension, respectively. The IMC (2011) assessment for the proposed RHM indicates that the proposed longwall panels are of supercritical width (based on cover depth and panel extraction width) in the earlier mined western panels, becoming subcritical in the later eastern panels as depth of cover increases (refer to **Appendix I1**). Maximum surface subsidence is expected to be generally less than six metres based on modelling of a long wall thick seam coal extraction method with an extraction thickness of 10 metres of coal from the GMS (in reality, the extraction depth will be less than 10 metres across most of the footprint). Surface tension cracks as a result of subsidence are expected to be in the order of a maximum width of 0.5 metres and a maximum depth of 10 metres in the worst case instances.

The SCT (2010) assessment for the Broadmeadow extension indicates that maximum subsidence is expected to be generally less than 3.8 metres based on conventional longwall mining. The Tertiary units appear to subside in a passive manner over the Permian section. Clay units within the Tertiary have the potential to shear in the high strain areas of the subsidence zone; however the clays in the mid to lower section remain in compression. In the near surface region, tension fractures may form; however, these are not expected to extend beyond 0.5 metres wide and 10 metres deep.

Experience with the operation of the BRM indicates that subsidence induced cracks that develop in the Tertiary sediments do not appear to develop any major open fracture systems connected into the fractured Permian strata below. The clay units within the Tertiary are soft, plastic clays, which subside without causing significant vertical open fractures, acting as aquitards to the water bearing sands, limiting leakage into the underlying Permian formations and workings.

Management of the impacts of subsidence on soil erosion, surface water, groundwater, flora and fauna are addressed in the relevant chapters of the EIS (refer to **Section 5.3.3**, **Section 7.3.7**, **Section 8** and **Section 9.8**).

Resource Utilisation

The extent of areas to be mined is shown on **Figure 5.3-9**. The project will be developed to maximise resource utilisation by using efficient mine planning and mining techniques, including thick seam mining as described in **Section 3.6**. The proposed mining methodology was considered to determine the effectiveness in achieving the optimum utilisation of the coal resources within the EIS study area.

Underground mining using the newer longwall thick seam mining technique will maximise the recovery of coal from the GMS compared to traditional longwall mining techniques in areas where the mineable coal seam thickness exceeds 7.5 metres. Thick seam mining is estimated to achieve approximately 80 per cent recovery of coal, compared to approximately 50 per cent if conventional long wall mining was used. Geotechnical investigations will be undertaken as underground mining progresses to optimise the mining and maximise extraction of coal within the GMS. To enable safe underground mining a portion of land between the open-cut and underground mine areas, known as a ‘barrier’, will not be mined. This barrier area is required for safety reasons so the open-cut face is not subsided and thus destabilised by the underground mine. Once underground mining has been completed and subsidence has occurred some of the barrier area may be mined through open-cut operations.

Although underground mining will not recover as much coal as open-cut mining methods, it is generally more economic, especially as the depth to coal increases. Underground mining methods also substantially reduce the energy consumption and waste rock generation that would occur if open-cut methods were used.

The proposed underground mining area does not cover the full extent of the Moranbah Coal Measures within the EIS study area. There are additional potential longer-term coal resources in the area. Further feasibility assessments, including exploration programs, are necessary before these can be developed. If a decision is made to mine these areas in the future, any necessary additional environmental approvals would be obtained.

The Rangal Coal Measures only outcrop in the far east of the EIS study area and, due to rank, quality and resource geometry, do not form a viable target for a hard coking coal product. The Fort Cooper Coal Measures contain thick, stone banded, poor quality coal seams that are not considered economic.

Resource Sterilisation

The areas of proposed resource utilisation, infrastructure, and resource sterilisation are shown on **Figure 5.3-9**.

Within the EIS study area, if an external petroleum exploration permit overlaps with any of BMAs mining leases, any negotiations will be managed by BMA in accordance with applicable legislation *Petroleum and Gas (Production and Safety) Act 2004*. The extraction of IMG as part of mining is permitted under the relevant mining legislation (refer to **Section 3.8**).

It is considered that underground mining would not sterilise deep petroleum reserves, should they exist, and that access to these resources would be feasible.

The project has been planned to minimise sterilisation of economic coal resources. The existing GRM MIAs are located to the west of the existing open-cut mines. The Red Hill CHPP will be constructed to the south of the Riverside MIA, as discussed in **Section 3**, over the uneconomic German Creek Formation and so will not impact on the coal resources.

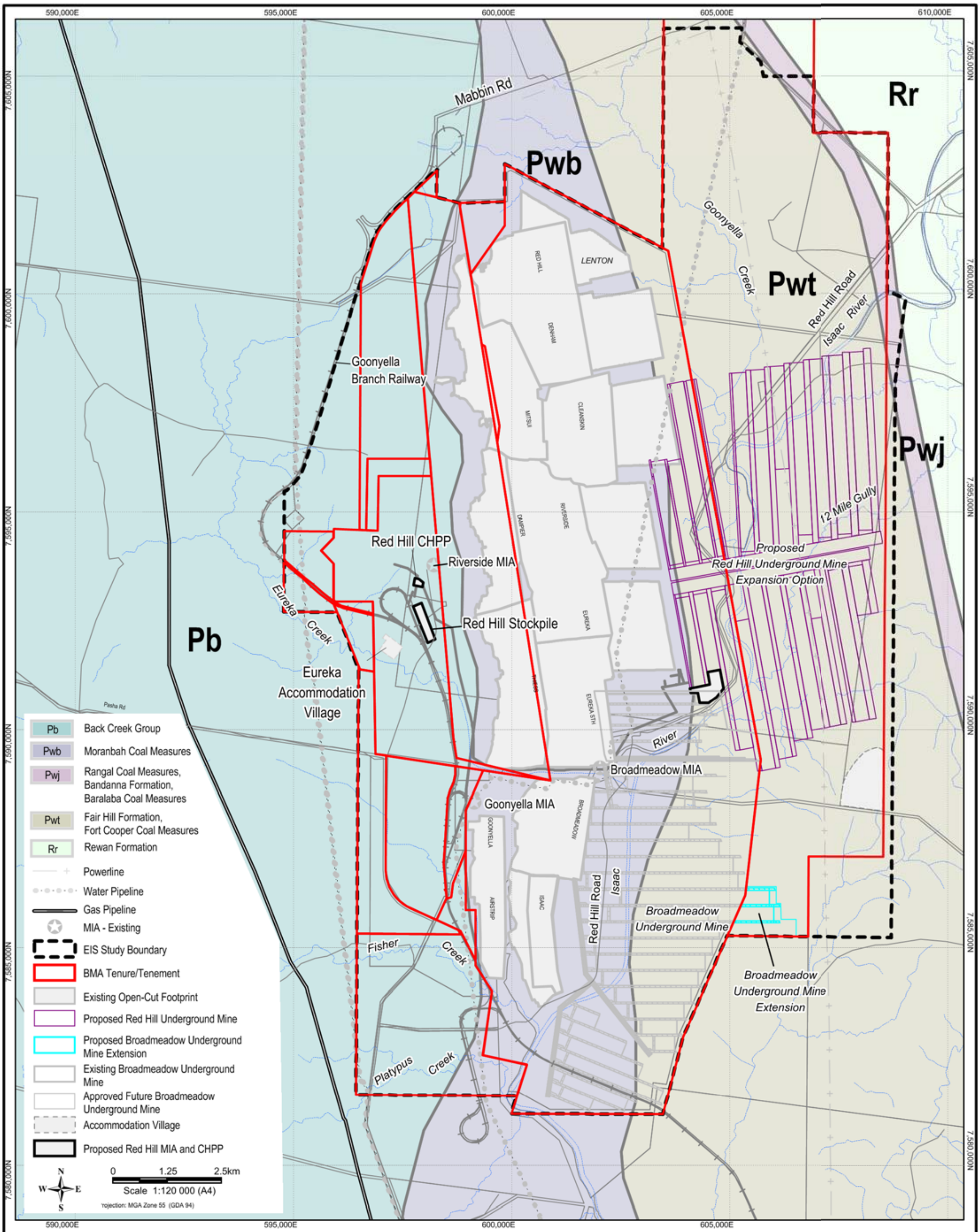
The new Red Hill MIA will be located between the RHM and BRM. The location of this MIA may sterilise coal in the GLS, which is not currently planned for extraction; however if extraction of the GLS was sought in the future, the MIA could be relocated. There are no suitable locations for the MIA that do not overly some coal resource. The Red Hill accommodation village is also proposed to be located over coal resources which are not targeted for mining at present, but which may become economic to mine in the future. If this was the case, the accommodation village could be relocated.

Seams below the GMS will be unaffected by longwall mining, however seams above such as the GUS will be affected by subsidence with the effect reducing with an increasing separation distance from the GMS. Mining of subsided coal seams over longwall panels is possible and so the upper seams overlying the underground mine areas are not regarded as sterilised if mining of these thinner seams becomes economically viable.

Spontaneous Combustion

A preliminary investigation of the spontaneous combustion propensity of coal from the EIS study area was conducted by the University of Queensland's Spontaneous Combustion Testing Laboratory (UniQuest 2006) using an adiabatic oven test procedure that is routinely used by the coal industry to obtain the R70 self-heating rate of the coal. This test also produced a value for the relative ignition temperature of the coal. A large database of R70 and relative ignition temperature values is held by University of Queensland, therefore comparisons between the project and other previous studies was used to obtain a relative indication of the propensity of the coal to spontaneously combust.

Generally, the GMS has a low inherent spontaneous combustion propensity (Class 1) based on Queensland conditions.



BMA BHP Billiton Mitsubishi Alliance

RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

AREAS OF RESOURCE UTILISATION

URS

LAND RESOURCES - GEOLOGY

Figure: **5.3-9**

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The underground workings and run-of-mine and product stockpiles will require appropriate management systems to detect and prevent conditions conducive to spontaneous combustion. The most important aspect of managing spontaneous combustion is to manage stockpile inventory such that coal does not remain in the stockpile for a long periods of time. Other techniques include minimising air leakage, minimising production of fines, reducing the coal temperature and establishing an environment that does not allow the coal to dry. Management may include consideration of wind direction, compaction and the use of coal wetting systems.

Fossils

Based on the age and depositional nature of the sediments located within the proposed mining area, there is the potential for fossil specimens to be uncovered during construction and operations. However, based on experience in the existing mines on site and other coal mines in the area, the potential for location of significant fossils is expected to be low.

Should significant fossil specimens be identified within the mine, then steps will be taken to secure and protect the fossils. The Queensland Museum will be notified to allow for the identification and correct preservation and removal.

Rehabilitation and Closure

Mining will permanently impact on the geological resources within the disturbed area. Coal, interburden, and overburden will be removed and rehabilitation (backfilling) will result in the alteration to the pre-mining geology. Underground operations will permanently subside undermined areas and may result in increased interconnectivity as discussed in **Section 8** of the EIS.

The mine will develop a closure plan to minimise the impacts and rehabilitate the overburden and soils to allow for pre-mining land use where possible. Details regarding decommissioning and rehabilitation are presented in **Section 5.5** of the EIS.

5.3.3 Soils and Land Suitability

This section of the EIS describes the environmental values identified for the project, in terms of soil resources. The description and distribution of topsoil resources are provided and their suitability for rehabilitation assessed. The potential impacts that the proposed mining activities may have upon the environmental values of the soils in the EIS study area are assessed and any mitigation measures that may be required are outlined.

The following information has been taken from the detailed soils report, presented in **Appendix F2**.

5.3.3.1 EIS Study Area

The EIS study area for the soils assessment includes all of the land within the EIS study area boundary including areas to be disturbed by the project within existing mining leases which have been previously assessed as part of the ongoing GRM. The extent of these areas and broad soil types are shown on **Figure 5.3–10**. The EIS study area includes currently undisturbed areas that are proposed to be used for underground mining, IMG drainage infrastructure, haul roads, CHPP and balance areas not currently proposed to be developed. The EIS study area considered in the soils assessment has an area of 12,327 hectares.

The EIS study area has been divided into key areas of disturbance for assessment purposes**.** The key disturbance areas are described as follows:

- **Underground mine footprint** (IMG infrastructure and subsidence disturbance): This area consists of approximately 3,721 hectares (including 121 hectares for the Broadmeadow extension) and includes land to be subsided by longwall mining on average three to five metres and up to six metres. Topsoil disturbance will also occur across this area for IMG drainage infrastructure as described in **Section 3.8**. Given the predicted subsidence profiles surface water drainage, ponding and erosion issues are also considered.
- **Surface facilities and infrastructure**: This area consists of approximately 250 hectares.

5.3.3.2 Study Objectives

The major objectives of the soil and land suitability assessment were to:

- **Objective 1 - Classify and determine the soil types within the EIS study area**

  To satisfy Objective 1, the soil taxonomic classification system used was the Australian Soil Classification (ASC) system (Isbell 2003). This system is routinely used as the soil classification system in Australia. The scale of mapping used for this project was 1:25,000 for disturbance areas and 1:50,000 across the overall site.

- **Objective 2 - Assess the pre-mining and post-mining land suitability (LS) classes within the EIS study area**

  To satisfy Objective 2, the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME 1995) were used. This includes a standard list of limitations for assessing agricultural land suitability in Queensland.

- **Objective 3 - Assess the pre-mining and post-mining agricultural land classes (ALC) within the EIS study area**

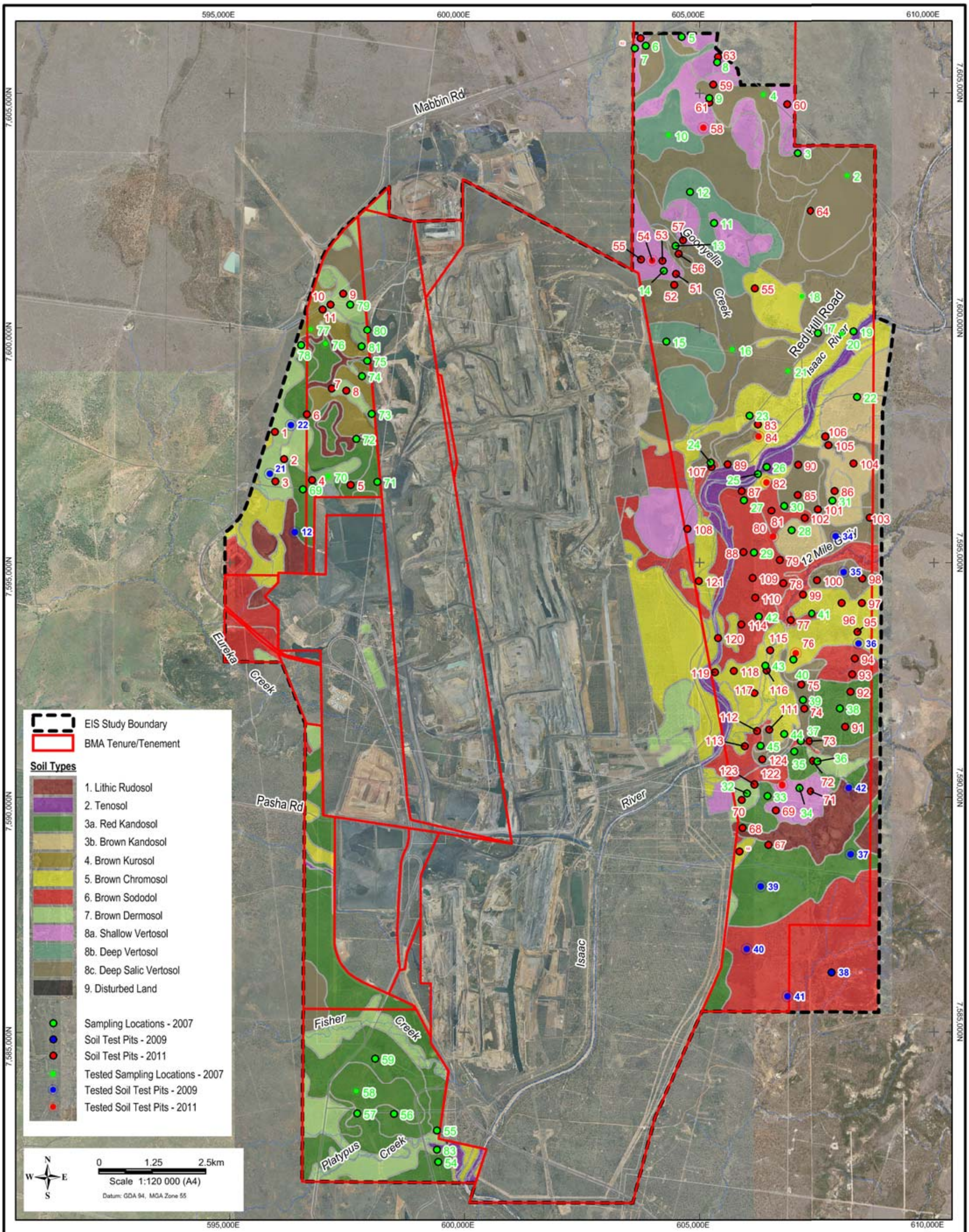
  To satisfy Objective 3, the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI 1993) was used. This guideline defines four classes of agricultural land.

- **Objective 4 - Assess the pre-mining and post-mining GQAL classes within the EIS study area**

  To satisfy Objective 4, the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI 1993) was used. This guideline sets conditions for land in terms of limitations, rating the ability of the land to maintain a sustainable level of agricultural productivity.

- **Objective 5 - Assess the pre-mining and post-mining SCL within the EIS study area and provide soil management recommendations for the topsoil management**

  To satisfy Objective 5, the relevant guideline applied was the *Protecting Queensland's strategic cropping land; Guidelines for applying the proposed strategic cropping land criteria* (DERM 2011). The guideline provides guidance on assessing SCL in terms of preliminary assessment, field mapping, criteria and next steps for validation.



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

SOIL TYPES

LAND RESOURCES - SOIL

Figure: **5.3-10**

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- **Objective 6 - Assess the suitability of the current topsoil for future rehabilitation including the identification of unfavourable materials in the EIS study area**

  To satisfy Objective 6, the *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas* (Elliot and Veness 1981; Elliot and Reynolds 2000) was utilised to determine the soils that are suitable for conserving and utilisation in the EIS study area's rehabilitation program. The approach described in this guideline remains the benchmark for land resource assessment in the Australian mining industry.

- **Objective 7 - Assess the potential erosion rates for various scenarios during the construction, operational and post mining phases of the project**

  To satisfy Objective 7, the Revised Universal Soil Loss Equation (UDSA 1930) was used to calculate erosion rates and potential erosion hazards, as sourced from Landcom (2004).

5.3.3.3 Description of Environmental Values

Soil Mapping

An initial broad scale reconnaissance soil map for the EIS study area was developed using the following background information, resources and techniques:

- aerial photographs and topographic maps;
- reference information:
  - colour aerial photography – BMA Goonyella Project (AAMH 3155-2c) flown 25 July 2005 by AAM Hatch, Runs 1 and 2 at a nominal scale 1:36,000;
  - colour aerial photography – BMA Goonyella Project (AAMH 3102-3c), flown 22 March 2005, Run 1 at nominal scale 1:40,000;
  - EIS study area topographic data provided by BMA with 0.5 and 2 metre contour intervals;
  - Geological Survey of Queensland (GSQ) Geoscience Data 1:100,000 Sheet areas Harrybrandt (8554) and Wyena (8454), compiled by Natural Resource Sciences – GSQ (2004);
  - CSIRO Australia Land Research Series No.19 – Lands of the Isaac-Comet Area Queensland by Story *et al*. (1967);
  - Land Suitability Study of the Collinsville-Nebo-Moranbah Region, Department of Natural Resources and Mines, Land Resources Bulletin QB 84010 ISSN 0155-221X, by P.G. Shields, Department of Primary Industry (1984);
  - Land Reclamation Services Pty Ltd (January 1993) Report on Soil Survey of Future Open Cut Mining Areas of the Goonyella Riverside Mine;
  - Galloway *et al.* (1967) 1:500,000 Isaac-Comet Land Systems;
  - GJR Holdings (2007); and
  - GSS Environmental (GSSE) (2009).

Field Survey Methodology

A soils survey of the EIS study area was undertaken using a qualitative integrated free survey technique. An integrated survey assumes that many land characteristics are interdependent and tend to occur in correlated sets (NSCT 2008). Background reference information derived from sources cited above was used to predict the distribution of soil attributes in the field. Characteristics evaluated included geology, landform and vegetation. A free survey is a conventional form of integrated survey and its strength lies in its ability to assess soil and land at medium to detailed-scales by focussing on transitions from one soil type to another (NCST 2008). Survey points are located irregularly, according to the survey teams' expertise and judgement, to enable the delineation of soil boundaries.

The soil mapping was undertaken at a high intensity survey scale of 1:25,000 for the areas that will be impacted upon by the project, while the overall area was surveyed at a medium scale of 1:50,000. This survey scale offers an adequate dataset of soil types within the EIS study area and appropriate detail to assess the potential impact on these soils following the proposed operations. To satisfy this scale in accordance with the *Guidelines for Surveying Soil and Land Resources* (NCST 2008), the number of observations per unit area required was: one observation per 6.25 hectares for the 1:25,000 scale area, and one observation per 25 hectares for 1:50,000 scale. The majority of these observations were considered 'minor' observations, such as inspection of exposed cuttings, 0.30 metre auger holes, and inspection of rock outcrops.

The soil profiles were assessed in accordance with the Australian Soil and Land Survey Field Handbook soil classification procedures. Detailed soil profile descriptions were logged using soil data sheets. The information recorded consisted of the parameters specified in **Table 5.3-4**. Photographs and global positioning system (GPS) locations were taken at each site and all soil test pits were backfilled immediately after the field assessment.

Table 5.3-4 Detailed Profile Description Parameters

Descriptor	Application
Horizon depth	Weathering characteristics, soil development
Field colour	Soil naming convention, permeability, susceptibility to dispersion /erosion
Field texture grade	Erodibility, hydraulic conductivity, moisture retention, root penetration
Boundary distinctness and shape	Erosional / depositional status, textural grade
Consistence force	Structural stability, dispersion, ped formation
Structure pedality grade	Soil structure, root penetration, permeability, aeration
Structure ped and size	Soil structure, root penetration, permeability, aeration
Stones – amount and size	Water holding capacity, weathering status, erosional / depositional character
Roots – amount and size	Effective rooting depth, vegetative sustainability
Ants, termites, worms	Biological mixing depth

Soil layers at each profile site were also assessed according to a procedure devised by Elliot and Veness (1981) and Elliot and Reynolds (2000) for the recognition of suitable top dressing material. This procedure assesses soils based on grading, texture, structure, consistency, mottling and root presence.

Laboratory Testing

Laboratory results have been used to distinguish physical and chemical properties of 11 soil units across the EIS study area, according to *Guidelines for Agricultural Land Evaluation in Queensland* (DPI 1990), and were analysed at National Association of Testing Authorities (NATA) accredited laboratories, for the following parameters:

- Every sample:
  - electrical conductivity (ECe), pH and chloride.
- Every major soil horizon:
  - exchangeable cations;
  - cation exchange capacity (CEC);
  - particle size analysis (PSA); and
  - total phosphorus, potassium, sulphur.
- Surface soil horizon:
  - micronutrients;
  - aluminium;
  - free and total iron;
  - sulphate;
  - total nitrogen; and
  - organic carbon.

Results are presented in **Section 3.2** of **Appendix F2**, and discussed in the analysis of soil types below.

Representative samples were also analysed for the following parameters in order to satisfy other requirements of the TOR:

- colour;
- gravimetric water content; and
- K-factor.

Land Systems

The results of the field assessment identified that the EIS study area is comprised of the following land systems:

Durrandella Land System

The Durrandella Land System is characterised by hills with lancewood and narrow-leaved ironbark on weathered Tertiary and Permian materials. Landforms are most commonly Tabular hills and breakaways / small stony hills. This land system also includes foot hills and alluvial flats. Rocky outcrops are widespread and sheet erosion and gullying have been observed to be active in steeper margins.

Soil types are mainly shallow and rocky soils, which include loamy red and yellow earths and texture contrasts. A variety of vegetation assemblages characterise this land system, including savannah woodland, lancewood or bendee, mixed scrub and brigalow.

Connors Land System

The Connors Land System is characterised by alluvial plains with box trees on texture contrast soils. Common landforms include alluvial plains, terraces and levees. Additionally back swamps and channels are present throughout the landscape. Large areas of land are subject to flooding and permanent water holes may be associated with this land system.

Soil types are predominantly texture contrast soils with sandy surface soils. There are also uniform, medium to fine textured alluvial soils and cracking clay soils. Vegetation assemblages consist primarily of Savannah woodland, and to a lesser extent mixed shrub woodland and brigalow.

Monteagle Land System

The Monteagle Land System is characterised by lowlands with box and texture contrast soils on un-dissected Tertiary land surface. Land forms are most commonly plains, lowlands and colluvial footslopes. Also present are rises and interfluves, depressions and shallow valleys, and alluvial flats. Throughout the landscape there are occasional gilgai and gravels, and gullying has been observed.

Soil types include texture contrast soils of thin sandy or loamy surface soils with strongly alkaline subsoils and, to a lesser extent, cracking clay soils and sandy red earths. Vegetation assemblages consist primarily of savannah woodland, with brigalow and mixed shrub woodland also present. The details of this study were used as a source of reference for soil types encountered in the field.

Soil Classification

Soil Types Overview

The ASC system nomenclature was adopted to identify and label soil units within the EIS study area, as required by the ToR. This standard is routinely used as the soil classification system in Australia and will form the key descriptor throughout this assessment. In this system, soil layers are termed horizons and the A and B horizons are together referred to as the Solum.

Within the EIS study area 11 soil types were identified. **Table 5.3-5** provides an overview of each soil type and their quantitative distribution within the EIS study area. **Figure 5.3–10** illustrates their spatial distribution.

Table 5.3-5 Soil Types

Soil Type Number	Soil Types	EIS Study Area		
		EIS Study Area within Proposed MLA (ha)	EIS Study Area within Existing ML (ha)	Area (%)
1	Lithic Rudosol	426	3	3
2	Tenosol	270	25	2
3a	Red Kandosol	2,052	<1	17
3b	Brown Kandosol	386	17	3
4	Brown Kurosol	187	nil	1
5	Brown Chromosol	1,445	417	15
6	Brown Sodosol	1,757	176	16
7	Brown Dermosol	817	168	8
8a	Shallow Vertosol	692	155	7
8b	Deep Vertosol	589	nil	5
8c	Deep Salic Vertosol	2,675	37	22
n/a	Disturbed Terrain	2	35	<1
Total		**11,298**	**1033**	**100**

These soils types have been derived from the current survey (**Appendix F2**) as well as previous field surveys of the site (GJR Holdings 2007; GSSE 2009). Laboratory results from all three surveys can be found in **Appendix F2**. These soil types are detailed in the following section. The area of proposed disturbance has not been calculated for each soil type as the surface area requiring disturbance by the IMG management infrastructure is not fully defined.

Field Assessment

Soil Type 1 – Lithic Rudosols

<u>Description:</u> The Lithic Rudosols are of limited extent throughout the EIS study area, and are characterised by shallow rocky (skeletal) soils with a clay loam or clayey soil matrix associated with, or underlain by shallow bedrock or gravelly colluvium. They are mainly shallow (less than 0.5 metres) and exhibit minimal profile development apart from some darkening near the surface due to the influence of organic matter. The topsoil is structurally stable with low potential for dispersion, and is generally of moderate salinity and is strongly acidic. Similarly, the subsoil has a low potential for dispersion, is generally moderately saline and is strongly acidic. In places the Lithic Rudosols comprise ferruginous gravel and gravelly colluvium derived from weathering of the Permian and Tertiary sedimentary rocks in the area. No samples of this soil type were collected for laboratory analysis as information was available from previous studies.

<u>Location:</u> These soils occur on the low hills and on lower escarpment slopes of sections throughout the eastern and western area of the EIS study area. They also occur in association with somewhat deeper uniform and gravelly clay soils (Soil Type 7: Brown Dermosols) on low hilly lands and rises, encompassing an area of 426 hectares, or four per cent of the EIS study area. This soil type is represented by site B12.

Land Use: The land overlying these soils is currently used for grazing; however, clearing has been limited to the flatter areas where this soil type occurs. The steeper slopes and crests of the small hills are covered by native tree species with some native and introduced grass species.

Management: This soil type is generally shallow with coarse rocky topsoil. The topsoil is considered generally unsuitable for use as surface cover in rehabilitation due to its shallow, gravelly, and strongly acidic nature.

Soil Type 2 – Tenosol

Description: The Tenosol soils are characterised by poor structure and loose sandy texture. They comprise deep (greater than one metre) sand or silty sand grading to loamy or light clayey sand subsoils, usually with some ferruginous concretions associated with mottled sandy clay-clayey sand substrate soils. The topsoil is generally non-dispersive, and has low levels of salinity, with a neutral pH. The subsoil is slightly-to-moderately dispersive, low in salinity and generally neutral pH. There were no samples of this soil type collected for laboratory analysis. This soil type includes unconsolidated uniform sand, silty sand or gravelly sand deposits in the channel floor in the Isaac River or its main tributaries.

Location: This soil type occurs on the flat lower area of the catchment, within drainage lines or on the immediate floodplain of the Isaac River, on the eastern side of the EIS study area, encompassing an area of 270 hectares, or two per cent of the EIS study area. This soil type is represented by site C120.

Land Use: The land overlying these soils is currently used for grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species. However, on the immediate banks of the Isaac River riparian vegetation is largely intact.

Management: These soils are considered suitable for use in rehabilitation. The silty sand topsoil does not display any specific management risk related to potential disturbance during stripping. The loamy sand subsoil also displays characteristics beneficial for use in rehabilitation. It is recommended that the topsoil be stripped to a depth of 0.4 metres, and that the subsoil be stripped to a depth of 0.8 metres; however, the subsoil is moderately dispersive and should only be used as an intermediate layer in rehabilitation.

Soil Type 3a – Red Kandosols

Description: The Red Kandosol includes ferruginous (lateritic) gravelly and non or sparse gravelly massive red earth soils. These are mostly deep (greater than one metre) soils with a sandy loam to loamy surface grading to yellowish red or red clay loam, or medium to heavy clay subsoils, locally underlain by ferruginous gravelly clay-clayey gravel substrates. The topsoil is non-dispersive to moderately dispersive, mainly non-saline to slightly saline with a sample that was moderately saline. The topsoil varies from slightly acidic to mildly alkaline, although when tested it was consistently neutral. The subsoils are typically non-dispersive, although extremely sodic soils with elevated levels of dispersability are also present. The subsoil is generally non-saline to slightly saline, and from mildly alkaline to neutral.

Location: This soil type occurs on gently to moderately inclined slopes and undulating low rises, as well as some higher alluvial terraces and outwash slopes, on undulating plains and dissection slope interfluves, on crestal plains, lower slopes and on mid to lower valley slopes. They encompass an area of 2,052 hectares, or 18 per cent of the EIS study area. This soil type is represented by sites B37, C68 and C91.

Land Use: The land overlying these soils is currently used for grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

Management: Generally the topsoil and immediate subsurface soil of this soil type do not display any specific management risk related to potential disturbance during stripping. Both layers exhibit structure and chemical characteristics that would be suitable as surface cover in rehabilitation. The increased presence of clay with depth throughout the profile restricts the use of the subsoil as a topdressing material. Therefore, topsoil can be salvaged for reuse in rehabilitation at a recommended depth of approximately 30 centimetres.

Soil Group 3b – Brown Kandosol

Description: The Brown Kandosol comprise deep (greater than one metre) mainly massive yellow-brown earths with sandy loam to light clayey surface soils grading to light to medium or heavy clay subsoils, locally with ferruginous gravelly layers included. The topsoil is typically slightly-to-moderately dispersive, non-saline, though in some instances slightly saline, and mainly neutral to slightly acidic. The subsoils are moderately to strongly dispersive, generally non-saline, with some slightly-to-moderately saline soils present, and mildly to moderately alkaline.

Location: This soil type occurs on gently inclined slopes to drainage lines, on flat to depressional plains, in depressional drainage ways and on gently inclined, broadly rounded interfluves and low rises. They encompass an area of 386 hectares, or three per cent of the EIS study area. This soil type is represented by site C104.

Land Use: The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

Management: Generally the topsoil does not display any specific management risk related to potential disturbance during stripping. The topsoil layer exhibits structure and chemical characteristics that would be suitable as surface cover in rehabilitation. The subsoil ranges from moderate to strongly dispersive and would require erosion control structures to be implemented if disturbed. An application of gypsum to reduce the management risks in the subsoil when stripped may be beneficial. The recommended stripping depth of this soil is 0.5 metres.

Soil Group 4 – Brown Kurosols

Description: The Brown Kurosol is comprised of a deep loamy surface duplex soil with a pale gravelly clay sub-surface horizon, an acidic to strongly acidic dark brown heavy clay subsoil horizon, underlain by mottled reddish-brown and grey heavy clay lower subsoil where approaching the (very strongly acidic) weathered rock substrate. The topsoil is moderately dispersive and slightly-to-moderately saline with a neutral pH. The subsoil's were strongly dispersive, highly saline and highly acidic.

Location: This soil type occurs on gently to moderately inclined foot slopes in a small area to the north-west of the EIS study area, encompassing an area of 187 hectares, or two per cent of the EIS study area. This soil type is represented by site A77.

Land Use: The land overlying these soils is currently used for grazing, having been largely cleared of trees, cultivated and improved with native and exotic pasture species.

Management: Generally the topsoil does not display any specific management risk related to potential disturbance during stripping. The topsoil layer exhibits structure and chemical characteristics that would be suitable as surface cover in rehabilitation. However, where stone content becomes prohibitive to re-use on rehabilitation, material should not be salvaged for that purpose. The subsoil is strongly dispersive, highly saline and highly acidic and is therefore not suitable for use as topdressing in rehabilitation. Furthermore, erosion control measures should be implemented during the exposure of this soil. The recommended stripping depth of this soil is 0.3 metres.

Soil Group 5 – Brown Chromosol

Description: The Brown Chromosol includes deep (>1 metre) mostly thick sandy and loamy surface duplex soils generally with a pale (A2) horizon over brown or yellow-brown, sometimes diffusely mottled non-sodic to marginally sodic, non-saline sandy clay or medium to heavy clay subsoils. The topsoil is structurally stable with a low potential for dispersion. The majority of topsoil is non-saline although it can be slightly saline and is slightly acidic to moderately alkaline. The subsoil varies from slightly dispersive to strongly dispersive, is generally slightly to non-saline, although occasionally moderately saline, and is neutral to slightly alkaline pH value.

Location: These soils occur on alluvial terraces and on broadly rounded rises and dissection slope interfluves, common throughout the eastern areas of the EIS study area, encompassing an area of 1,445 hectares, or 13 per cent of the EIS study area. This soil type is represented by sites C82 and C121.

Land Use: The land overlying these soils is currently used for grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

Management: Generally, the topsoil of this soil unit does not display any specific management risk related to potential disturbance during stripping. The clay subsoils should not be recovered or used as a surface cover in rehabilitation due to high clay content, massive structure and alkalinity. The sandy loam topsoil is considered generally suitable as a surface cover during rehabilitation. The topsoil is suitable for stripping to a depth of 0.4 metres.

Soil Group 6 – Brown Sodosols

Description: The Brown Sodosol comprise medium to deep hard-set thin loamy surface duplex soils usually with a pale or bleached sub-surface (A2) horizon with dark brown, yellowish-brown and, in places, reddish-brown, light medium to heavy clay deep subsoils. The topsoil is non-dispersive to moderately dispersive, is generally moderately saline, and the topsoil was generally neutral, or in some instances moderately acidic. The subsoils are generally highly sodic and dispersive, moderately to highly saline, and moderately acidic to moderately alkaline.

Location: These soils occur on alluvial flats, back-plains and older alluvial plains, on gently inclined plains, gently undulating rises dissection and on slope interfluves and slopes to drainage, encompassing an area of approximately 1,757 hectares, or 16 per cent of the EIS study area. This soil type is represented by site B40.

Land Use: The land overlying these soils is currently used for grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

Management: Generally the sandy clay loam topsoil does not display any specific management risk related to potential disturbance during stripping. The clay subsoils are generally considered unsuitable for stripping, mainly due to the high sodicity and associated dispersion characteristics of Sodosols. The clay subsoils should not be recovered or used as surface cover for rehabilitation. Due to the variation in the topsoil depth, the sandy loam topsoil is considered suitable for stripping to a depth of 0.25 metres. The topsoil is suitable as a surface cover in the establishment of vegetation.

Soil Group 7 – Brown Dermosols

Description: The Brown Dermosols generally include deep (greater than one metre) mainly uniform clay soil profiles in places with a hard-set or thin weak self-mulching clay loam to medium clay surface horizon over dark brown structured clay soils (locally tending to incipient cracking clay soils); or, brown to yellow-brown weakly structured to massive, clay subsoils. The topsoil is non-dispersive to moderately dispersive, is non-saline and varied from slightly acidic to moderately alkaline, with occasionally high gravel content. The subsoils are generally moderately to highly dispersive, though are occasionally slightly to non-dispersive, are mainly saline and varied from acidic to highly alkaline.

Location: These soils occur on alluvial plains, on depressional plains with prominent gilgai development and on older alluvial plains. The soils are common throughout the western areas of the EIS study area, encompassing an area of 817 hectares, or seven per cent of the EIS study area. This soil type is represented by sites B21 and C72.

Land Use: The land overlying these soils is currently used for grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

Management: The topsoil is generally considered suitable for stripping for use as surface cover or intermediate layer below the surface layer in rehabilitation. The clay subsoils are considered to be unsuitable for stripping for use as surface cover due to high sodicity, moderate salinity and pH ranges generally limiting for the growth of vegetation. The recommended stripping depth for this soil is 0.2 metres.

Soil Group 8a – Shallow Vertosols

Description: The Vertosols comprises shallow to medium deep (smaller than one metre) cracking clay soils with a thin weak self-mulching surface soil over dark brown or brownish black sodic moderately saline heavy clay subsoils underlain by weathered rock. The topsoil is typically non-dispersive, although occasionally has moderate dispersion ratings, is non-saline to slightly saline, and neutral to slightly alkaline. The subsoils are sometimes non-dispersive, although are generally moderately to highly dispersive. They vary from non-saline to highly saline and are slightly acidic to moderately alkaline. The key characteristics of the Vertosols is their uniform medium to heavy clay texture throughout the profile, pronounced swelling and shrinkage properties on wetting and drying, and usually moderate to high levels of sodicity and/or salinity in the subsoil horizons. Unlike the Deep Vertosols, the Shallow Vertosols are not typically associated with gilgai presence.

Location: These soils occur on undulating plains and gently to moderately inclined slopes, but mainly on crestal areas and lower slopes in strongly undulating lands and on low rocky rises associated with the Tertiary Basalt geological regime. They encompass an area of 692 hectares, or six per cent of the EIS study area. This soil type is represented by site C54.

Land Use: The land overlying these soils is currently used for grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

Management: There is no need to strip topsoil in these areas. These soils are texturally unsuitable for use as surface cover for rehabilitation. Potential for these soils to impact on infrastructure such as the IMG management infrastructure should be assessed as part of detailed design, and management such as use of hydrated lime may be required.

Soil Type 8b – Deep Vertosol

Description: Vertosols are characterised by deep (greater than one metre) cracking clay soils with a thin weak self-mulching surface soil over dark brown or brown strongly structured mostly sodic heavy clay subsoils, tending to massive, strongly sodic, often calcareous heavy clay in the deeper subsoils. The topsoil is mainly non-dispersive, occasionally moderately dispersive. It varies from non-saline to moderately saline and is slightly acidic to slightly alkaline. The subsoils are generally non-dispersive to moderately dispersive, moderately saline to extremely saline, and neutral-to-moderately alkaline. The key characteristics of the Vertosols is their uniform medium to heavy clay texture throughout the profile, pronounced swelling and shrinkage properties on wetting and drying. The Deep Vertosols are widely associated with gilgai micro relief.

Location: This soil type occurs extensively, mainly in the northern sector of the EIS study area comprising drainage-ways, drainage flats and alluvial plain, on near level older alluvial plains and gently undulating plain, and on gently inclined slopes, foot-slopes and low rises. They encompass an area of 589 hectares, or five per cent of the EIS study area. This soil type is represented by observation point A10.

Land Use: The land overlying these soils is currently used for grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

Management: There is no need to strip topsoil in these areas. These soils are texturally unsuitable for use as surface cover for rehabilitation. Potential for these soils to impact on infrastructure such as the IMG management infrastructure should be assessed as part of detailed design, and management such as use of hydrated lime may be required.

Soil Group 8c – Deep Salic Vertosols

Description: Vertosols are characterised by deep (greater than one metre) cracking clay soils mostly with self-mulching surface soils over dark grey-brown or brownish black strongly structured heavy clay subsoils with shiny slickensides surfaces tending to massive calcareous, marginally to highly saline heavy clay in the deeper subsoils. The topsoil is mainly non-dispersive, varies from non-saline to high saline and is moderately acidic to moderately alkaline. The subsoil is mainly non-dispersive to, occasionally moderately dispersive, is moderately saline to extremely saline and neutral to moderately alkaline. The key characteristics of the Deep Vertosols are: their uniform medium to heavy clay texture throughout the profile, pronounced swelling and shrinkage properties on wetting and drying, and usually moderate to high levels of sodicity and/or salinity in the subsoil horizons. The Deep Salic Vertosols are widely associated with gilgai micro relief.

Location: This soil type occurs extensively in the EIS study area and is particularly common in the north-eastern areas, comprising drainage-ways, drainage flats and alluvial plain, on near level older alluvial plains and gently undulating plain, and on gently inclined slopes, foot-slopes and low rises. They encompass an area of 2,675 hectares, or 24 per cent of the EIS study area. This soil type is represented by pit B35.

Land Use: The land overlying these soils is currently used for extensive grazing, having been previously cleared of trees, cultivated and improved with native and exotic pasture species.

Management: There is no need to strip topsoil in these areas. These soils are texturally unsuitable for use as surface cover for rehabilitation. Potential for these soils to impact on infrastructure such as the IMG management infrastructure should be assessed as part of detailed design, and management such as use of hydrated lime may be required.

Land Suitability Assessment

Agricultural land suitability of the EIS study area has been assessed largely using criteria provided in the *Guidelines for Agricultural Land Evaluation in Queensland* (DPI 1990). The method of land suitability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The classification does not necessarily reflect the existing land use. Rather, it indicates the potential of the land for such uses as crop production, pasture improvement and grazing (**note** that this is a separate assessment to the SCL assessment now required under the *Strategic Cropping Land Act 2011*).

The system allows for land to be allocated into five possible classes (with land suitability for productive agriculture decreasing progressively from Class 1 to Class 5) on the basis of a specified land use that allows optimum production with minimal degradation to the land resource in the long term. Land is considered less suitable for certain uses as the severity of limitations for that land use increases. Increasing limitations may reflect any combination of:

- reduced potential for production;
- increased inputs to achieve an acceptable level of production; and/or
- increased inputs required to prevent land degradation.

The agricultural land suitability classes are described in **Table 5.3-6.**

Table 5.3-6 Scheme for Classifying Land Suitability

LS Class	Orders	LS Class Descriptor	Description
1	S Suitable	S1 None/Minor Limitations (Highly Suitable)	Land with negligible limitations for the proposed use, which is highly productive requiring only simple management practices to maintain economic production.
2		S2 Minor Limitations (Moderately Suitable)	Land with minor limitations for the proposed use, which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production.
3		S3 Moderate Limitations (Marginally suitable)	Land with moderate limitations for the proposed use, which either further lower production or require more than those management practices of Class 2 land to maintain economic production.
4	N Not Suitable	N1 (or S4) Marginal Land (Presently Unsuitable)	Marginal lands with severe limitations, which make it doubtful whether the inputs required achieving and maintaining production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production).
5		N2 (or S5) Unsuitable	Unsuitable land with extreme limitations that preclude its use for the proposed purpose.

Source: NCST 2008.

A land suitability assessment provides an analysis on how 'fit' a given area of land is for a specific type of land utilisation, in this case rainfed cropping or grazing. The analysis considers the area's land use characteristics (e.g. soil pH) and land quality attributes (e.g. moisture availability) and how these match conditions that are necessary for 'successful and sustained' implementation of a specific land utilisation type (NCST 2008; DME 1995; Shields and Williams 1991).

The land suitability analysis provides a proportional land suitability assessment whereby each soil type's characteristics and attributes are cross-referenced against the DME (1995) 'criteria checklist' for 'rainfed broadacre cropping' and 'beef cattle grazing'. The overall land suitability ranking for each specific soil type is determined by the most severe limitation, or a combination of the varying limitations. For this reason the major limiting factors determining land suitability have been presented.

Land Suitability Rankings

The EIS study area's soil units have been assessed against the criteria for 'rainfed cropping' and 'broadacre grazing' land utilisation types as per the guidelines. The first limitation for land utilisation is moisture and each soil unit's average plant available water capacity (PAWC) is provided in **Table 5.3-7**. The adjusted water availability value considers soil characteristics as well as the requirement for adequate rainfall required for sustainable yields. Where soil units have been classified as unsuitable for cropping (**Table 5.3-7**), these soil units have been subsequently assessed for their suitability for pastoral activities (refer to **Table** 5.3-8). **Figure 5.3-11** and **Figure 5.3-12** illustrate their spatial distribution.

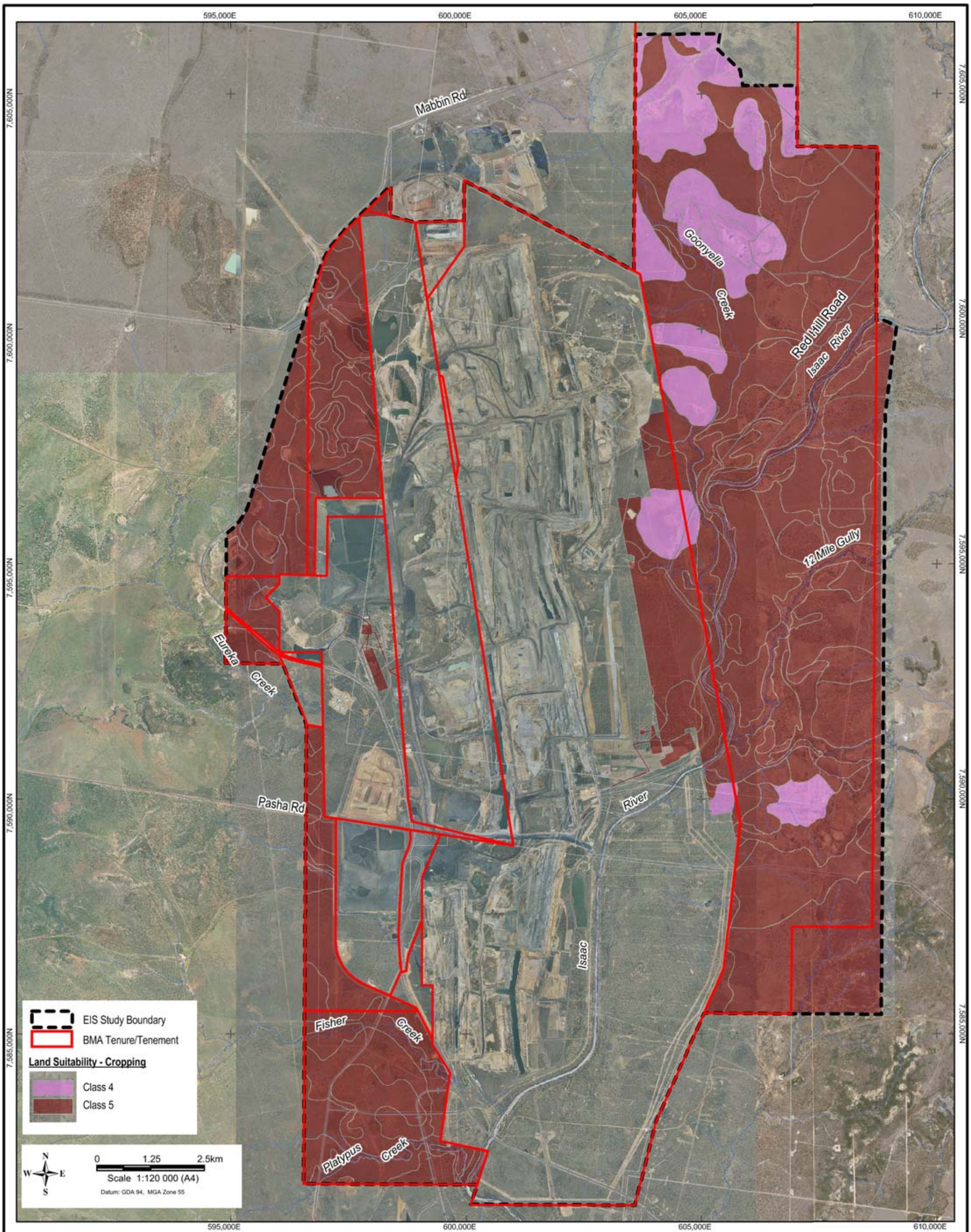
Table 5.3-7 Land Suitability (LS) Class for Rainfed Broadacre Cropping

Limitations	Soil Types									
	1	2	3a	3b	4	5	6	7	8a	8b	8c
Tabled Water availability	n/a	**5**	1	2	**5**	1	1	**5**	3	1	**5**
Adjusted Water availability	5	5	5	5	5	5	5	**5**	4	4	5
Nutrient deficiency	n/a	n/a	2	3	2	2	2	**5**	2	2	2
Soil physical factors	3	2	2	2	3	3	3	3	2	3	3
Soil workability	2	1	1	1	2	2	2	2	1	2	2
Salinity	n/a	n/a	1	1	**5**	1	1	**4**	1	1	1
Rockiness	**4**	1	1	2	2	1	1	1	1	1	1
Microrelief	1	1	1	1	1	1	1	1	1	3	3
Wetness	1	1	1	1	1	3	2	1	2	3	3
Topography	1	1	2	2	1	2	3	1	1	1	1
Water erosion	**4**	2	2	2	3	2	3	2	2	2	2
Flooding	1	2	1	1	1	1	1	1	1	1	1
Overall Class	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**4**	**5**
Suitable for Cropping	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**Marginal**	**Marginal**	**No**

Table 5.3-8 Land Suitability (LS) Class for Beef Cattle Grazing

Limitations	Soil Types										
	1	2	3a	3b	4	5	6	7	8a	8b	8c
Water availability	n/a	**4**	1	1	**5**	1	1	5	2	1	5
Nutrient deficiency	1	2	1	1	1	1	1	1	2	2	2
Soil physical factors	2	1	1	1	2	2	2	2	2	3	3
Salinity	n/a	n/a	1	1	2	1	1	2	1	1	1
Rockiness	2	1	1	2	2	1	1	1	1	1	1
Microrelief	1	1	1	1	1	1	1	1	1	2	2
pH	n/a	n/a	2	2	2	2	2	3	3	3	3
ESP%	n/a	n/a	1	1	2	1	1	4	1	2	3
Wetness	1	2	2	2	1	2	2	2	2	2	2
Topography	1	1	1	1	1	1	1	1	1	1	1
Water erosion	3	1	1	1	1	1	3	1	1	1	1
Flooding	1	2	1	1	1	1	1	1	1	1	1
Vegetation regrowth	1	1	1	1	1	1	1	1	1	1	1
Overall Class	**3**	**4**	**2**	**2**	**5**	**2**	**3**	**3***	**3**	**3**	**3***
Suitable for Grazing	**Yes**	**No**	**Yes**	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

*modified due to field observations.



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CROPPING LAND SUITABILITY ASSESSMENT

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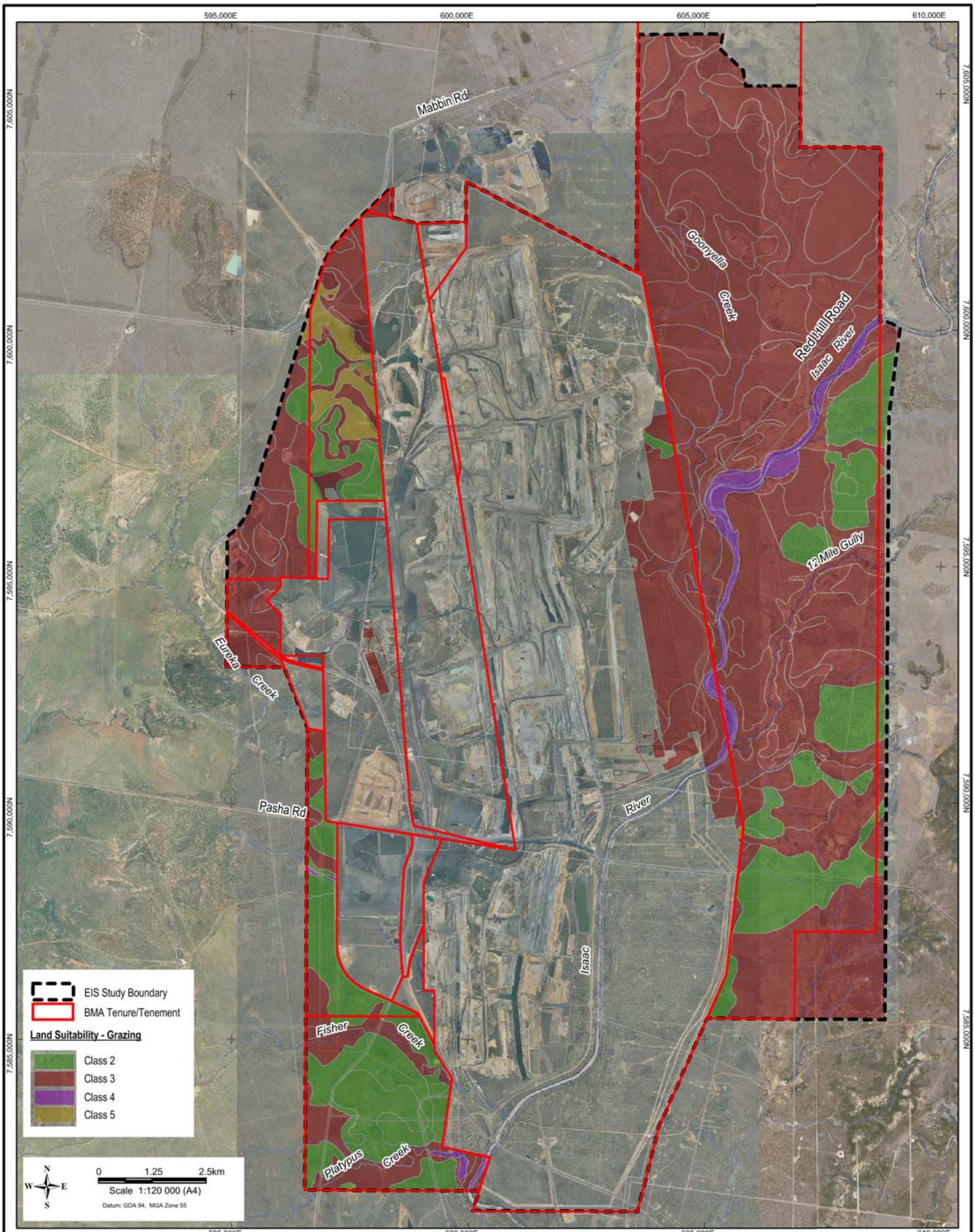
LAND RESOURCES - SOIL

Figure: **5.3-11**

File No: **42627136-g-1067.wor** Drawn: **VH** Approved: **CT** Date: **17-06-2013** Rev.**A** A4



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GRAZING LAND SUITABILITY ASSESSMENT

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LAND RESOURCES - SOIL

Figure: **5.3-12**

File No: **42627136-g-1068.wor** Drawn: **VH** Approved: **CT** Date: **17-06-2013** Rev. **A** A4

Good Quality Agricultural Land

Soils of the EIS study area were assessed against the agricultural land classification system, which is used to identify potential GQAL in accordance with the *Planning Guidelines – The Identification of Good Quality Agricultural Land* (DPI 1993) (referred to as the GQAL guidelines). Agricultural land is defined as land used for crop or animal production, but excluding intensive animal uses (i.e. feedlots and piggeries). GQAL is land that is capable of sustainable use for agriculture, with a reasonable level of inputs, and without causing degradation of land or other natural resources.

The Department of Primary Industries (DPI) guidelines were introduced to provide local authorities and development proponents with a system to identify areas of GQAL for planning and project approval purposes. Descriptions of the agricultural land classes are provided in **Table 5.3-9**.

The agricultural land classification classification system combines land suitability assessments for a number of specific land utilisation types into a single land classification. This classification system has four categories: arable (A), limited arable (B), pastoral (C) and non-agricultural (D) (refer to **Table 5.3-10**.

Table 5.3-9 Scheme for Classifying Agricultural Land

Class	Name	Description
A	Arable land (crop land)	Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels.
B	Limited arable land (limited crop land)	Land that is marginal for current and potential crops due to severe limitations and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping.
C	Pastoral land	Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.
D	Non-agricultural land	Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage.

Source: DPI (1993).

Table 5.3-10 Broadacre Cropping Land Suitability Ranking and Agricultural Land Class Correlation

LS Ranking	Description	ALC
1	High quality land with few or minor limitations for most agricultural activities.	A
2	Land with minor limitations for agricultural activities.	A
3	Moderate limitations to sustaining its use for agriculture.	A
4	Marginal land requiring major inputs to sustain the agricultural use.	B or C
5	Unsuitable for agricultural use due to extreme limitations.	C or D

The overall land suitability rating of 1 to 5 is translated into an agricultural land classification rating of A to D. Additionally, for the Central West Queensland region, agricultural land class C is further divided into three sub-classes of C1, C2 and C3, according to potential grazing quality, as outlined in **Table 5.3-11** below.

Table 5.3-11 Beef Cattle Grazing Land Suitability Ranking and Agricultural Land Class

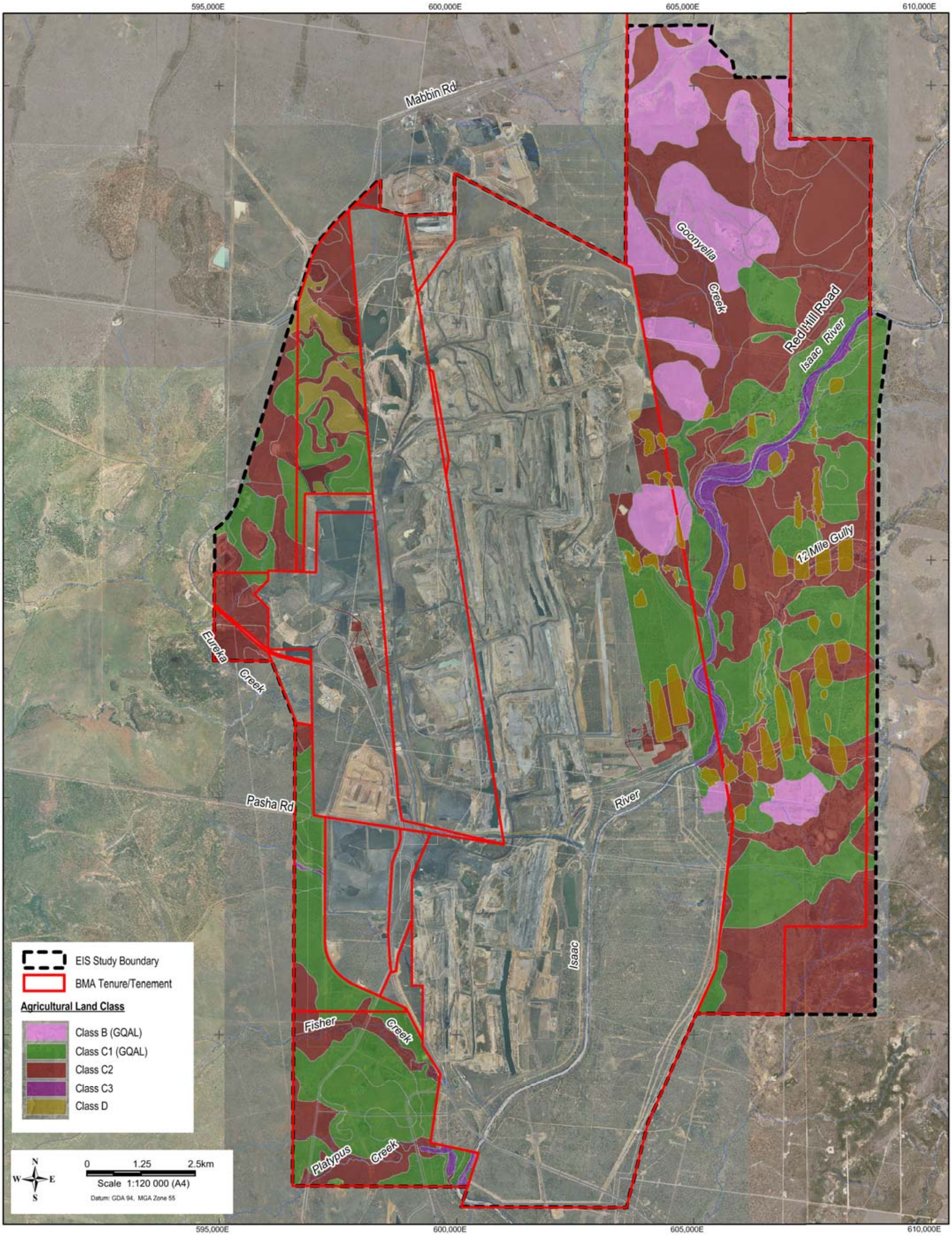
LS Rating	Land Suitability Description (DME, 1995)	ALC	Agricultural Land Classification Description	Basis for Correlation (1)
1	High quality land with few or minor limitations.	C1	Good quality grazing and/or highly suitable for pasture improvement.	Brigalow vegetation; appropriate for fattening beef cattle; good grazing on sown pastures and can withstand ground disturbance.
2	Land with minor limitations.	C1		Brigalow vegetation and/or transitional vegetation to poplar box vegetation communities.
3	Moderate limitations to sustaining its use.	C2	Moderate quality grazing and/or moderately suitable for pasture improvement.	Eucalypt woodland, poplar box, narrow-leaved eucalyptus, gum-top woodlands; low-moderate PAWC and low-moderate fertility; good grazing on native pastures without ground disturbance; appropriate for beef cattle breeders.
4	Marginal land requiring major inputs to sustain the use.	C3	Low quality grazing, grazing of native pastures with limited suitability for pasture improvement.	Tea-tree vegetation; usually characterised by steep country or mangrove flats.
5	Unsuitable due to extreme limitations.	D	Not suitable.	Unsuitable due to extreme limitations.

Source: B. Forster DERM (pers comm., 2010)

The Isaac Regional Shire Council classifies the agricultural land classes A, B and C1 as GQAL. As such, **Table 5.3-12** shows the amount of GQAL in the EIS study area. According to the Isaac Regional Shire Council Planning Scheme, agricultural land classes A, B & C1 are considered GQAL. The EIS study area contains approximately 6,161 hectares of GQAL under the above definition. The spatial distribution of this classification prior to development of the proposed project is shown in **Figure 5.3-13**.

Table 5.3-12 Agricultural Land Class and Good Quality Agricultural Land

Soil Type	Cropping LS Rating	Grazing LS Rating	Equivalent ALC	GQAL	EIS Study Area		
					Area within proposed MLA (ha)	Area within existing ML (ha)	%
1. Lithic Rudosol	N/A	3	C2	No	426	2.8	3
2. Tenosol	N/A	4	C3	No	270	25	2
3a. Red Kandosol	N/A	2	C1	Yes	2,052	<1	17
3b. Brown Kandosol	N/A	2	C1	Yes	386	17	3
4. Brown Kurosol	N/A	5	D	No	187	x	1
5. Brown Chromosol	N/A	2	C1	Yes	1,445	417	15
6. Brown Sodosol	N/A	3	C2	No	1,757	176	16
7. Brown Dermosol	N/A	3	C2	No	817	168	8
8a. Shallow Vertosol	4	3	B	Yes	692	155	7
8b. Deep Vertosol	4	3	B	Yes	589	x	5
8c. Deep Salic Vertosol	N/A	3	C2	No	2,675	37	22
				Total	**11,298**	**1,033**	**100%**



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AGRICULTURAL LAND CLASSES

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Figure: **5.3-13**

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Strategic Cropping Land Assessment

An assessment of the potential for the project to infringe on SCL has been undertaken using the *Protecting Queensland's Strategic Cropping Land: Guidelines for applying the proposed strategic cropping land criteria* (DERM 2011; referred to as the policy) as guidance.

In 2010 the Queensland Government released the policy to protect Queensland's best cropping land from permanent alienation or diminished productivity due to the competing land uses of agricultural, mining and urban development. This policy provides a new framework and approach for the conservation and management of Queensland's best cropping land for long term food production and regional growth. This land is called SCL and includes the best land that is currently being cropped, as well as the best land resources that could be cropped in the future.

SCL is defined by soil, climatic and landscape characteristics which result in an area being highly suitable for crop production. A staged assessment process has been used to identify whether SCL is present, as shown below in **Table 5.3-13**.

Table 5.3-13 Process of Assessing Strategic Cropping Land

Step	Process	Action
1	Check if the land is in an SCL zone.	**Yes** – Proceed to Step 2 **No** – Land outside of the SCL zone is not subject to the SCL policy
2	Is the land shown as likely SCL on the trigger map?	**No** – Development proponent: No further assessment required under SCL policy. **No –** Landholder: May wish to conduct an assessment of the land to determine whether it is likely to be SCL and apply to 'opt in' to trigger map. **Yes –** Proceed to Step 3.
3	Identify which SCL zone the land is in – Western Cropping, Eastern Darling Downs, Coastal Queensland, Wet Tropics or Granite Belt.	Consult the appropriate SCL criteria.
4	Conduct an on-ground assessment using the appropriate SCL criteria and guidelines. Proceed to Step 5.	
5	If the land is SCL and within a Strategic Cropping Protection Area, no further SCL validation assessment is required and development will be assessed under the SCL policy. If the land is SCL and within the Strategic Cropping Management Area, the property will also need to be assessed for a history of cropping. If the land meets the SCL criteria and the history of cropping test, no further SCL validation assessment is required and development will be assessed under the SCL policy. Otherwise, the SCL policy will not apply.	

Source: DERM 2011

Initially, publicly available trigger maps were consulted to determine whether the EIS study area was likely to interact with an area of SCL. There are approximately 500 hectares of trigger mapped SCL, however none of these areas are proposed to be impacted by the project activities. Preliminary field investigations were undertaken prior to the release of the SCL assessment guidelines in September 2011. This preliminary fieldwork found that there was potential SCL within the trigger mapped areas, however this would require further investigation and testing against the final SCL criteria to accurately determine if soil conditions meet the requirements. The soil criteria used to identify SCL is outlined below in **Table 5.3-14**.

Table 5.3-14 Summary of Criteria for Identifying SCL

Criteria	Criteria Thresholds for each SCL Zone				
	Western Cropping	Eastern Darling Downs	Coastal Queensland	Wet Tropics	Granite Belt
1. Slope	≤ 3%	≤ 5%			
2. Rockiness	≤ 20 % for rocks > 60 mm diameter				
3. Gilgai microrelief	< 50% of land surface being gilgai microrelief of >500 mm in depth				
4. Soil depth	≤ 600 mm				
5. Soil wetness	Has favourable drainage				Has satisfactory drainage
6. Soil pH	For non-rigid soils, the soil at 300 mm and 600 mm soil depth must be greater than pH 5.0 For rigid soils, the soil at 300 mm and 600 mm soil depth must be within the range of pH 5.1 to pH 8.9				
7. Salinity	Chloride content < 800 mg/kg within 600 mm of the soil subsurface		$EC_{1.5}$ < 0.56 dS/m within 600 mm of the soil surface		
8. Soil water storage	≥ 100 mm to a soil depth or soil physio-chemical limitation of ≤ 1,000 mm		≥ 75 mm to a soil depth or soil physio-chemical limitation of ≤ 1,000 mm	≥ 50 mm to a soil depth or soil physio-chemical limitation of ≤ 1,000 mm	≥ 25 mm to a soil depth or soil physio-chemical limitation of ≤ 1,000 mm

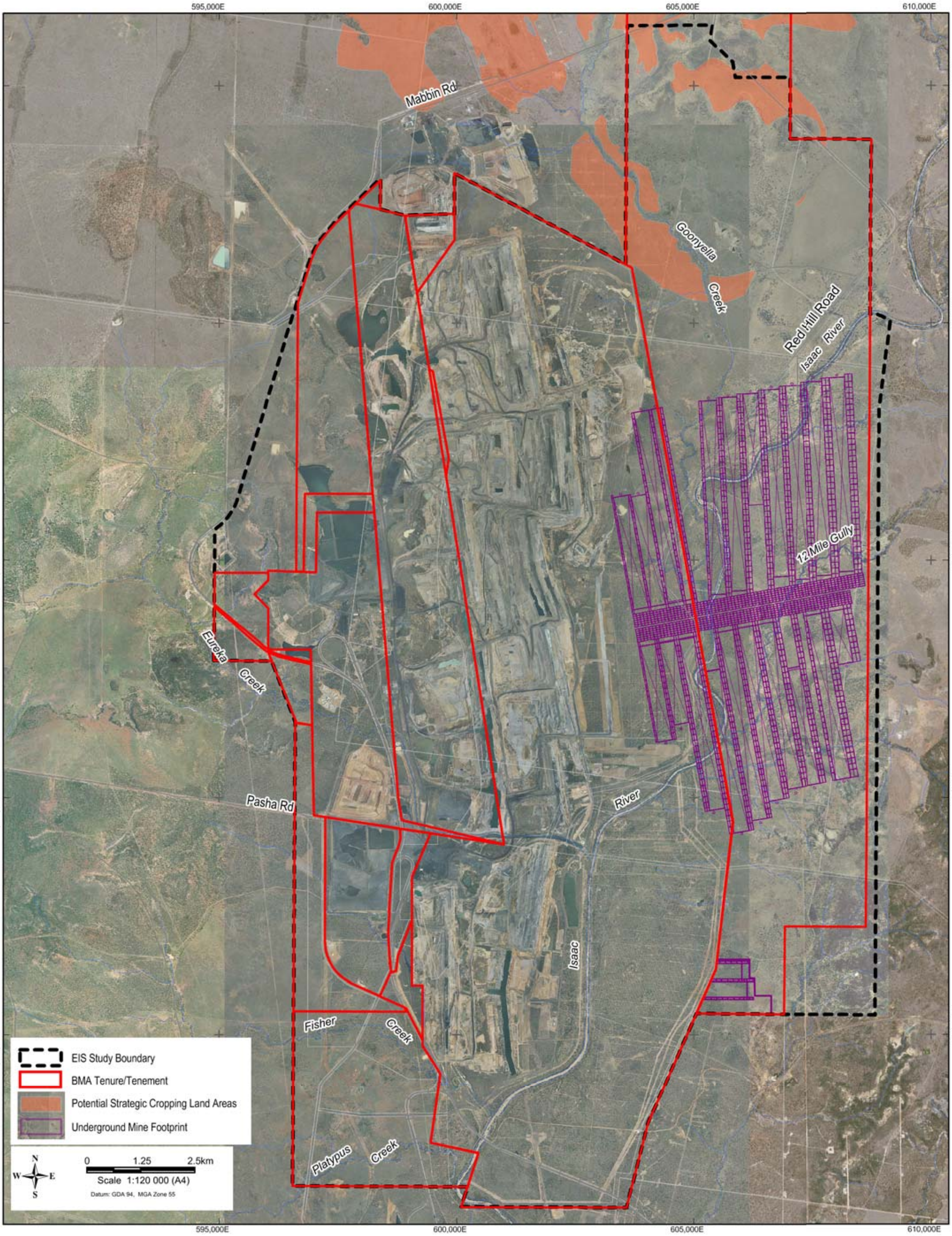
Section 4 of the *Protecting Queensland's strategic cropping Land – Guidelines for applying the proposed strategic cropping land criteria* (DERM 2011) outlines the detail of each of the eight criteria and methodology for assessment. **Figure 5.3-14** shows the presence of trigger mapped SCL in the north-eastern area of the EIS study area. This part of MLA70421 is not within the current proposed mining footprint and hence the project is not anticipated to have an impact.

While preliminary field investigations found some areas meeting most criteria outlined above, there was no evidence of regular cropping and no evidence of cropping within the last 10 to 15 years. The history of cropping is a requirement for an area to be assessed under the SCL policy within the SCL management zone, which includes the EIS study area, as shown in Point 5 of **Table 5.3-13**. There has been no evidence of cropping in potential SCL areas within the last 10 to 15 years. Further, given that the project activities are not proposed to disturb any mapped area of SCL, further consideration of the mapped SCL areas is not warranted as part of the EIS.

Erosion Potential of Soil Types

Soil samples were laboratory tested for dispersion using the Emerson Aggregate Test (EAT) and for sodicity using the Exchangeable Sodium Percentage (ESP). These tests indicate the susceptibility of a soil to losing its structure and binding capacity when wet, and therefore the erosion potential of the soil. Furthermore, a selection of soils was tested to determine the soil erodibility or k-factor by considering particle size analysis, mechanical dispersion and organic carbon.

In general, all surface soils displayed low to moderate k-factors and therefore low to moderate erodibility. One sample of Brown Chromosol surface soil contained a high rating. Details of the results are outlined in the Soil and Land Suitability Assessment in **Appendix F2**.



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ENVIRONMENTAL IMPACT STATEMENT

STRATEGIC CROPPING LAND

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LAND RESOURCES - SOIL

Figure: **5.3-14**

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Acid Sulfate Soil Potential

The potential for acid generation from regolith material (topsoil and subsoil) within the EIS study area is low. This does not include acid generation potential within the mineral waste that might be extracted as part of underground mine development which has been assessed separately, with results presented in **Section 6**.

Acid sulphate soils (ASS), which are the main cause of acid generation within the soil mantle, are commonly found less than five metres above sea level, particularly in low-lying coastal areas such as mangroves, salt marshes, floodplains, swamps, wetlands, estuaries, and brackish or tidal lakes. The EIS study area is located within the Central Highlands region (which is approximately 150 kilometres from the coast at greater than 260 metres AHD).

There has been little history of acid generation from regolith material within this region. On this basis, acid sulphate soil testing compliant with the Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland (Ahern *et al.* 1998) was not undertaken.

The results of laboratory testing for acidity indicating that all soils within the disturbance area are not likely to have acid problems.

5.3.3.4 Potential Impacts and Mitigation Measures

Post-mining Land Suitability

The proposed post-mining land use for the EIS study area is expected to be grazing, over a mosaic of grassland and bushland as it is now. However, given the proposed post mining landform there will also be areas of ponding throughout the disturbance footprint. In terms of soil conservation and agricultural land suitability, there is minimal planned disturbance over the areas suitable for rainfed cropping. However, disturbance within the RHM, which is dominated by grazing land, is anticipated to include surface disturbance for IMG management infrastructure and subsidence of longwall panels on average three to five metres and up to six metres. Note that the IMG drainage requirements for the Broadmeadow extension are expected to be minimal and have not been included in the current assessment. The subsided landform will potentially create moderate to steep slopes above the edges of longwall panels which could increase the risk of erosion, especially with livestock movements to and from freshwater ponds. The status of erosion on these moderate to steep slopes will be monitored regularly and mitigation measures implemented if erosion becomes unacceptable. The proposed disturbances are predicted to have an impact on the land suitability classes associated with beef cattle grazing, as outlined in **Table 5.3-15** below and shown in **Figure 5.3-15**).

Table 5.3-15 Land Suitability Pre and Post Mining

Land Suitability Class (Beef Cattle Grazing)	Existing Area within proposed MLA [1]	Existing Area within existing ML [2]	Post Mining Area within proposed MLA [3]	Post Mining Area within existing ML [4]
	ha	ha	ha	ha
2	3,886.8	17.1	3,838.2	7.6
3	7,002.7	955.3	6,665.2	813.9
4	269.51	25.2	260.71	25.2
5	135.44	nil	530.34	150.9
Total Area	**11,294.45**	**997.5**	**11,294.54**	**997.5**

Note 1: Existing areas of each land class located within the whole of the MLA70421.
Note 2: Existing areas of each land class located within the footprint to be disturbed within the exiting ML.
Note 3: Areas of each land class located within the whole of the MLA70421 post mining.
Note 4: Areas of each land class located within the footprint to be disturbed within the exiting ML, post mining.

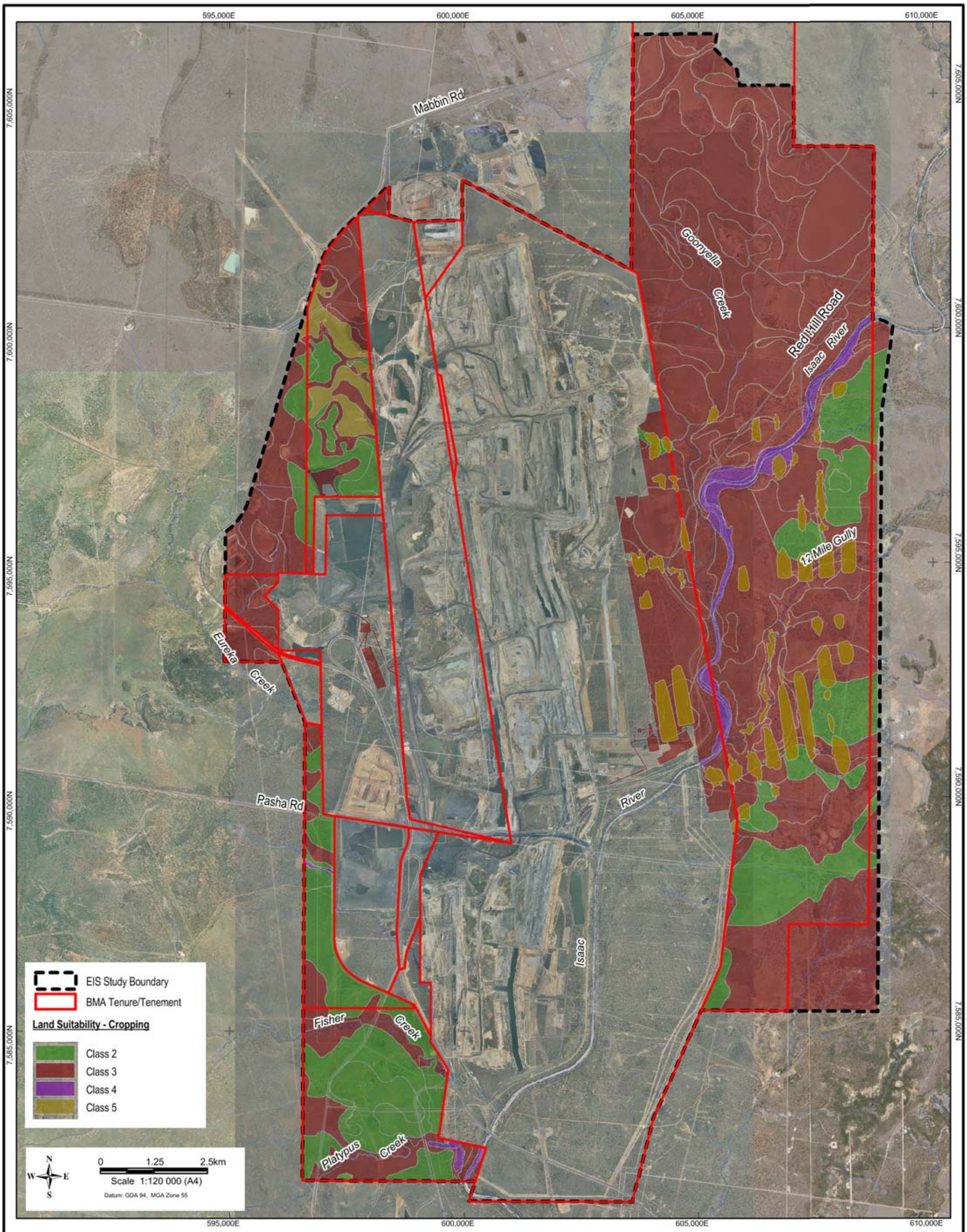
Modelling of ponding has been undertaken and is provided in **Section 7.3.7**. The mapping of potential subsidence void ponding extents and volumes (outside the Isaac River channel) identified 44 significant ponding areas (larger than two hectares). The areas of potential ponding would be up to 40 hectares, and the average area would be approximately 12 hectares.

For ponds associated with the Isaac River, the geomorphology assessment predicts that if no drainage works are undertaken, erosion of the flow paths and sediment load in floodwaters will gradually fill in these ponded areas (refer to **Section 7.3.7**). However, for ponds associated with the 12 Mile Gully catchment, this is not the case and partial drainage is proposed (refer to **Section 7.3.7**). However, this will have minimal impact on the area of the ponds, and these ponds can be considered effectively permanent.

Despite these relatively simple assumptions to define a worst case scenario for potential ponding in the subsidence voids, the mapped potential ponding extents were considered a reasonable basis on which to assess the worst case potential impacts of ponding on land suitability and agricultural land classes.

The change in land suitability includes 546 hectares being converted from grazing land to unsuitable for agricultural activities. This loss of agricultural land is considered a minor loss at a regional and state level.

In order to sustain the desired land use without degradation, it is important that the post-mining land use be in accordance with the limits of the land suitability class. Soil conservation practices such as erosion and sediment control, stocking rate control and establishment or re-establishment of permanent pasture are recommended for areas of mining impact. The overriding principle is to maintain the most beneficial future use of land that can be sustained in view of the range of limiting factors.



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POST MINING GRAZING LAND SUITABILITY ASSESSMENT

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Figure: **5.3-15**

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The proposed post-mining land must provide and sustain a sufficient bulk of nutritious forage in addition to the following management considerations in the event of future low density grazing:

- ability to access and manage livestock;
- flood free and relatively dry ground conditions in non-ponded areas; and
- adequate stock drinking water and shelter.

Accordingly, the following matters need to be incorporated into the rehabilitation plan:

- Success criteria in relation to extent of ground cover achieved before stock access is allowed: 70 per cent grass cover is a suitable objective for this region.
- Success criteria in relation to absence of erosion: visual inspection should show no evidence of rill, gully or sheet erosion before cattle access is allowed.
- Stocking rates should be determined as part of the final rehabilitation process and communicated to the landholder as part of site handover post-closure.

Impact on Good Quality Agricultural Land

Based on the anticipated ponding in the proposed post mining landform, there is a reduction of 395 hectares within MLA70421 and 151 hectares within ML1763, of grazing land (ALC – C). This is largely due to conversion to permanent or semi-permanent ponding unsuitable for grazing (ALC – D). The ponding may be considered a potential water storage source for cattle however for the purposes of this assessment it is considered ALC – D.

This represents a relatively small loss of agricultural land resources at a regional or state level. No further mitigation measures are proposed over and above implementation of the proposed rehabilitation plan.

Impact on Strategic Cropping Land

Current assessments of soils and land suitability across the EIS study area indicate that SCL is likely to be present; however, validation surveys on mapped SCL trigger areas in the north-east of the EIS study area have not yet been undertaken at the required intensity. These areas are outside the planned area of disturbance associated with the proposed project and, hence, even if validation confirms these areas to be SCL, no direct impact on SCL resources is expected for these proposed activities.

As there is no evidence of previous cropping in the area of potential SCL within the last 10 to 15 years, there is no need to assess the area under the SCL guidelines (DERM 2011). A validation application will be prepared by BMA and submitted to NRM for a decision, as described in sections 42 and 44 to 50 of the *Strategic Cropping Land Act 2011*, where project activities are proposed on land designated as SCL.

Should validation assessments indicate that these areas are indeed SCL, then protection measures will be developed to avoid indirect impacts and an SCL protection decision will be sought from NRM as required by sections 95 to 97 of the *Strategic Cropping Land Act 2011*.

Topsoil Management

Topsoil Stripping Criteria

The potential for major land disturbance is likely to result from earthworks at the proposed infrastructure areas. It is proposed that topsoil be recovered from these areas of disturbance prior to construction commencing.

Soil analysis results were used in conjunction with the field assessment to determine the depth of soil materials suitable for recovery. Structural and textural properties of subsoils are the most significant limiting factors in determining depth of soil suitable for re-use. Salinity levels, pH and dispersion potential are also limiting factors in some soils in the EIS study area. Elliot and Reynolds (2000) described the basic procedure adopted in this survey for the recognition of suitable topdressing materials (refer **Table 5.3-16**). This procedure has been adapted to include sandy loams as suitable.

Table 5.3-16 Topsoil Stripping Criteria

Descriptor	Reasoning	Desirable Criteria
Structure Grade	Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade and depends on the proportion of coarse peds in the soil surface. Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.	• 30% peds present • coherent when wet or dry • EAT: < 2 (2) • conductivity: < 1.5 dS/m • exchangeable Na% < 12% • pH: > 4.5 & < 8.4 • no mottle present • finer than sandy loam • sand and gravel content < 60%
Consistence – Shearing Test	The shearing test is used as a measure of the ability of soils to maintain structure grade. Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the extraction, transportation and spreading of topdressing material. Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.	
Consistence – Disruptive Test	The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates	
Mottling	The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeability; however some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.	

Potential Soil Stripping Depths

Table 5.3-17 lists the recommended stripping depths for each soil type within the EIS study area, however the soil types likely to undergo surface disturbance and be stripped of topsoil are those that lie on the areas which will be required for surface facilities. Soils within the subsidence disturbance area will not be stripped for reuse and soil types 1, 8a, 8b and 8c should be stripped as required and that material replaced when rehabilitated. Land areas required for all surface facilities and infrastructure associated with these activities, and including IMG drainage infrastructure, will be stripped and stockpiled for reuse. Recommended topsoil stripping depths are subject to further investigation prior to commencement of disturbance in each location.

Table 5.3-17 Potential Stripping Depth for each Soil Type

Soil Type #	Soil Type	EIS Study Area (ha) [1]	Potential Topsoil Stripping Depth (m) to be used as topdressing in rehabilitation	Potential Subsoil Stripping Depth
1	Lithic Rudosol	429	As Required	Nil
2	Tenosol	295	0.4	0.8
3a	Red Kandosol	2052	0.3	Nil
3b	Brown Kandosol	403	0.5	Nil
4	Brown Kurosol	187	0.3	Nil
5	Brown Chromosol	1861	0.4	Nil
6	Brown Sodosol	1934	0.25	Nil
7	Brown Dermosol	985	0.2	Nil
8a	Shallow Vertosol	847	As Required	Nil
8b	Deep Vertosol	589	As Required	Nil
8c	Deep Salic Vertosol	2712	As Required	Nil

Note 1: Figures based on the soils EIS study area (as described in **Section 5.3.3.1**).

Topsoil Management

As topsoil is easily degraded, careful management is required during stripping, while storing soils and during replacement. As IMG management infrastructure may be in place for eight to ten years, topsoil storage may be required for a number of years and careful management will be required to maintain a viable resource.

The following management and mitigation strategies are based on assessment of the existing site conditions and experience with the management of mining surface impacts at sites throughout New South Wales and Central Queensland, and will be applied to both topsoil and subsoil stripping:

- Strip material to the depths stated in **Table 5.3-17**, subject to further field investigations during stripping activities.
- Strip soils while in a slightly moist condition. Where practicable, avoid stripping material either in an excessively dry or wet condition. Soils can be wetted with truck mounted sprays of low salinity water if necessary.
- If possible, place stripped material directly into the area to be rehabilitated and spread immediately to avoid the requirement for stockpiling. This may be achievable for the IMG management infrastructure as this will be progressively installed across the site.

- If topsoil is to be stockpiled, grade or push soil into windrows with graders or dozers.
- Remove soil from windrow stockpiles using open bowl scrapers or front end loaders loading into dump trucks or other equipment as appropriate to avoid driving heavy equipment across topsoil stockpiles.
- When developing stockpiles, avoid tracking over previously placed soil by either direct dumping from dump trucks, pushing soil into windrows using scrapers or use of light equipment to form windrows.
- Leave surfaces of soil stockpiles in as coarsely structured a condition as possible in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.
- Maintain a maximum stockpile height of three metres. Store clayey soils in lower stockpiles for shorter periods of time compared to coarser textured sandy soils.
- If long-term stockpiling is planned (i.e. greater than 12 months), seed and fertilise stockpiles as soon as possible. Sow an annual cover crop species that produces sterile florets or seeds and establish rapid growing and healthy annual pasture sward to provide sufficient competition to minimise the emergence of undesirable weed species.
- Assess levels of weed infestation prior to re-spreading stockpiled topsoil onto disturbed areas. Use herbicides to control weeds in stockpiles prior to reuse or, if weed infestation is particularly significant, 'scalp' stockpiles to remove weed seed layers. Particular, attention to weed levels in topsoil stockpiles is required where topsoil is to be reused in areas to be regenerated with native trees or shrubs.
- Maintain an inventory of available soil to ensure adequate topsoil materials are available for planned rehabilitation activities.
- Spread topsoil to a minimum depth of 0.1 metres where sufficient resource is available. Soil respreading on steep slopes at depths exceeding 0.1 metres can be deleterious because of the 'sponge' effect which can cause slippage of the topsoil from the slope.

Further information on management and reuse of topsoil is provided in **Section 5.5**.

Erosion

Overview of Potential Impacts

While soils on the site have been assessed as having low to moderate erodibility, erosion can affect all soils if exposed to rain, surface water flows or wind. Erosion has several undesirable impacts:

- Topsoil and subsoil resources are lost and cannot be used for rehabilitation of the site. Prestripping and management of valuable topsoil resources as described in **Section 5.4** will minimise this impact.
- Sediment can be released into waterways, causing water quality degradation, smothering of aquatic habitat and in extreme cases, changes in stream geomorphology. Impacts of surface water quality degradation on surface water resources and aquatic ecosystems are addressed in **Section 7.3.5** and **Section 10**.
- Extreme erosion can contribute to slope instability and may lead to slope collapse.

Potential Erosion Rates and Impacts

There are two disturbance types to be caused by the project, consisting of the underground mining footprint and infrastructure such as access tracks, IMG management facilities, Red Hill accommodation village and the Red Hill CHPP. The Revised Universal Soil Loss Equation (RUSLE) has been used for the assessment of these areas to estimate the long term average soil loss rates that may result from sheet and rill flow during various levels of disturbance. It must be noted that this method indicates the potential for erosion to occur. Sediment control structures which may capture eroded material are not considered: however, in practice these measures would be implemented. Wind and gully erosion are discussed separately in the section below.

The RUSLE calculates annual erosion rates based on the following equation:

$$A = R . K . LS . C . P$$

Where: A = annual soil loss due to erosion [tonnes per hectare per year (t/ha/yr)]

R = rainfall erosivity factor

K = soil erodibility factor

LS = topographic factor derived from slope length and slope gradient

C = cover and management factor

P = erosion control practice factor.

Table 5.3-18 offers a comparison of disturbance levels that aims to highlight the higher risk activities in regard to erosion rates. It must be noted that assumptions have been made as to the specific values of soil and overburden characteristics, vegetation establishment success, climatic conditions, slope gradients and lengths and various management practices, and therefore the following values should only be used for comparison purposes. The calculations were made based on 'worst case' scenarios used consistently for all disturbance levels.

Table 5.3-18 Estimated Erosion Rates using the Revised Universal Soil Loss Equation

Disturbance Level	Rainfall Erosivity Factor (R)	Adjusted* Soil Erodibility Factor (K)	Topographic Factor (LS)	Cover and Management Factor (C)	Erosion Control Practice Factor (P)	Annual Soil Loss (A) (t/ha/yr)
Undisturbed surface pre-disturbance and subsided underground mining areas	1804	0.030	1.00	0.01	1.0	0.54
Surface cleared of vegetation and topsoil (MIA, CHPP, accommodation village)	1804	0.020	1.00	1.00	1.3	47.84
Reshaped levee	1804	0.036	3.07	0.45	0.8	71.78
Established rehabilitated Levee	1804	0.036	3.07	0.03	0.8	4.79

* Adjusted for dispersive materials by +20 per cent

The underground mining footprint and infrastructure such as access tracks, IMG drainage infrastructure, Red Hill accommodation village and the Red Hill CHPP have been calculated to cause a maximum potential annual soil loss of 71.78 tonnes per hectare per year (t/ha/year) without sediment control mitigation.

Table 5.3-18 shows the disturbance level during mining and infrastructure construction activities, where the highest risk of severe erosion rates is the reshaped levee or any exposed slopes. The most significant contributing factor is the topographic factor (LS) as the soils could be temporarily pushed up to the angle of repose. However, it is recommended that these areas and times of highest risk should have adequate sedimentation controls in place downstream to capture any material eroded from these slopes. Given the short duration of exposure and assuming typical sediment controls are established, this rate of soil loss would be adequately captured within the site and, therefore, is considered an acceptable risk.

Subsidence will cause troughs with relatively steep sides; however, runoff will drain into these troughs and sediment will tend to be trapped in the troughs. Some surface cracking may be evident and may require repair (refer to **Section 7.3.7**).

The surface cleared of vegetation and topsoil category is relevant to a range of surface facilities and infrastructure, as well as the IMG management infrastructure. As these are located on flat to gently undulating land, risk of erosion is moderate. However, erosion control will be required for each of these areas, with measures outlined below.

Gully erosion is not considered within the RUSLE equation above, however, given the succession of erosion severity from rill to gully erosion, it is predicted that the same disturbance levels will contain the same risk rankings for gully erosion rates, as the RUSLE equation has displayed. Erosion and sediment control measures as outlined below will generally minimise the risk of gully erosion; however, if gully erosion does occur these areas will need to be repaired and rehabilitated as soon as possible to reduce further erosion and sedimentation downstream.

Wind erosion has the potential to cause loss of material from exposed surfaces during the mining process. Management practices during mining will limit the extent of wind erosion as outlined in **Section 11**.

Erosion and Sediment Control Measures

The critical aspect to minimising erosion related impacts is to avoid or minimise erosion, as well as introducing measures to contain sediment within the site if necessary.

Broadly, this will be achieved by applying the following fundamental principles of erosion and sediment control:

- Where practical, divert clean water flows around disturbed areas and proposed infrastructure.
- Take measures to minimise exposure of soils to erosive forces.
- Where erosion is unavoidable, install devices to minimise the release of sediment laden water from disturbed areas.

Site and activity specific erosion and sediment control plans will be developed prior to surface disturbance in any particular area. These plans will include an assessment of erosion risk at each location, and selection of appropriate diversion, erosion prevention and sediment capture methods.

Current relevant erosion and sediment control guidelines will be utilised in preparation and implementation of erosion and sediment control measures.

The following general measures are likely to be incorporated in these erosion and sediment control plans.

Clean water flow diversion will be utilised where necessary at the accommodation village, with flows diverted by cut off drains directing flows to existing drainage lines. Scour protection will be installed at outlets to prevent scouring.

Clean water diversion will also be used for drilling pads for IMG drainage wells wherever these have significant upstream catchments. In this case, diversion will most likely utilise temporary bunds which will be removed once the wells are installed and the bulk of the drilling pad is reinstated. However, for steeper areas or areas where significant overland flow will occur, clean water diversion may be left in place. For access tracks associated with the IMG management system, spoon drains may be used to prevent surface water from flowing across tracks in steeper areas.

The following measures may be utilised to minimise the exposure of soils to erosive forces during construction activities and in relation to installation of IMG management infrastructure:

- Where practicable, vertosols will be avoided when locating IMG infrastructure and other surface infrastructure. This is mostly at the southern extent of the underground footprint.
- Where practicable, time between clearing of vegetation and commencement of construction will be minimised.
- On completion of construction of underground services, including gas and water pipelines for IMG management, these areas will be backfilled, topsoil replaced and sown with pasture species. Soil profiles will be restored when backfilling trenches.
- On completion of IMG drainage wells, the majority of the drill pad will be stabilised by replacement of topsoil and seeding with pasture or mulching. Other methods may be required where these are located in predicted ponding areas. The remaining area will be gravelled if assessed as being of high risk of erosion.
- For all other areas, on completion of construction, exposed soils will be either revegetated with pasture grass and landscaped or covered with mulch, gravel or hardstand. More details on methods for reinstatement of disturbed areas are provided in **Section 5.5**.
- Dust management measures will be implemented as discussed in **Section 11**.

Sediment capture from runoff from the MIA and CHPP will be via stormwater systems with captured water returned to the mine water management system.

Sediment capture devices may be required for some of the IMG management infrastructure while access tracks and land around each well remains exposed. These devices may include check dams or sediment ponds. Sediment fences may be used as short term measures or in locations where check dams or sediment ponds are not practical. If check dams or other structures are installed on streams or drainage lines, these will be in accordance with the *Guideline - activities in a watercourse, lake or spring associated with mining operations* (NRM 2012). Ongoing monitoring and maintenance of access tracks and cleared areas around gas wells will be required to identify and rectify erosion early.

Sediment capture will also be required for the accommodation village and will most likely utilise sediment control dams installed as part of the stormwater management system.

Sediment capture from subsided areas is not proposed because runoff will generally be into subsidence troughs which will provide effective sediment retention basins. More information on managing the land surface and streams after subsidence is provided in **Section 7.3.7**.

For all construction activities undertaken in the wet season, diversion and sediment control measures will be installed prior to other surface disturbance taking place. These measures may not be necessary in the dry season, or may be able to be modified depending on assessment of erosion risk at each location.

Erosion and sediment control measures will require regular inspection during the wet season to check that the measures are:

- effective in addressing erosion at each location and appropriate for the management of any sodic and saline material;
- in good repair and not blocked with captured sediment; and
- not causing scouring or other unintended effects.

Where erosion damage such as gullying has occurred, immediately steps will be undertaken to repair damage. This may include diversion of flows around the affected area, earthworks to reduce slope angles, placement of topsoil and revegetation.

As subsidence occurs, the subsided area will also be inspected for plant death and associated exposure of soils. Management and reinstatement of vegetation in subsided areas is discussed further in **Section 5.5**.

With these measures in place, sediment releases from the mining and construction activities will be minimised.

Landform

Subsidence may result in steep slopes along the edges of subsidence troughs. These slopes will generally be short, that is, less than six metres in terms of vertical fall. Regardless, where these slopes exceed approximately 17 per cent or about 10 degrees, they may be susceptible to erosion. In many cases, erosion of these slopes will have minimal impact on downstream waters as sediment will collect in the base of the sediment trough. However, erosion of slopes around the edge of the sediment troughs may affect revegetation of the land surface and, hence compromise the achievement of the final rehabilitation concept of a stable landform suitable for grazing.

Slopes along the edge of subsidence troughs will need to be monitored for signs of erosion. Mitigation measures may include diversion of flows away from the edge of the subsidence trough or battering of the slope using small earthworks equipment to achieve a shallower slope. An adaptive management approach will be taken to subsidence to allow learnings from other locations, and from early experiences within the project to be incorporated into future management. This will be documented in the proposed subsidence management plan.

5.4 Land Contamination

5.4.1 Description of Environmental Values

5.4.1.1 Overview

As part of the project EIS, a preliminary site investigation was undertaken within the EIS study area (refer to **Appendix G**). The objective of the preliminary site investigation was to examine and identify any environmental issues or risks that have a potential to impact the environment within the EIS study area as a result of land contamination caused by current and/or past land use practices, and that may be a liability for future owners or operators of the site.

The preliminary site investigation comprised a desktop review including historical and current title searches, historical aerial photograph interpretation, searches of the EHP Environmental Management Register (EMR) and Contaminated Land Register (CLR), physical inspections of selected areas within the EIS study area and interviews with landholders between 2006 and 2011. In addition, the NICH study (**Section 16.2**) identified two minor waste dumps in the vicinity of Riverside Homestead. Finally, BMA maintains a contaminated land register which provides information on those potentially contaminating activities within the current mining operations.

5.4.1.2 Summary of Results

The EIS study area covers 51 land parcels as presented in **Section 5.1**. The majority of the land parcels associated with the project are currently utilised for cattle grazing or are part of established mining areas. A review of the current and historical aerial photographs indicated that the EIS study area consisted of cattle grazing grasslands until the development of the Goonyella (1971), Riverside (1982), and Broadmeadow (2005) mines.

A search of EHP's EMR and CLR was carried out for land parcels not allocated as infrastructure titles (i.e. roadways, railways). Lots included within the current mining operations were not searched, as BMA currently maintains an operational contaminated sites register for these sites. Fourteen of the 27 lots searched in EHP registers are listed on the EMR. Nine of these lots are a result of being subdivided from a lot that was previously listed on the EMR. The lots are listed for notifiable activities including: chemical storage, mine wastes, landfill, oil or petroleum storage, abrasive blasting, or livestock dip/spray race.

Inspections of the EIS study area were undertaken in 2006 (Riverside Homestead area), 2009 (inspection of accessible areas of the exploration leases) and 2011 (inspection of additional EIS study area inclusions). These inspections identified a livestock dip and associated stockyards, and minor fuel and oil storage at the Riverside Homestead. A second livestock dip was located adjacent to the Broadmeadow Homestead, which also housed minor fuel and oil storage. Waste disposal areas associated with the homesteads were also identified as areas of potential soil and groundwater contamination.

Secondary areas of concern include unidentified soil/material stockpiles, portable fuel associated with mobile plant, the Star Crushing area, as well as minimal fuel storage and waste stockpiling at Broadmeadow Cottage 1. There were no other recognised significant potential contamination concerns observed during the site visit or review of historical site data. The EIS study area appeared generally well maintained and few potential sources of contamination were identified over relatively small portions of the site.

Primary sites of interest identified during the site inspection and desktop study were focused within and near the two homestead complexes that lay within the EIS study area, as shown on **Figure 5.4-1**, and include:

- Site 1 – Riverside Homestead – this homestead has minor chemical, fuel and oil storage, as well as domestic waste disposal areas. A stockyard inclusive of a dip was also identified.
- Site 2 – Broadmeadow Homestead – this homestead has minor chemical, fuel and oil storage, as well as domestic waste disposal areas. Additionally, a stockyard with a pneumatic crush was identified adjacent to the Homestead area.
- Site 3 – Broadmeadow Stockyard - an additional stockyard was noted approximately one kilometre to the east of the Broadmeadow Homestead. The area consisted of several holding yards, three crushes and one stock dip.

Secondary sites of interest identified during the site inspections and desktop study include:

- Sites 4 and 5 – Broadmeadow Cottages 1 and 2 – some general waste and minor fuel storage was identified.
- Site 6 – Star Crushing/quarry – heavy equipment usage, excavation works and potential fuel and chemical storage.
- Sites 7 and 8 – soil stockpiles – topsoil stockpiles of unknown origin.
- Portable fuel storage for mobile plant was also identified in some areas.
- Site 9 (Red Hill Heritage or Archaeological Site (RHHAS)-01) – minor waste dump identified by NICH study (Section 16.2) containing mostly household and farming debris.
- Site 10 (RHHAS-04) – minor waste dump identified by NICH study (**Section 16.2**) containing mostly household and farming debris.

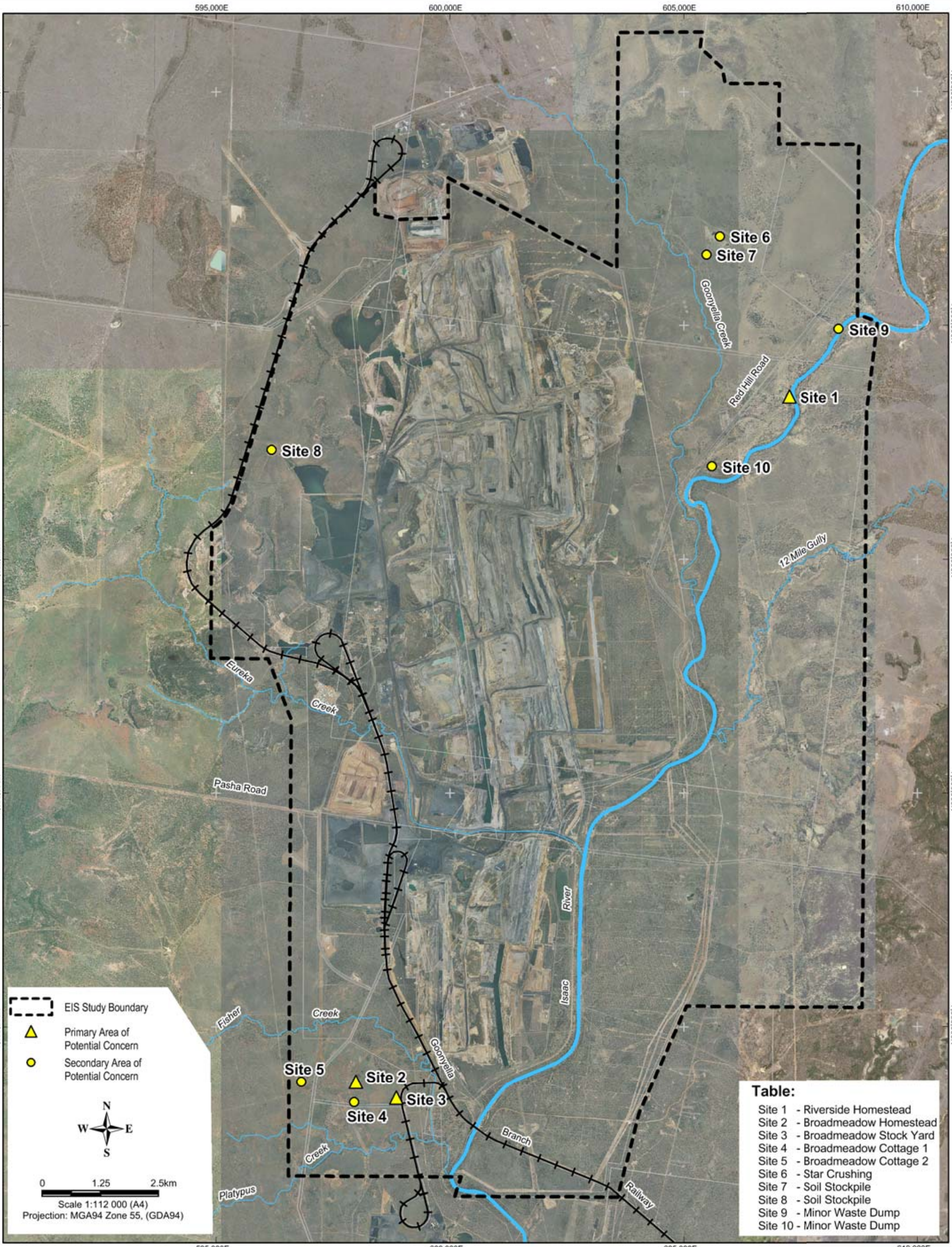
Sites within the current mining operations are detailed in the GRM Environmental Plan of Operations July 2012 to June 2013 (Table 3 List of notifiable activities) in accordance with EPML00853413 (formerly EA MIN100921609). This documentation was relied upon by URS Australia Pty Ltd (URS) for the details of areas where environmentally relevant activities (ERA) and notifiable activities exist within the current mining plan. A total of 72 occurrences of notifiable activities under the EP Act have been identified within the current mining operations.

5.4.2 Potential Impacts and Mitigation Measures

5.4.2.1 Overview

Impacts relating to contaminated soils may arise from:

- disturbance of existing contaminated soils which may in turn result in mobilisation of contaminants to the environment as well as potential workplace health and safety risks associated with contact with or inhalation of contaminants; and
- future releases of contaminants to land creating new or additional contaminated soils.



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

LOCATION OF POTENTIALLY CONTAMINATED SITES

URS

LAND RESOURCES - LAND CONTAMINATION

Figure: **5.4-1**

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5.4.2.2 Disturbance of Existing Contaminated Soils

Site 3 (stock dip) is located close to the existing rail loop but will not be disturbed as part of the proposed project.

Site 1 (Riverside Homestead domestic waste, cattle dip and fuel storage) and site 10 (Riverside minor waste dump area) are within the underground mine footprint and may be affected both by installation of IMG management infrastructure and subsequent subsidence. In both cases, disturbance of these areas may lead to potential mobilisation of contaminants to receiving environments, as well as potential human health impacts associated with dermal contact or inhalation of potential contaminated materials.

Further investigation of sites 1 and 10 is required to determine whether contaminants are present at levels exceeding the National Environmental Protection Measures (NEPC 2013). A protocol for investigation of these areas adhering to the Guidelines for the contaminated land professional (EHP 2013) will be developed, prior to disturbance of potentially contaminated land. This will include, but is not limited to site inspections, and a sampling program to identify potential contaminants. If soil contamination is identified, an appropriate remediation or site management strategy should be implemented. Options may include on site containment or off site disposal

Should contaminated soils need to be removed off site; they will be disposed of in an appropriately authorised waste management or disposal facility in accordance with soil disposal procedures specified in the EP Act and associated regulations.

Regardless of soil contamination levels, wastes, fuel, oil and chemical storage containers and other debris associated with the cattle dip and waste disposal areas should be removed prior to disturbance in these areas. These materials will require disposal at an authorised landfill.

Construction of the Red Hill MIA, CHPP and conveyor will take place on lots that are on the EMR. As such, soils in these areas must be considered potentially contaminated. If excess spoil is generated during construction of any of these components, and this spoil is required to be disposed of outside the boundaries of the individual land parcel from which it originated, assessment of the soil may need to be undertaken in order to comply with soil disposal procedures within the EP Act. If contaminated, the soil will need to be disposed of to an appropriately authorised waste management or disposal facility in accordance with soil disposal procedures specified in the EP Act and associated regulations.

As there is potential for further contaminated soils to be uncovered in the course of construction of the accommodation village and installation of the IMG management infrastructure, the environmental management plan should contain a procedure for isolating and managing suspected contaminated soils. Workers involved in earthworks, and clearing of vegetation should be familiar with this procedure and be given training on possible signs of contamination.

In the event that workers identify potentially contaminated areas, specific work procedures will apply, and these procedures should include:

- Stopping work and isolating the potentially affected area. This may also require steps to prevent worker exposure or further release to the environment.
- Contacting the site environmental advisor for assistance. The site environmental advisor will then determine whether further investigation is needed and engage suitably qualified personnel to carry out investigations in accordance with the draft guidelines (Department of Environment 1998).

5.4.2.3 Contamination of Soils

The principal risks for new areas of land contamination from the construction and operation of the project result from:

- hydrocarbon storage and use;
- chemical storage and use;
- waste and reject handling and storage; and
- introduction of notifiable activities to new land parcels.

Hydrocarbon Storage and Use

Due to the size of the project and the equipment to be used, the site will have an inventory and usage of hydrocarbons (fuel and lubricants) and chemicals. Spills from the use or storage of these materials have the potential to impact human health and the receiving environment.

Small quantities of hydrocarbons may be released from mobile construction equipment and from equipment used to install IMG management infrastructure. The most common cause of such releases is breaks in hydraulic hoses, resulting in small amounts (10 to 20 litres) of hydrocarbon being released to soils. These will result in minor and localised levels of soil contamination on access tracks and work areas. Generally, quantities of hydrocarbon contaminants that would be mobilised will be small and unlikely to cause any significant impacts to the receiving environment. In the event that minor spills are identified, local remediation will be implemented, through on site treatment (using natural biodegradation processes) or off site disposal in accordance with appropriate soil management procedures. Minor spills that occur on hardstand within the Red Hill MIA and CHPP area will be contained within the mine water management system, minimising the likelihood of releases to the receiving environment. If spills within the MIA or CHPP are not located on hardstand, then local remediation measures should be implemented, as described above.

More significant releases of hydrocarbons may arise from accidents during refuelling of equipment and plant or in the event that storage containers are ruptured or leak. The impact will then depend on the nature and sensitivity of the receiving environment. Further discussion on impacts to potential receiving environments can be found in **Sections 7**, **8**, **9** and **10**.

Hydrocarbon storage will be located within secondary containment on hardstand within the MIA and CHPP areas and, hence, contained within the mine water management system, minimising the likelihood of releases to the receiving environment. Refuelling of construction equipment and equipment used in installation of IMG management infrastructure may occur outside areas that drain to the mine water management system. This in addition to hydrocarbon wastes and wastes contaminated with hydrocarbons may also have potential to cause soil and groundwater contamination. In the event that releases are identified local remediation should be implemented through on site treatment (using natural biodegradation processes) or off site disposal in accordance with appropriate soil management procedures.

A further assessment of risks associated with storage and handling of hydrocarbons and hydrocarbon wastes is provided in **Section 20**.

Chemical Storage and Use

Chemicals to be stored and used at the proposed project will be located on hardstand within the MIA or CHPP areas and, hence, contained within the mine water management systems. Quantities of most chemicals will be small, and the nature of chemicals to be used means that these pose little risk to the environment. Risks associated with chemical storage and handling are further assessed in **Section 20**.

Waste Reject Handling and Storage

The incorrect handling and storage of mine waste (rejects and dewatered tailings) could result in poor quality seepage, acid mine drainage, and salinity impacts on the receiving environments (groundwater and surface water). A small quantity of overburden will also be generated from construction of the mine access (drift) and underground workings. A detailed assessment of the management and potential impacts of these waste streams is presented in **Section 6** of this EIS.

Introduction of New Land Uses/Notifiable Activities

New notifiable land uses may be introduced as part of the development of the project. In particular, the waste water treatment plant for the Red Hill accommodation village would be considered a potentially contaminating and therefore notifiable activity (Department of Environment 1998).

Mitigation Measures

Mitigation measures to avoid the contamination of soil, surface water and groundwater are detailed below:

- All new land parcels included in the proposed mining activity will be added to EHP's EMR/CLR.
- Stockpiles, workshop areas, chemical stores, fuel tanks and other waste disposal/storage areas will be located on hardstand, compacted soils or concrete pads. Secondary containment will be provided for all areas where liquid fuels and chemicals are stored or handled.
- Runoff from the MIA, stockpile and CHPP areas will be collected and contained with the mine water management system.
- Stormwater management systems in the MIA and CHPP areas will be designed to allow these systems to be isolated in the event of a major spill.
- Fuel storage facilities will be designed and operated in accordance with Australian Standard 1940:2004 'The storage and handling of flammable and combustible liquids'. This standard includes bunding of storage and refuelling areas.
- Other chemical storage areas will be designed in accordance with relevant Australian Standards.
- Material safety data sheets (MSDS) for chemicals used or brought to the site will be kept in a central register on site and at the area of use. They will be readily available to workers at all times.
- Hazardous wastes will be stored in contained areas and removed from site regularly (see also **Section 15**).
- Regular inspections of all hydrocarbon and chemical storage areas will be undertaken by site environmental officers. This will include inspection of containers, bund integrity, valves, and storage and handling areas.

- Spill kits will be available at the MIA and CHPP and mobile spill kits will also be available at the location of IMG management infrastructure construction and well installation activities. Workers will be trained in the use of the spill kits to respond promptly to small and medium sized spills and in the proper collection of contaminated material.
- Where mobile refuelling is to be undertaken, a procedure will be developed to minimise the risk of spills and a spill kit suitable for small and medium size spills will be available. Workers involved in mobile refuelling will be trained in the use of the spill kits to respond promptly to small and medium sized spills and the proper collection of contaminated material.
- Response to large fuel and chemical spills will be incorporated into the site emergency management plan and consultation undertaken with the Queensland Fire and Rescue Service in relation to spill response requirements and resources. A trained spill response team will be available.
- Contaminated material arising from fuel or chemical spills will be appropriately stored and either treated on site or removed from site as soon as possible.
- An incident report form will be completed for every fuel and chemical spill outside a bunded area. The report form will contain details on the location of the spill, type and quantity of material spilt and steps taken in initial response and follow up using BMA's "First Priority" system.
- Chemical or hydrocarbon spills over 20 litres occurring outside bunded areas will be investigated in accordance with site incident investigation procedures.
- Incidents and land uses requiring notification will be added to the BMA site contaminated land register.
- All staff will be trained as part of their site induction in appropriate handling, storage and containment practices for chemicals, fuel and other potential contaminants, as relevant.

All mine waste, rejects and dewatered tailings will be handled in accordance with the mitigation measures outlined in **Section 6** of this EIS. These mitigation measures will include the adequate containment of the material to prevent potential groundwater and surface water impacts, as well as the appropriate management of potential acid rock drainage material to reduce the potential for acidification and resultant groundwater and surface water impacts.

5.5 Rehabilitation and Decommissioning

EHP requires that land disturbed by mining be rehabilitated to achieve stable and beneficial agreed future uses. The three mandatory rehabilitation outcomes stipulated by EHP are landform stability, beneficial use, and protection of water quality.

The progressive and final rehabilitation strategies and methods outlined in this section for disturbed areas comply with the rehabilitation goals and objectives of the then DERM (2011) *Guideline 18 - Rehabilitation requirements for mining projects*. More specifically, the strategies provide for intergenerational equity, protection of biodiversity and maintenance of essential ecological processes. Further, this EIS section has been prepared in accordance with the requirements of section 4.11 (Rehabilitation and Decommissioning) of the TOR for the project (Coordinator-General 2013).

A description of the rehabilitation strategy and decommissioning procedures for the GRM incremental expansion and the RHM underground expansion option have been compiled.

Should the GRM incremental expansion and the RHM underground expansion option proceed, a rehabilitation management plan will be prepared prior to commencement of the proposed GRM incremental expansion and the RHM to outline the control strategies and monitoring programs, as identified in this EIS. These plans will be prepared in accordance with the appropriate BMA corporate standards and guidelines in place at the time, as well as relevant guidelines from administering agencies and will draw on lessons learned from the adjacent GRB mine complex Rehabilitation Management Plan (BMA 2011).

It is noted that the Rehabilitation Management Plan for RHM does not need to include tailing storage facilities, rejects disposal or spoil/overburden dumps. The CHPP will generate dewatered tailings which will be disposed of within the GRM spoil dump areas. Similarly, rejects from processing of coal and spoil from drift construction will be disposed of in the GRM spoil dump areas. The quantity of spoil generated from the underground mine is minimal. Rehabilitation of these areas will be covered by the existing GRB mine complex Rehabilitation Management Plan (BMA 2011).

Rehabilitation of the Broadmeadow extension component of the project will take place as part of the ongoing BRM rehabilitation.

5.5.1 Rehabilitation Objectives

Planning for mine closure includes integrating the closure design for the entire EIS study area, identifying the timing of the planning process, considering issues that relate to specific rehabilitation methods and financial and community objectives, as well as making sure adequate financial provision has been made.

The principal objectives of rehabilitation and mine closure planning incorporated into the project include:

- to provide an overall framework for mine closure, including rehabilitation and decommissioning strategies;
- to establish clear and agreed criteria with all relevant stakeholders, that can be used as the standard for the final mine rehabilitation and post mining land use assessment;
- to reduce or eliminate adverse environmental effects once the mine ceases operation;
- to ensure closure is completed in accordance with good industry practice as well as meeting the statutory requirements that may be applicable; and
- to ensure the closed mine does not pose an unacceptable risk to public health and safety.

The rehabilitation objectives to be achieved for the project are as follows:

- Achievement of acceptable post-disturbance land use suitability – mining and rehabilitation should aim to create a landform with land use capability and/or suitability compatible with the land-use pre-mining, unless other beneficial land uses are pre-determined and agreed.
- Creation of stable post-disturbance landform – disturbed land and subsided areas will be rehabilitated to a condition that is self-sustaining or a condition where maintenance requirements are consistent with an agreed post-mining land use. Surface waters such as dams retained on the lease should be safe, self-sustaining and be acceptable for the post mining land uses.

- Preservation of downstream water quality – water quality of surface and ground waters that leave the mining leases should be adequate to maintain environmental values and beneficial uses downstream of the proposed EIS study area.

Following final rehabilitation, the project area will be safe, stable and sustainable.

5.5.2 Post-Mining Land Use Concept

Current expectations in relation to post mining land use are that rehabilitation will return those areas of the EIS study area disturbed by the project to a stable landform capable of supporting cattle grazing as per the current land use. Cattle grazing currently takes place on a mosaic of introduced pasture with some remnant bushland and a patch of native grassland. A key pre-mining feature of the site to be protected and restored is the Isaac River riparian zone, which provides north-south connectivity for native animal movement. Native grasslands in the underground mine footprint are also to be protected and restored, as is bushland not affected by surface disturbance or ponding. The post mining landform will also include areas of ponding throughout the underground mine disturbance footprint that will be managed as aquatic habitat.

Thus, the nominated post-mine land use for the EIS study area is grazing within a mosaic of bushland, native and non-native grassland and ponded areas. Further information on these ponded areas is provided below in **Section 5.5.3**.

5.5.3 Land Suitability Pre and Post-Mining

The agricultural land suitability of the EIS study area has been assessed and is provided in **Appendix F2**. The land suitability assessment was largely based on criteria provided in the *Guidelines for agricultural land evaluation in Queensland* (DPI 1990). Some areas of the EIS study area have been mapped in SCL trigger maps, however these areas are not within the proposed mine footprint (refer to **Section 5.3.3**). Current land suitability is summarised in **Table 5.5-1** and described in more detail in **Section 5.3.3**.

Some changes to the land surface will occur progressively during the proposed underground mining activity. As described in **Section 3.8** installation of IMG management wells and infrastructure will result in varying degrees of surface disturbance across the underground mine footprint. These facilities will remain in place for 10 to 15 years but will be decommissioned and surface features removed prior to mining of each longwall panel. With erosion and sediment controls, and setting aside of topsoil from disturbed areas, these features should not affect long term land suitability.

A mining industrial area, accommodation village and other surface facilities will also be installed as described in **Section 3.7** and will remain in place for the duration of the mining activity. Some earthworks will be required to level these sites; however, these changes should not prevent the future use of these areas for grazing as the land will be rehabilitated to support a grazing land use.

The other substantial change that will occur to the landscape will arise from subsidence. This will result in the creation of surface depressions with a predicted maximum depth of six metres (refer to **Appendix I7**). Subsidence will result in local topographical changes and changes in local hydrology. Ponding is anticipated to occur as described in **Section 7.3.7**. The areas in which permanent or semi-permanent ponds occur will not be suitable for grazing. In addition, it is noted that some of the subsidence depressions may have steep slopes and, while it is not anticipated that this will preclude grazing, it will be important to monitor these areas for signs of erosion and remediate.

The proposed post-mining land use for the EIS study area is expected to be a return to sparse grazing within a mosaic of grassland and bushland that is consistent with the existing grazing land use; however, given the proposed post mining landform there will also be areas of ponding throughout the disturbance footprint. In terms of soil conservation and agricultural land suitability, there is minimal planned disturbance to soil and therefore the proposed post mining land use is expected to be substantially unchanged except for the effects of subsidence, which will create (seasonal) ponded areas.

Table 5.5-1 shows anticipated post mining land suitability classes, in comparison with pre-mining, based on the categories established by the Queensland DPI (1990). The areas shown relate to land within MLA70421 and ML1763.

Table 5.5-1 Land Suitability Pre- and Post-Mining

Land Suitability Class (Beef Cattle Grazing)	Existing Area within proposed MLA [1]	Existing Area within existing ML [2]	Post Mining Area within proposed MLA [3]	Post Mining Area within existing ML [4]
	ha	ha	ha	ha
2 (suitable for grazing)	3,886.8	17.1	3,838.2	7.6
3 (suitable for grazing)	7,002.7	955.3	6,665.2	813.9
4 (marginally suitable)	269.51	25.2	260.71	25.2
5 (not suitable)	135.44	nil	530.34	150.9
Total Area	**11,294.45**	**997.5**	**11,294.54**	**997.5**

Note 1: Existing areas of each land class located within the whole of the MLA70421.
Note 2: Existing areas of each land class located within the footprint to be disturbed within the exiting ML.
Note 3: Areas of each land class located within the whole of the MLA70421 post mining.
Note 4: Areas of each land class located within the footprint to be disturbed within the exiting ML, post mining.

As discussed in **Section 7.3.7** of this EIS, the mapping of potential subsidence void ponding extents and volumes (outside the Isaac River channel) identified 44 ponding areas larger than two hectares. The areas of potential ponding would be up to 40 hectares, and the average area would be approximately 12 hectares.

Based on the assessment presented in **Table 5.5-1**, the majority of the mining area will remain suitable for the proposed post mining land use of grazing with the exception of areas that will be ponded due to subsidence. As is the case with any grazing land use, whether or not the grazing takes place on a previously mined area, the land use will cause damage to the soils and land suitability if not managed appropriately in accordance with the limits of the land suitability class. Soil conservation practices will therefore be required, such as erosion and sediment control, stocking rate control and establishment or re-establishment of permanent pasture.

Further discussion on measures required to achieve and sustain the post mining land use are provided in **Section 5.3.3**.

5.5.4 Rehabilitation Strategy

All areas significantly disturbed by mining activities will be rehabilitated to a safe, non-polluting and stable landform with a self-sustaining vegetation cover. Where possible, rehabilitation will be undertaken progressively. Where appropriate, rehabilitation will be consistent or complementary with the rehabilitation strategy adopted for GRM and BRM, as detailed in condition **F4** and **F5** of the existing EPML00853413 (formerly EA MIN100921609). Progressive rehabilitation of areas disturbed by IMG drainage infrastructure and subsidence will be undertaken. Results derived from ongoing subsidence monitoring and management (BRM) will be used to inform and guide the rehabilitation program.

To achieve the objectives in **Section 5.5.1**, rehabilitation of disturbed land at the proposed EIS study area will be conducted so that:

- All infrastructure on the site is removed or made safe to ensure the closed mine does not pose an unacceptable risk to public health and safety and is usable for post mining land use of cattle grazing.
- In areas requiring revegetation, suitable types of vegetation are planted and established to achieve the nominated post-mine land uses for each of the disturbance areas.
- Potential for erosion is minimised.
- Potential for environmental impacts being caused by altered drainage as a result of subsidence will be minimised.
- The quality of surface water and seepage released from the EIS study area is such that a release of contaminants is not likely to cause environmental harm.
- The final landform is stable and not subject to subsidence, slumping or erosion.

5.5.4.1 Current Rehabilitation at Goonyella Riverside and Broadmeadow Mine Complex

Rehabilitation works at GRB mine complex is carried out under the GRB mine complex Rehabilitation Management Plan (BMA 2011). The GRB mine complex also has a Closure Plan (BMA 2007), which identifies risks and provides indicative costs associated with the closure of the GRB mine complex. The Closure Plan is reviewed annually.

As of September 2011, approximately 982 hectares of land had been rehabilitated (re-contoured, topsoiled and seeded) at the GRB mine complex (BMA 2011). Vegetation has generally been established using broadcast seeding methods on ripped and usually topsoiled surfaces at a rate of six to eight kilograms of seed per hectare. The rehabilitation varies in structure and floristics, and comprises a combination of the species outlined in **Section 5.5.6** of this EIS.

A number of rehabilitation trials have been undertaken at the GRB mine complex site, including direct tree seeding method (in 2000), tube-stock planting (in 2001), and establishment of selected species including *Acacia harpophylla* (brigalow) and *Eucalyptus argophloia* (western white gum).

5.5.4.2 Landform Design and Planning

Rehabilitation planning for the proposed project will focus on both short and long term strategies to enhance resilience of the landscape during and after subsidence. Further details on rehabilitation methods to be used are discussed in **Section 5.5.6**.

Rehabilitation of the final landform will be undertaken on a domain basis, in accordance with the DERM (2011) *Guideline 18 - Rehabilitation requirements for mining projects*. The domains, which represent land management units or discrete rehabilitation areas/post-mine landforms, will be rehabilitated using varying techniques suited to type of disturbance and proposed post-mine land use.

The domains, and associated post-mining land uses are summarised in **Table 5.5-2**. A conceptual final landform is depicted in **Figure 5.5-1.** The rehabilitation strategy for each individual domain is discussed below.

Table 5.5-2 Post-Mine Land Use and Ecosystem for each Domain for Proposed Operations

Domain	Post-mining Land Use and Ecosystem			
	Grazing Pasture	Native Bushland and Grassland	Riparian	Other
Industrial areas, infrastructure and power facilities	✓		✓	
Water storages and sediment control dams	✓ (where decommissioned)			Water storages may be left in place if beneficial for the end land use of grazing.
Underground access and main headings	✓			Entrance sealed.
Exploration and test drilling disturbances	✓ (if present pre-disturbance)	✓ (if present pre-disturbance)		
Gas drainage infrastructure disturbance	✓		✓	
Subsided areas	✓ (if present pre-disturbance)	✓ (if present pre-disturbance)	✓	Water body if suitable.

Tailings Storage Facilities

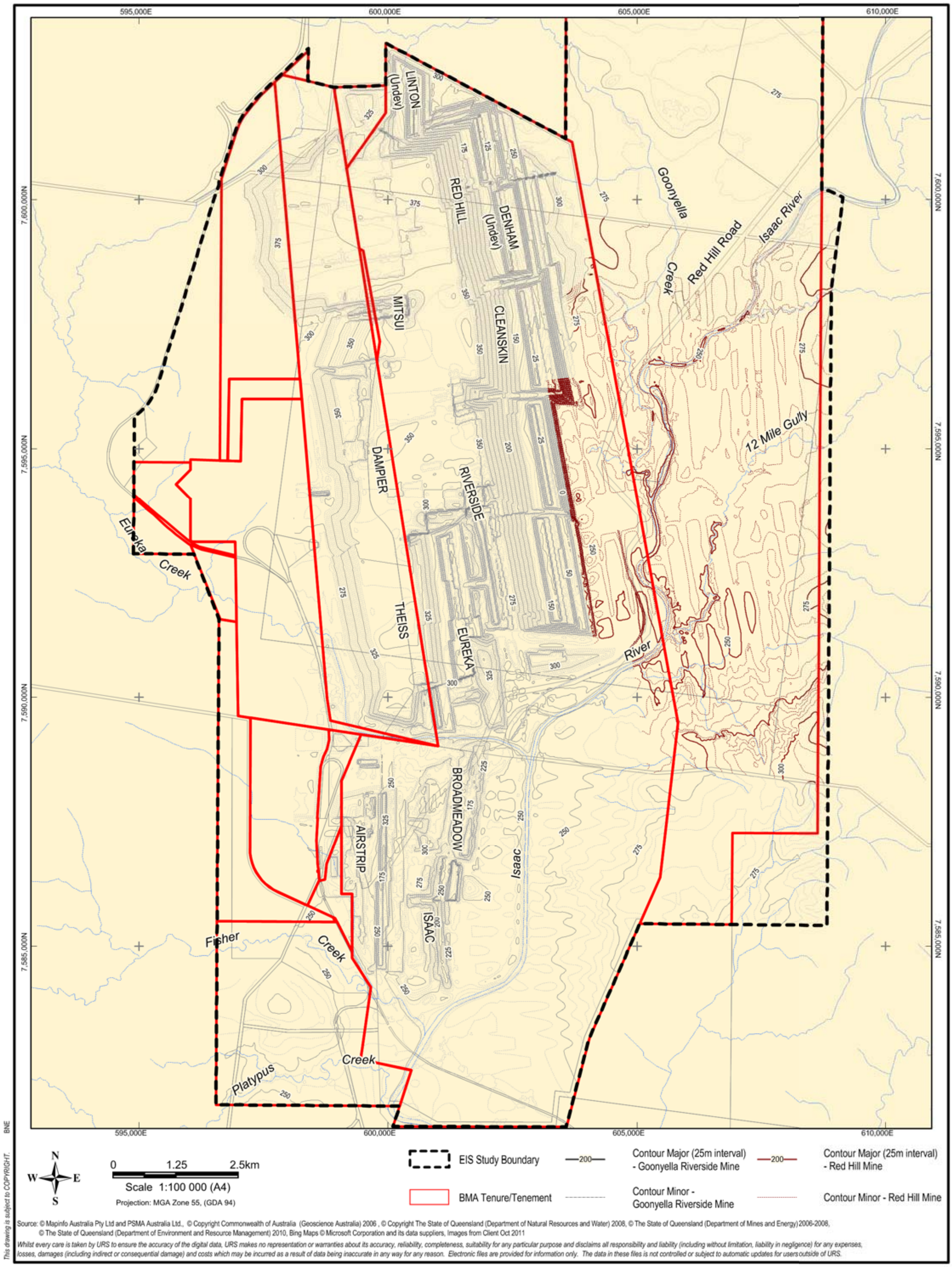
Tailings generated by coal processing at the GRB mine complex are deposited into the two tailing storage facilities (TSF) on the western side of the GRB mine complex. These TSF are designed to provide adequate safety factors that meet ANCOLD Guidelines (1999). No new TSF are required for the proposed project as belt press filters are proposed in the Red Hill CHPP. Dewatered tailings from the belt press filters will be co-disposed with rejects, which will be placed into existing spoil dumps by truck or conveyor and buried in spoil. Rehabilitation of the existing TSF will therefore be undertaken as per the existing commitments in the GRB mine complex Rehabilitation Management Plan (2011) and Closure Plan (BMA 2007).

Underground Access and Main Headings

In addition to the management of subsidence throughout the mine life, decommissioning of underground workings will also be required at mine closure. Any mining equipment or service supply lines and cables that are no longer required and are not readily recoverable for salvage or reuse will be left in the underground mine.

Brick rubble, concrete rubble or other inert waste from the decommissioning of the mine infrastructure area may be placed in the drift. Entrances to the underground workings will then be blocked off and sealed to prevent access and ventilation shafts will also be decommissioned and sealed.

All entrances to underground workings will undergo a final safety inspection and certification against mine safety legislation in place at the time of closure.



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

CONCEPTUAL LANDFORM AT CLOSURE OF UNDERGROUND MINE

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LAND RESOURCES - REHABILITATION & DECOMMISSIONING

Figure: **5.5-1**

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Subsided Areas

The proposed RHM will mine the GMS to the north-east of the existing BRM. There will also be an extension to the existing BRM.

An impact of longwall mining is the subsidence of the land as the longwall progresses. The majority of the subsidence at the ground surface occurs over the centre of the longwall and tapers off around the perimeter of the longwall adjacent to and over the gate roadway pillars. For further details on expected subsidence refer to **Section 3.6.5**.

The main subsidence related impacts on the land will likely include cracking, surface water ponding and possibly erosion. Modelling of subsidence by IMC predicts a maximum vertical subsidence over the longwall panels of six metres (refer to **Appendix I1**).

Tension cracks may develop parallel and adjacent to the pillars as the panel area subsides and the area in the vicinity of the pillars is preferentially supported. Subsidence predictions for the project indicate that worst case tension cracks on the ground surface may develop in the order of a maximum width of 0.5 metres and a maximum depth of 10 metres in the worst case instances, although cracking of this magnitude has not been observed at the adjacent BRM to date. The zone of rehabilitation over surface tension cracking following seam undermining is anticipated over the chain pillars and may extend some 35 metres either side into the panels. Remedial measures will therefore be required to ensure impacts relating to subsidence are minimised, and these are described in **Section 5.5.6.2**.

Compressive strains are predicted over the central parts of the longwall panels. The surface manifestation of compression / humping is also considered likely and may require minor remedial earthworks, which may involve ripping and seeding areas where persistent cracking is evident. As the longwall progresses, regular inspections will be carried out to identify where remedial works are required in these broadly subsided areas. Where vegetation in subsided areas is affected, it will be seeded with pasture species for an agricultural land use, as discussed above in **Section 5.5.3**.

Tilt is predicted to reach an absolute maximum of around 6.4 per cent in the first northern and southern longwall panels being mined in the shallow, western supercritical panels. Again, regular inspections will be carried out to identify where remedial measures might be required to address erosion or safety issues arising from steeper slopes.

If grazing is to be ongoing during the mining activity, fencing may be required to keep stock out of steep sloped areas where erosion risk is high. Fencing will also assist in keeping cattle out of recently rehabilitated areas while vegetation is being established. Ultimately, a goal of the final landform will be that it is safe for cattle grazing and workers involved in cattle management.

The management of subsidence and remediation of related impacts in relation to timing of subsidence will require ongoing consideration throughout the mine life. Regular inspections will be used to continually guide the rehabilitation program. Annual monitoring of rehabilitated areas will be undertaken and areas will be checked after high rainfall events. This monitoring will include the identification of any further remedial works required. Further detail on the rehabilitation methodology for subsidence related impacts is provided in **Section 5.5.6.2**.

Due to the expected subsidence caused by underground mining, ponding of water within the subsided zones will occur. The surface water assessment conducted as part of this EIS (refer to **Section 7.3.7** and **Appendix I7**) investigated the option of draining these voids and the potential benefit of doing so with regards to mitigating the loss of flow into the catchment due to ponding in the voids. Given the predicted size of the voids in the final landform as a result of subsidence, the works that would be required to completely drain the voids to produce a free-draining landform would introduce another physical disturbance to the landscape. In any case, for voids associated with the Isaac River, it is anticipated that these will fill in within decades (refer **Section 7.3.7**).

The surface water assessment did however identify a need to partially drain some of the larger subsidence voids in the 12 Mile Gully catchment as sediment runoff from this smaller catchment is low and the rate of infilling is therefore very low (refer to **Section 7.3.7** and **Appendix I7**). The extent of drainage works to be implemented will be determined in more detail as part of mine closure planning at RHM, which will be informed by ongoing monitoring of actual subsidence effects and associated ponding. In addition, the impacts on surface drainage will require ongoing monitoring and management through subsidence management strategies. Further discussion on post-mining land suitability is provided in **Section 5.3.3.2**.

Watercourses and Subsidence Impacts

Subsidence associated with the project may result in impacts on the Isaac River, 12 Mile Gully and localised drainage lines. For the Isaac River, these potential impacts may include the deepening of the river bed downstream of the subsided area as a result of a reduction in the sediment supply being trapped by subsidence voids/hollows, avulsion and headward erosion (Earth Tech 2006). A detailed investigation into the potential impacts of the project on the Isaac River is presented in **Section 7.3.6** of this EIS, which found that based on the assessment of subsidence impacts on geomorphology, it is expected that the subsidence voids in the Isaac River will eventually fill with sediment and their storage capacity will diminish. It should be noted that the Isaac River downstream of the RHM underground footprint was diverted in the 1980s as part of approved open-cut mining operations.

In 2007, BMA commissioned Alluvium Consulting (Alluvium) to design and implement a monitoring, evaluation and review program for the Isaac River and adjacent landforms within its existing mine leases. Baseline monitoring was undertaken in 2007, with operations monitoring undertaken in 2008, 2009, 2010 and 2011. The purpose of this monitoring was to establish baseline data on the condition of the diversion and to monitor any changes in the diversion's condition over time. It also established whether any subsidence had occurred so that impacts requiring management could be identified and minimised. The monitoring was conducted by specialists in geomorphology, ecology and waterway management using quantitative (index of diversion condition) and qualitative means (Alluvium 2013). The index of diversion condition is the method accepted by EHP for recording and monitoring the condition of diversions and adjacent upstream and downstream reaches.

The monitoring program is ongoing and includes stream bed and bank surveys, as well as vegetation, geomorphological and ecological condition assessments, including the establishment of fixed monitoring points. The monitoring program is based around the ACARP Project 'Monitoring and Evaluation Program for Bowen Basin River Diversions' (ACARP Project C9068) (ID and A 2001).

As part of this monitoring program a number of monitoring points have been established within a section of the Isaac River over the proposed RHM longwall panels. As such, baseline data has been established that will enable potential subsidence related impacts to be monitored and appropriate remedial measures to be implemented. The current Rehabilitation Management Plan for the GRB mine complex (BMA 2011) sets out remedial measures for rehabilitating riparian areas that have been impacted by subsidence.

Information gathered from these works has been input into the assessment of impacts of subsidence on waterways, as well as proposed mitigation and rehabilitation measures. These key design parameters will apply to the proposed project, and are discussed in further detail in **Section 5.5.6.2**.

Rehabilitation of riparian banks and floodplains (following diversion or subsidence) will include riparian species as discussed in the current rehabilitation plan (BMA 2011). There will also be an increased focus on habitat creation around watercourses and riverine areas impacted by subsidence. This includes, but is not limited to; the reinstatement of sandy substrate and placement of logs and large woody debris as in-stream habitat, and the placement of nest boxes in trees along the banks to encourage migrating, nesting or denning birds and mammals.

Further details relating to the rehabilitation methodology for subsidence impacts can be found in **Section 5.5.6.2**.

Industrial Areas, Infrastructure and Power Facilities

Following completion of mining of the future RHM, some infrastructure such as the CHPP, accommodation facilities, and the bridge over the Isaac River, may remain on site for use by the adjacent current operations (GRB mine complex). Details on decommissioning and rehabilitation of industrial areas, infrastructure and power facilities can be found in **Section 5.5.6.1**.

Water Storages and Sediment Control Dams

Water storages created for the project are unlikely to have any beneficial use for the future land use as none of them capture overland flow. The storages will have contained mine water and will need to be emptied. Dams will therefore be drained, walls breached and the material removed by breaching the wall, which will be spread across the dam footprint, topsoiled and revegetated to grazing as per the detail provided in **Section 5.5.6**.

Where sediment dams are installed to manage run-off from disturbed areas (including post-mine landforms) these may be useful as water supply dams for the post mining land use. As these will not have contained mine water, no works are required to convert these to water supply dams.

Shafts and Boreholes

The decommissioning (sealing/capping/grouting) of ventilation shafts, service boreholes, dewatering and monitoring boreholes will be completed in accordance with relevant standards and guidelines, in particular the relevant requirements of *Minimum Construction Requirements for Water Bores in Australia* (Land and Water Biodiversity Committee 2003) or other relevant guidelines in place at the time of decommissioning.

5.5.5 Success Criteria

Preliminary success criteria (or closure criteria) for the rehabilitation of the mine areas for the proposed operations have been provided in **Table 5.5-3**. These measure the success of rehabilitation practices in terms of achieving a sustainable system for the proposed post-mine land use. Monitoring against these success criteria will be carried out. When it can be demonstrated that these, or equivalent success criteria have been achieved, the rehabilitation will be judged to have been successfully achieved. At this stage, the mining lease can be relinquished, financial assurance returned to the proponent and the landholder can take over management of the site for the proposed post mining land use of grazing.

The success criteria have been developed to comprise indicators for vegetation, fauna, soil, stability, land use and safety on a landform-type basis that adequately reflect the nominated post-mine land use of bushland and grazing. For each element, standards that define rehabilitation success at mine closure are provided; these have been developed in accordance with the DERM (2011) *Guideline 18 - Rehabilitation requirements for mining projects*. Based on the generic indicators, each criterion will be further developed to be specific, measurable, achievable, realistic and outcome based, and to reflect the principles of sustainable development. The further development of each criterion will be based on results of research, monitoring of progressive rehabilitation areas and risk assessments. The success criteria will be reviewed every three to five years with stakeholder participation to ensure the criteria remain realistic and achievable and identify whether new criteria are required to address emerging issues.

Table 5.5-3 Rehabilitation Success Criteria

Rehabilitation Element	Indicator	Criteria
1. Subsided Areas		
Landform Stability	Slope gradient	Slopes are stable with more than 70% vegetation cover and generally accessible to cattle.
	Erosion control	Subsided surfaces free of active rills, gullies and sheet erosion as demonstrated by five years of monitoring.
	Surface water quality	Sediment inputs to surface waters are within typical levels for grazing lands in the catchment.
	Groundwater	Results of monitoring show that subsidence has not caused changes to beneficial uses of groundwater resources.
	Cracks	No surface cracking that poses a risk to cattle or humans.
Watercourses	Surface water drainage	Reduction in flow in Isaac River downstream of site due to ponding is less than 1%.
Topsoil	Depth	Topsoil depth is adequate to allow revegetation. For pasture grass, this will be a minimum of 100 mm.
	Salinity (electrical conductivity)	Soil salinity content is <0.6 dS/m.
	pH	Soil pH is between 5.5 and 8.5.
	Sodium content	On sloping sites soil exchange sodium percentage (ESP) is <12% (majority of topsoil for use in rehabilitation should have an ESP of <12%).
	Nutrients	Adequate macro and micro-nutrients for vegetation establishment are present as judged by health of vegetation.
Vegetation	Land use	All non-ponded areas can be used as grazing land. A sustainable grazing land management plan has been prepared in consultation with future landholder and takes into account constraints arising from the former mining activity.
	Surface cover	Levels of ground cover (such as vegetation, rocks and logs) comparable to that of relevant reference sites (values to be determined). Pasture cover at better than 70%.
	Species composition	Comprise a mixture of shrubs and grasses representative of regionally occurring where possible (values to be determined from reference sites) or palatable native and naturalised pasture grasses depending on land suitability constraints and slope gradient.

Rehabilitation Element	Indicator	Criteria
	Community structure	Groundcover, understorey and overstorey structure along Isaac River riparian zone is similar to that of appropriate upstream reference site(s).
	Resilience to disturbance	Established species survive and/or regenerate after disturbance. Weeds do not dominate the vegetation after disturbance or rain. Pests do not occur in substantial numbers or visibly affect the development of plant species.
	Weeds	Presence of declared weeds and other weeds is similar or less than nearby reference sites.
	Sustainability of bushland areas	Evidence of second generation of shrub species in retained bushland areas. Bushland vegetation develops and maintains a litter layer evidenced by a consistent mass and depth of litter over subsequent seasons. More than 75% of shrubs and/or trees in Isaac River riparian zone and any retained bushland areas are healthy. This is to be validated by a survey.
Fauna	Vertebrate species	Evidence that Isaac River riparian zone is utilised by native animals in a similar manner as pre-mining, as evidenced by species composition and observed use of the area. Additional criteria to be developed for ornamental snake, depending on outcomes of targeted surveys.
	Pest animals	Species and numbers of pest animals similar to pre-mining and to levels at nearby reference sites.
	Invertebrate species	Presence of representatives of a broad range of invertebrate functional indicator groups involved in different ecological processes based on values of reference sites (to be determined).
Safety	Risk to community and landholder	No recorded ground movements due to subsidence No access to very steep slopes
2. Surface Facilities and Infrastructure		
Landform Stability	Slope gradient	Area has smoothed gradients consistent with surrounding areas.
	Erosion control	No evidence of sheet, gully or rill erosion as evidenced by visual inspection over a period of five years.
	Surface water drainage	No concentration of flow.
Topsoil	Depth	Topsoil depth is adequate to allow revegetation. For pasture grass, this will be a minimum of 100 mm.
	Salinity (electrical conductivity)	Soil salinity content is <0.6 dS/m.
	pH	Soil pH is between 5.5 and 8.5.
	Sodium content	On sloping sites soil exchange sodium percentage (ESP) is <12% (majority of topsoil for use in rehabilitation should have an ESP of <12%).
	Nutrients	Adequate macro and micro-nutrients for vegetation establishment are present as judged by health of vegetation.
Buildings and structures	Safety and future use	Written agreements in place regarding any buildings, other structures and infrastructure that remain including below ground components. Maps provided to landholder showing location of all underground components left *in situ*. Otherwise, no above ground buildings or infrastructure remain.

Rehabilitation Element	Indicator	Criteria
Vegetation	Land use	All areas can be used as grazing land A sustainable grazing land management plan has been prepared in consultation with future landholder and takes into account constraints arising from the former mining activity.
	Surface cover	Levels of ground cover (such as vegetation, rocks and logs) comparable to that of relevant reference sites (values to be determined). Pasture cover at better than 70%.
	Species composition	Comprise a mixture of shrubs and grasses representative of regionally occurring where possible (values to be determined from reference sites) or palatable native and naturalised pasture grasses depending on land suitability constraints and slope gradient.
	Community structure	Groundcover, understorey and overstorey structure along Isaac River riparian zone is similar to that of appropriate upstream reference site(s).
	Resilience to disturbance	Established species survive and/or regenerate after disturbance. Weeds do not dominate the vegetation after disturbance or rain. Pests do not occur in substantial numbers or visibly affect the development of plant species.
	Sustainability of bushland areas	Evidence of second generation of shrub species in retained bushland areas. Bushland vegetation develops and maintains a litter layer evidenced by a consistent mass and depth of litter over subsequent seasons. More than 75% of shrubs and/or trees in Isaac River riparian zone and any retained bushland areas are healthy. This is to be validated by a survey.
Fauna	Pest animals	Species and numbers of pest animals similar to pre-mining and to levels at nearby reference sites.
	Invertebrate species	Presence of representatives of a broad range of invertebrate functional indicator groups involved in different ecological processes based on values of reference sites (to be determined).
Safety	Risk to community and landholder	No access to any underground mine workings. All surface features removed or made safe.
3. Water Storages		
Landform Stability	Slope gradient	If storages are to be retained by the landholder, storages have been inspected and certified against dam safety standards current at the time of decommissioning. A copy of the certification and other documentation relating to construction and maintenance of the dam has been provided to the landholder.
	Erosion control	No evidence of sheet, gully or rill erosion as evidenced by visual inspection over a period of five years.
	Water quality	If dams are to be retained for future use. Water quality in storages meets relevant Australia and New Zealand Environmental Conservation Council (ANZECC) guidelines for stock use.
Topsoil	Depth	Topsoil depth is adequate to allow revegetation. For pasture grass, this will be a minimum of 100 mm.

Rehabilitation Element	Indicator	Criteria
Vegetation	Land use	Former dam areas can be used for grazing. A sustainable grazing land management plan has been prepared in consultation with future landholder and takes into account constraints arising from the former mining activity.
	Surface cover	Levels of ground cover (such as vegetation, rocks and logs) comparable to that of relevant reference sites (values to be determined). Pasture cover at better than 70%.
	Species composition	Comprise a mixture of shrubs and grasses representative of regionally occurring where possible (values to be determined from reference sites) or palatable native and naturalised pasture grasses depending on land suitability constraints and slope gradient.
	Community structure	Groundcover, understorey and overstorey structure along Isaac River riparian zone is similar to that of appropriate upstream reference site(s).
	Resilience to disturbance	Established species survive and/or regenerate after disturbance. Weeds do not dominate the vegetation after disturbance or rain. Pests do not occur in substantial numbers or visibly affect the development of plant species.
	Sustainability of bushland areas	Evidence of second generation of shrub species in retained bushland areas. Bushland vegetation develops and maintains a litter layer evidenced by a consistent mass and depth of litter over subsequent seasons. More than 75% of shrubs and/or trees in Isaac River riparian zone and any retained bushland areas are healthy. This is to be validated by a survey.
Fauna	Pest animals	Species and numbers of pest animals similar to pre-mining and to levels at nearby reference sites.
	Invertebrate species	Presence of representatives of a broad range of invertebrate functional indicator groups involved in different ecological processes based on values of reference sites (to be determined).
Safety	Risk to community and landholder	No remnant contamination associated with decommissioned dams. Landholder understands responsibility in relation to maintenance and inspections of any retained dams.
4. IMG Management Infrastructure		
Landform Stability	Slope gradient	Slopes are stable with more than 70% vegetation cover and generally accessible to cattle.
	Erosion control	Subsided surfaces free of active rills, gullies and sheet erosion as demonstrated by five years of monitoring.
	Surface water quality	Sediment inputs to surface waters are within typical levels for grazing lands in the catchment.
Topsoil	Depth	Topsoil depth is adequate to allow revegetation. For pasture grass, this will be a minimum of 100 mm.
	Salinity (electrical conductivity)	Soil salinity content is <0.6 dS/m.
	pH	Soil pH is between 5.5 and 8.5.

Rehabilitation Element	Indicator	Criteria
	Sodium content	On sloping sites soil exchange sodium percentage (ESP) is <12% (majority of topsoil for use in rehabilitation should have an ESP of <12%).
	Nutrients	Adequate macro and micro-nutrients for vegetation establishment are present as judged by health of vegetation.
Vegetation	Land use	All non-ponded areas can be used as grazing land. A sustainable grazing land management plan has been prepared in consultation with future landholder and takes into account constraints arising from the former mining activity.
	Surface cover	Topsoil depth is adequate to allow revegetation. For pasture grass, this will be a minimum of 100 mm.
	Species composition	Comprise a mixture of shrubs and grasses representative of regionally occurring where possible (values to be determined from reference sites) or palatable native and naturalised pasture grasses depending on land suitability constraints and slope gradient.
	Community structure	Groundcover, understorey and overstorey structure along Isaac River riparian zone is similar to that of appropriate upstream reference site(s).
	Resilience to disturbance	Established species survive and/or regenerate after disturbance. Weeds do not dominate the vegetation after disturbance or rain. Pests do not occur in substantial numbers or visibly affect the development of plant species.
	Sustainability of bushland areas	Evidence of second generation of shrub species in retained bushland areas. Bushland vegetation develops and maintains a litter layer evidenced by a consistent mass and depth of litter over subsequent seasons. More than 75% of shrubs and/or trees in Isaac River riparian zone and any retained bushland areas are healthy. This is to be validated by a survey.
Fauna	Vertebrate species	Evidence that Isaac River riparian zone is utilised by native animals in a similar manner as pre-mining, as evidenced by species composition and observed use of the area. Additional criteria to be developed for ornamental snake, depending on outcomes of targeted surveys.
	Pest animals	Species and numbers of pest animals similar to pre-mining and to levels at nearby reference sites.
	Invertebrate species	Presence of representatives of a broad range of invertebrate functional indicator groups involved in different ecological processes based on values of reference sites (to be determined).
Safety	Risk to community and landholder	No exposed pipes or wells. Wells have been capped in accordance with current guidelines for gas extraction wells. Pipes at stream crossings have been removed to maximum extent of potential channel erosion and will not be exposed by future erosion.

5.5.6 Rehabilitation Methods

5.5.6.1 Surface Facilities and Infrastructure

Surface facilities and infrastructure requirements for the project elements are described in **Section 3.7** and consist of:

- the Red Hill CHPP, to be constructed and operated adjacent to the Riverside MIA;
- the Red Hill MIA to support the future RHM operations: This will include site offices, washrooms, and technical services; laydown, storage and parking areas; a water storage, power and water supply to support the expanded operations; equipment hardstands, fuel and underground fuel storage, workshops, maintenance areas, laboratories and emergency services rescue equipment. A levee may also be required to protect the MIA from flooding of the Isaac River. The levee may remain in place if required to protect ongoing mining activities at the GRB mine complex from flooding. Otherwise, if not required, the levee will be removed and the underlying area rehabilitated;
- the Red Hill accommodation village: the village is expected to be demountable type accommodation with dining and recreational facilities. All necessary services including power, water, a dedicated sewage treatment plant and internal roads will also be provided;
- a bridge across the Isaac River;
- a bitumen road connecting the accommodation village to Red Hill Road;
- gas wells, gas and water pipelines, power supply, a production water storage dams and access tracks associated with IMG management requirements; and
- site services for power, water and communications.

New above ground infrastructure and facilities are not required for the Broadmeadow extension component of the project. With regards to gas drainage, IMG drainage requirements for the Broadmeadow extension are expected to be minimal and have not been included in the current assessment.

If not required by other mining operations or future landholders, decommissioning of all surface facilities and infrastructure on site would be undertaken. A summary of the envisaged decommissioning that would take place for various infrastructure and facilities associated with the project is provided below. It is noted, however, that while the infrastructure and surface facilities is planned to be decommissioned and the footprint rehabilitated at closure, some infrastructure may remain for use by the adjacent mining operations (GRB mine complex). This may include, but is not limited to, the Red Hill CHPP, Red Hill accommodation village and the bridge over the Isaac River.

More information on techniques for soil management and revegetation is provided in **Section 5.5.6.3** and **Section 5.5.6.4**.

Site Services

If not required for the adjacent GRB mine complex operations, services including power, water, data and telephone communication for the entire site will be isolated, disconnected and terminated to make them safe. The inspection pits and junction boxes for underground services will be sealed. Typically, all underground services will be made safe and left buried in the ground. Overhead power lines will be removed and the materials (i.e. poles and wire) recovered for potential re-sale or recycling as applicable. Switch room buildings will be disconnected and demolished. Unless required for other projects, substations will be removed from the site and, if compatible with power supply requirements at the time of decommissioning, either re-used by BMA for another project or sold to a third party.

Equipment and Buildings

Equipment and buildings will be removed from the site unless these can be reused *in situ* to support nearby mining activities.

Sumps will be dewatered and the excess coal removed prior to the commencement of demolition. All unwanted equipment will be de-oiled, degassed, depressurised and isolated, and all hazardous materials removed from site. All unwanted buildings, including administration buildings, workshops, CHPP and fixed plant (including stacker/reclaimers, conveyors and gantries, transfer points, sizing station, coal feed bins and vehicle wash) will be re-used or sold to other mines where possible, or demolished and transported from the site as required.

All recoverable scrap steel will be sold and recycled, with the remaining non-recyclable wastes either being taken to a licensed landfill or, if inert, placed in the drift and main headings before sealing.

All concrete footings and pads will be broken up to a depth of 1.5 metres below the surface and provided these are as non-contaminated waste material, these will be placed in the drift and mains headings or disposed of at the adjacent GRM by burial in final voids. The carbonaceous material on the base of the run-of-mine and product stockpile areas will be stripped to a depth of at least 0.5 metres and if this cannot be reprocessed to recover usable coal, will be buried in the backfill of open-cut voids on the adjacent GRM.

The Red Hill CHPP may remain in place for use in ongoing mining activities at the GRB mine complex, or, if technology remains current and condition of the equipment is suitable, removed for use at another BMA site.

Once the unwanted infrastructure is removed, the areas will be dozer trimmed to facilitate the appropriate drainage of surface runoff, and surfaces will be ripped by deep ripping to a depth of at least one metre along the contour with large dozers. The site will be rock raked to remove all rocks bought to the surface that are greater than 500 millimetres. Surface water management structures (contour banks, drains and sediment control dams) will also be constructed as necessary and topsoil applied as required to support pasture vegetation. Seed and fertiliser will then be applied to assist in the establishment of a grazing post-mine land use within a mosaic of bushland.

Roadways, Car Parks and Hardstand

The unwanted bitumen roadways, car parks and hardstand areas around the MIA, workshops and administration areas will be ripped up and disposed of as inert waste material either by placement in the drift and main headings of the RHM or burial within open-cut pits at the adjacent GRM.

Material contaminated by hydrocarbons, carbonaceous or otherwise unsuitable material, will be removed from the haul roads and hardstand surfaces, disposed of and covered in the backfill of the GRB mine complex open-cut pits. Minor dozer reshaping work will be undertaken to ensure surface level consistency with the surrounding areas. Any creek crossings and culverts will be removed, unless another arrangement is negotiated with the landowner, and the pre-existing drainage line re-instated.

Areas covered by roadways, car parks and hardstand areas will be ripped to a depth of at least one metre with large dozers prior to the application of topsoil. Then the entire area will be contour ripped and seeded with a small to midsized dozer or wheeled tractor. Seed and fertiliser will also be applied to assist in the establishment of the vegetation in support of grazing or bushland for post-mine land use.

All unwanted roadside markers (tyres and guideposts) and signs will also be removed from within the area as part of mine closure.

Water Storages

Two water storages will be established for the proposed GRM incremental expansion and the RHM:

- MIA water supply dam of nominal capacity 50 megalitres; and
- lined storage tank of nominal capacity 10 megalitres to temporarily store IMG production water before passing onto the GRB mine water management system.

It is proposed that the MIA and IMG storages will be decommissioned and rehabilitated upon closure of RHM. Neither of these has any substantial inflows and will therefore be of minimal benefit for future grazing activities. Decommissioning is likely to include:

- Draining of the dams, with water pumped to the adjacent GRM mine water management system.
- Testing of lining material for contamination. Unless unexpected contaminant levels are identified, lining material will then be removed and placed in waste disposal areas at the GRB mine complex.
- Levelling of dam walls restoration of suitable surface drainage patterns such that concentration of flow does not occur.
- Placement of topsoil across disturbed areas and these areas will be reseeded with pasture species.

Some small sediment control dams may be required during rehabilitation of the MIA or Red Hill accommodation village. These can be left in place if desired by the landholder, otherwise, these will be decommissioned by levelling the dam wall, spreading topsoil and seeding disturbed areas with pasture grass.

Incidental Mine Gas Management Infrastructure

IMG management infrastructure is described in **Section 3.8**. This infrastructure is the main cause of vegetation and soil disturbance across the mine footprint and will be installed and then removed progressively as mining progresses. Hence, a progressive rehabilitation approach will be taken.

Interim rehabilitation will be undertaken immediately after construction of each section of IMG management infrastructure as described in **Section 3.8**, including:

- Removal of temporary facilities associated with drilling.
- Rehabilitation of the bulk of the drilling pad area, leaving only a small area immediately around the well. These areas will be ripped as necessary, and then topsoil will be replaced and the areas seeded with pasture species.
- Rehabilitation over gas and water pipeline trenches, including contouring of the surface to promote drainage and minimise concentration of drainage, replacement of topsoil and seeding with pasture grass species.

Final decommissioning of this infrastructure will be undertaken progressively, immediately prior to mining in each longwall panel, as follows:

- All facilities above ground surface level associated with wells will be removed. While IMG drainage is ongoing, these units may be able to be reused across the site.
- Wells will be cut off below ground level and grouted and capped to create a seal in accordance with guidelines on decommissioning of gas wells that are current at the time. After subsidence, wells will be checked and if standpipes have become exposed, standpipes will be cut below ground level again.
- Pads around each well will be ripped, topsoil respread and the disturbed areas ripped, seeded and fertilised as necessary to support grazing.
- Water and gas pipelines will be emptied and made safe. These will be left *in situ* initially, but as subsidence and subsequent head cutting of channels through pillars and the main heading occurs, exposed water and gas pipelines will be removed and exposed ends sealed.
- Access tracks that are not required for future access for goaf drainage will be ripped, regraded and seeded.

Rehabilitation of goaf drainage infrastructure will be progressive, utilising similar techniques, with the specific scheduling of works to take into account the timing of the installation and removal of this infrastructure.

5.5.6.2 Subsided Areas

Subsidence impacts on the land surface may include cracking, surface water ponding and tree and shrub death and erosion.

To ensure subsided land is suitable for grazing, initial repair works will be undertaken where required behind the advancing face of the longwall. Repair works will focus on areas that may be highly susceptible to erosion due to slope, existing disturbance or surface drainage patterns.

Surface Cracks

As subsidence occurs, subsided areas will be inspected for the formation of surface cracks. Where it appears that surface cracks are unlikely to self-seal, rehabilitation of subsidence cracks will be undertaken as soon as practical post-subsidence.

Where cracks are small, self sealing is expected due to the amount of sediment in runoff from the local catchment. However, if numerous small cracks have appeared and are affecting vegetation health, the following steps will be undertaken:

- Undertake minimal clearing of areas around cracks to allow for ripping and seeding.
- Rip areas to provide suitable conditions for seeding.
- Seed and/or plant disturbed areas with appropriate species of vegetation to achieve a post-subsidence land use the same as that pre-subsidence (i.e. low intensity cattle grazing consistent with existing land suitability). If trees are to be planted, planting will take place after rain has fallen, soil has consolidated, and underground air pockets filled with finer particles so that suitable soil conditions exist to promote growth of seedlings.

For more substantial cracks and areas where ripping is not feasible due to the width of cracks:

- Topsoil will be stripped from areas adjacent to the crack and stockpiled.
- Clay material will be imported to fill and seal cracks.
- Topsoil will be respread once cracks have sealed.
- The area will be seeded with appropriate plant species.

In areas where grazing is continuing, fencing may be used to exclude stock from recently subsided and rehabilitated areas, including riparian areas, to prevent injury to animals and to allow grass cover and seed store to recover. People and vehicles will also be excluded and appropriate signage will be erected warning of the potential hazards due to subsidence.

The rehabilitation undertaken on subsided areas will be monitored annually, as described in **Section 5.5.7** below. Where the regeneration of dominant species disturbed by remediation works does not occur within one year, additional vegetation will be seeded or planted as required (BMA 2011).

More information on soil management and revegetation techniques is provided in **Section 5.5.6.3** and **Section 5.5.6.4.**

Surface Water Ponding

As discussed in **Section 7.3.7** some of the subsided areas will fill with water after rain events. Ponded areas associated with the Isaac River are predicted to fill in naturally with sediment, over a period of decades, depending on frequency and duration of rain and flow events. It is intended to monitor this process and intervene only where necessary to maintain the rehabilitation of the Isaac River channel. The proposed adaptive monitoring and management approach will allow changes to this management approach to be made if monitoring indicates that predicted behaviour does not occur.

Ponds forming near the MIA (ponds S02 and S03 on **Figure 7–19**) will be drained so that these ponds do not overflow to the MIA and mine access. Drainage may be achieved by cutting channels to direct this flow back to the Isaac River.

Ponds forming in the 12 Mile Gully catchment may be partially drained if required, as described in **Section 7.3.7**. This will be achieved by cutting channels two to three metres deep along the original creek lines to connect ponds and release water to the Isaac River.

Channels used to drain ponds will be designed and constructed to replicate natural channels as closely as possible and to lead to a stable landform. Subject to successful rehabilitation trials, these riparian zones will be replanted with brigalow or other native trees or shrubs suitable to the conditions.

Tree and Shrub Death

Subsidence will cause localised changes in hydrology and topography that may affect the root zones of trees and shrubs, causing impeded growth and death. Direct reinstatement of trees and shrubs in these areas may not be practicable due to the changed conditions.

Where monitoring identifies tree and shrub death or stress, these areas will be addressed through rehabilitation as follows:

- If dead trees and shrubs are in an area where they may provide useful microhabitat, they will be left in place.
- Where soil has been exposed by the death of trees or shrubs, these areas will be reseeded with:
  - other native trees or shrubs that may be able to grow in the location, having regard to localised post-subsidence soil and hydrology conditions; and
  - pasture species where post-subsidence conditions indicate that it may be difficult or inappropriate to re-establish trees or shrubs.

Erosion

Erosion may occur across the subsided landscape due to localised changes to hydrology and topography. The main areas at risk of erosion are along the Isaac River and tributaries, as well as along the slopes at the edge of subsidence troughs.

Regular inspection of all subsided areas will be undertaken to detect erosion at its earliest stages. If erosion occurs in other areas, for example on steep slopes around the edge of subsidence troughs, these areas will be reinstated as follows:

- small scale earthworks to divert flows away from affected areas and replace topsoil; and
- planting with pasture grass or other suitable fast growing species.

The subsided landform will potentially create moderate to steep slopes above the edges of longwall panels which could increase the risk of erosion, especially with livestock movements to and from freshwater ponds. These slopes will generally be short, that is, less than six metres in terms of vertical fall, which will limit occurrence of severe erosion. Regardless, where these slopes exceed approximately 17 per cent, they may be susceptible to erosion. In many cases, erosion of these slopes will have minimal impact on downstream waters as sediment will collect in the base of the sediment trough. However, erosion of slopes around the edge of the sediment troughs may affect revegetation of the land surface and, hence, compromise the achievement of the final rehabilitation concept of a stable landform suitable for grazing.

Slopes along the edge of subsidence troughs will need to be monitored for signs of erosion. Mitigation measures may include diversion of flows away from the edge of the subsidence trough or battering of the slope using small earthworks equipment to achieve a shallower slope with subsequent planting of pasture grass to achieve vegetative cover promptly. An adaptive management approach will be taken to subsidence to allow learning's from other locations, and from early experiences within the project to be incorporated into future management.

Subsidence of Isaac River and Tributaries

Subsidence will affect the Isaac River and 12 Mile Gully and to a lesser extent, Goonyella Creek. Subsidence will also affect other smaller tributaries and drainage lines. As subsidence will occur progressively, and given the relatively dynamic nature of the Isaac River, an adaptive management approach to subsidence of the Isaac River and tributaries is proposed.

BMA is currently managing subsidence impacts of the BRM in a similar manner and will use this experience to develop a management approach for the proposed RHM. BMA will also take an integrated approach to managing subsidence impacts on the Isaac River across the two mines.

Pre-emptive works that may be undertaken include:

- Installing timber groynes/pile field retards or other toe of bank protection measures at the base of the channel banks (extending into the channel) to mitigate erosion undercutting the channel banks and to facilitate creation of in-channel benches. The structures will be built between each of the subsided panels affecting the river before subsidence occurs.
- Implementing toe of bank protection measures near upstream limit of subsidence on the Isaac River. These measures will most likely also be in the form of timber groynes or pile fields.
- Maintaining and enhancing high density vegetation cover on the Isaac River and other tributaries where potential for avulsion or cut off is identified.

Once subsidence has occurred, monitoring will take place to examine the effect of flood events on bank stability and risk of avulsion or cut off, as well as areas where banks have been disturbed by installation of IMG management infrastructure. Where bank stability has been affected, management measures will be developed and implemented on a case-by-case basis, incorporating the following approaches:

- Maintain vegetation wherever possible.
- Provide a cover of topsoil in a weathered rock matrix to create a stable substrate for revegetation of channel banks. Weathered rock provides temporary erosion protection by covering erodible soils and minimising topsoil loss.
- In areas where less active bank erosion develops, place large woody debris in-stream to encourage the deposition of sediment and revegetation over time.
- Design local drainage works to prevent the uncontrolled flow of runoff from the subsided floodplain area over the channel banks. If necessary, install small diversion bunds directing floodplain runoff to stable areas to minimise bank erosion.
- Install grade control and bank protection measures on tributaries where necessary immediately after full subsidence has occurred.
- Treat un-channelised waterways and flow paths with appropriate grade control and flow management immediately after any headcuts are instigated following subsidence.
- Place topsoil and revegetate banks where bank erosion has occurred.
- Maintain and progressively restore riparian woodland vegetation along the Isaac River to maintain and restore ecological connectivity that may have been affected by subsidence.

- Exclude stock from riparian areas to a width of at least 30 metres from the top of bank and subsided floodplain areas in order to minimise further impacts on vegetation cover and land condition.

Any additional mechanisms, as identified by the annual subsidence monitoring or learnings from management of the BRM subsidence, will also be considered.

As discussed in **Section 7.3.6** of this EIS, based on the assessment of subsidence impacts on geomorphology it is expected that the subsidence voids in the Isaac River will fill with sediment and their storage capacity will diminish. However, some more specific mitigation measures are recommended for the Isaac River as well as tributaries and minor flow paths across the EIS study area.

While the Isaac River diversion lies downstream of the proposed RHM, changes in sediment supply and potential downstream instability induced by subsidence of the Isaac River may affect stability of the diversion. BMA will develop management measures to address impacts of both the proposed RHM and the existing BRM on the diversion. These are likely to include bank battering and revegetation.

5.5.6.3 Soil Management

Topsoil Recovery

Land disturbance from the project will include activities such as land clearing for gas management, road construction, infrastructure and surface facilities footprints, and levees, and water storage construction. Topsoil will be recovered from these areas of disturbance for later use in rehabilitation works. Although underground mining will result in subsidence of the land surface, this will not significantly disturb the topsoil (apart from cracking) and does not necessitate its recovery, except in some instances post subsidence where re-contouring, drainage control or crack repair is required and, as such, topsoil salvage may be required prior to any earthworks.

A topsoil management plan and inventory will be incorporated into the Rehabilitation Management Plan for RHM, and will include the following:

- all relevant aspects for topsoil retrieval such as stripping, stockpiling and re-spreading methodology and procedures;
- topsoil stripping quantities formulated from pre-mining soil survey information; and
- an inventory of available suitable surface cover material including stockpile locations.

For detail on the management, transport, handling and stockpiling of topsoil, refer to **Section 5.3.3**.

If topsoil is required to be stored, it will be stored in windrows no more than three metres high. If long-term stockpiling is planned (i.e. greater than 12 months), stockpiles will be seeded and fertilised as soon as possible, and an annual cover crop species will be sown to provide sufficient competition to minimise the emergence of undesirable weed species.

Suitability and Respreading

Sampling and analysis of topsoil resources, whether stockpiled or *in situ*, will be undertaken prior to respreading. This will assist in identifying potential soil deficiencies and estimating required rates of fertiliser or ameliorant (i.e. gypsum or lime) application.

Where topsoil resources allow, topsoil will be spread to a minimum depth of 100 millimetres and preferably 200 millimetres on surfaces requiring rehabilitation unless direct planting is to be undertaken. Topsoil will be spread, treated with fertiliser or ameliorants (if required) and seeded in one consecutive operation to reduce the potential for topsoil loss to wind and water erosion. Prior to re-spreading stockpiled topsoil (particularly onto designated tree seeding areas), an assessment of weed infestation on stockpiles will be undertaken to determine if individual stockpiles require herbicide application and/or 'scalping'.

Surface Preparation

Prior to revegetation of any disturbed areas, seedbeds will be prepared to ensure optimum establishment and growth of vegetation. Areas where subsoils have become compacted will be deep ripped. All topsoiled areas will then be contour ripped to create a 'key' between the soil and the underlying subsoil to increase infiltration and moisture storage. This can be undertaken using a fine-tyned plough or disc harrow. Ripping should be undertaken on the contour and the tynes lifted approximately two metres every 200 metres to reduce the potential for channelised erosion. Best results will be obtained by ripping when soil is moist and when undertaken immediately prior to sowing. The preparation of a loose and friable seedbed is essential for good vegetation establishment from seed. If it is very wet, the soil may become compacted and hence, topsoil replacement and seeding will not take place under very wet conditions.

5.5.6.4 Revegetation

A revegetation strategy is proposed for the project disturbance area that seeks to satisfy desirable post-mining land use objectives while maintaining effective erosion and weed controls. Three types of revegetation are proposed:

- Pasture grassland suitable for grazing - as grazing is the selected post mining land use, this will be the predominant type of revegetation across the site.
- Bushland maintenance and enhancement − Bushland maintenance and enhancement will aim to build on areas of native vegetation not affected by IMG management infrastructure and subsidence impacts such that these areas can continue to provide suitable habitat.
- Riparian zone maintenance, restoration and enhancement − As the Isaac River has been identified as providing an important north-south movement corridor for native fauna, loss of riparian and flood plain vegetation will be minimised through revegetation.

Some initial and progressive revegetation (pasture grassland) will take place over areas disturbed by the IMG management infrastructure. Enhancement of riparian areas at high risk of avulsion or bank instability will also be undertaken in advance of planned subsidence. Otherwise, revegetation will occur progressively after subsidence and in response to changes induced by subsidence.

Revegetation of areas such as the Red Hill MIA, Red Hill accommodation village and other non-gas related infrastructure will take place on removal of these facilities.

It is also noted that disturbance of the following habitat areas will be avoided where practical, and if not, will be rehabilitated to their pre-disturbance condition where possible:

- Grasslands: RE 11.8.11; and
- Brigalow: RE 11.3.1, RE 11.4.8, RE 11.4.9, RE 11.4.7, RE 11.5.16.

Where possible, the timing of these works will enable a preferred seasonal sowing of pasture and tree seed in autumn or spring. Access to revegetated areas by cattle and vehicles will be restricted until vegetation has reached pre-determined levels of establishment.

Bushland

Plant selection for areas to be maintained as bushland will focus on those native species that will successfully establish on the available growth medium, bind the soil and result in a variety of structure and food/habitat resources. A combination of native and naturalised pasture species will be used on the bushland sites where there is a chance of erosion. The use of each will depend on slope gradient. This will ensure the quick establishment of a continuous groundcover, thereby reducing the risk of erosion. Legumes may also be selected to assist in the supply of bio-available nitrogen to the soil. If the use of introduced grasses and/or legumes is deemed necessary for erosion control in the bushland areas, pasture seed (excluding buffel grass) and fertiliser will be applied at a lower rate than for grazing outcomes in order to reduce competition with tree seed and/or seedlings. Native grasses will be sown where the risk of erosion is less likely, and on the more protected aspects of landforms.

A tree and shrub mix, based on species utilised in the existing GRB mine complex Rehabilitation Management Plan (BMA 2011) and other species identified from site surveys is provided in **Table 5.5-4**. This list will be reviewed and amended periodically depending on the results of rehabilitation monitoring, species trials and changes in technology and best practice. Species to be sown will be selected from this list and the total sowing rate being about five kilograms per hectare (kg/ha).

Tree and shrub establishment on the proposed site will be predominantly by the direct seeding method currently used at the majority of coal mines in the Bowen Basin, (dependent upon the species, slope gradient and area to be revegetated). Species will be established through direct seeding or planting of tube stock/nursery-raised stock from local propagules. Seed will be collected from the EIS study area where practicable to ensure it is adapted to environmental conditions in the area.

Table 5.5-4 Preliminary Native Tree, Grass and Shrub Species Mix

Species Genus	Common Name	Maximum Seeding Rate (kg/ha)	Comment
Acacia harpophylla	brigalow	Tube stock densities based on current trial methods	Supplementary tube stock plantings in targeted areas to reintroduce biodiversity and add conservation value
Acacia holosericea	soapy wattle	0.5	Colonising midstorey species
Acacia leiocalyx	black wattle	0.3	Colonising midstorey species
Acacia salicina	sally wattle	0.7	Common midstorey species
Alectryon diversifolius	scrub boonaree	0.2	Shrub layer/ midstorey species
Archidendropsis basaltica	dead finish	0.3	Common shrub layer species
Aristida calycina	dark wiregrass	8	Common grass, clumping habit
Aristida caput-medusae	many headed wire-grass	4	Common grass, clumping habit
Astrebla lappacea	curly Mitchell grass	8	Common grass, clumping habit
Astrebla squarrosa	bull Mitchell grass	4	Common grass, clumping habit
Atalaya hemiglauca	white wood	0.3	Common midstorey species
Atriplex muelleri	annual saltbush	2	Common herb, spreading habit

Species Genus	Common Name	Maximum Seeding Rate (kg/ha)	Comment
Bothriochloa bladhii subsp. bladhii	forest blue grass	5	Common grass, clumping habit
Bothriochloa decipiens	pitted bluegrass	4	Common grass, clumping habit
Brachychiton australis	broadleaved bottle tree	0.1	Midstorey species
Brachychiton rupestris	bottle tree	0.1	Midstorey species
Cassia brewsteri	Leichhardt bean	0.2	Midstorey species
Carissa Ovata	currant bush	0.4	Dominant shrub layer/ midstorey species
Corymbia erythrophloia	gum-topped bloodwood	0.3	Common canopy species
Corymbia intermedia	pink bloodwood	0.2	Canopy species
Corymbia polycarpa	long-fruited bloodwood	0.3	Common canopy species
Corymbia tessellaris	Moreton Bay ash/ carbeen	0.2	Canopy species
Dichanthium sericeum	Qld or silky blue-grass	8	Common grass, clumping habit
Eremophila mitchellii	false sandalwood	0.8	Dominant shrub layer/ midstorey species
Eucalyptus cambageana	Dawson gum	0.5	Co-dominant canopy species
Eucalyptus crebra	narrow leaved ironbark	0.5	Co-dominant canopy species
Eucalyptus drepanophylla	grey iron bark	0.2	Canopy species
Eucalyptus populnea	poplar box	0.8	Dominant canopy species
Eucalyptus thozetiana	Thozet's box	0.1	Canopy species found on weathered lateritic soils
Flindersia dissosperma	scrub leopardwood	0.4	Common shrub layer/ midstorey species
Geijera parviflora	wilga	0.5	Dominant shrub layer/ midstorey species
Heteropogon contortus	bunched spear grass	5	
Iseilema membranaceum	flinders grass	8	Common grass, spreading habit
Panicum decompositum	native millet	5	Common grass, clumping habit
(Sorghum halepense x S.roxburghii) x S. arundinaceum	silk sorghum	10	Short lived pioneer species
Themeda triandra	kangaroo grass	8	Common grass, spreading habit
Terminalia oblongata ssp voluvris	yellowwood	0.3	Common shrub layer/ midstorey species

Pasture Grassland

Pasture seed will be sown using direct ground broadcasting methods and aerial seeding where required. The preliminary seed mix to be used to establish pasture grassland at the EIS study area is provided in **Table 5.5–5** (BMA 2011). Species to be sown will be selected from this list with the total sowing rate being about 10 kg/ha. Note that most of these species are introduced species.

Table 5.5-5 Preliminary Pasture Grass Species Mix

Species Genus	Common Name	Maximum Seeding Rate (kg/ha)
Pennisetum ciliare	buffel grass	7
Bothriochloa pertusa	Indian couch	8
Chloris gayana	Rhodes grass	7
Dichanthium sericeum	Qld or silky blue-grass	10
Iseilema membranaceum	Flinders grass	8
Panicum coloratum var. makarikariense	bambasti grass	8
Panicum decompositum	native millet	5
Setaria incrassate	purple pidgeon grass	8
Macroptillium atropurpureus	siratro	5
Stylosanthes spp.	stylo	5
Melinis repens	red natal grass	4
Urochloa mosambicensis	sabi grass	5
(Sorghum halepense x S.roxburghii) x S. arundinaceum	silk sorghum	20
Themeda triandra	kangaroo grass	8

Riparian Areas

Riverine areas requiring pre-subsidence enhancement will be seeded or planted with the species selected from identified in **Table 5.5-6**. This same mix will also be used for rehabilitation of areas affected by ponding following subsidence (BMA 2011). This species mix should be used in and around areas that experience ponding for between one to two weeks. For ponds that are present for greater than two weeks the species mix should be reduced to that of *Eucalyptus tereticornis* and *Eucalyptus coolabah*, with a higher seeding rate. These areas will become important wetland habitat and will be linked where possible to other riparian vegetation along nearby rivers. The total seeding rate should not exceed 5 kg/ha. Lower seeding rates may be possible in optimal conditions.

Table 5.5-6 Preliminary Riparian Species

Species Genus	Common Name	Maximum Seeding Rate (kg/ha)	Comment
Acacia salicina	sally wattle	0.4	Common midstorey species in riparian communities and floodplains
Astrebla lappacea	curly Mitchell grass	8	Common native grass species on floodplains
Atalaya hemiglauca	white wood	0.3	Common midstorey species on floodplains
Melaleuca viminalis	weeping bottle brush	0.5	Common midstory species on banks and riparian communities
Casuarina cunninghamiana	river sheoak	0.8	Co-dominant canopy species on banks
Corymbia clarksoniana	Clarkson's bloodwood	0.2	Canopy species on floodplains

Species Genus	Common Name	Maximum Seeding Rate (kg/ha)	Comment
Corymbia tessellaris	Morten Bay ash/ carbeen	0.8	Common midstorey and canopy species in riparian and floodplain communities
Crinum flaccidum	inland river lilly	0.4	Herbaceous groundcover found in riparian communities and floodplains
Cyperus dactylotes	sedge	4	Sedge in-stream and on lower bank edges
Cyperus difformis	sedge	2	Sedge in-stream and on lower bank edges
Cyperus exaltatus	tail sedge	2	Sedge in-stream and on lower bank edges
Dichanthium sericeum	Queensland blue grass	5	Quick to establish and provides conservation value
Enneapogon lindleyanus		4	Common native grass species on floodplains
Eucalyptus camaldulensis	river red gum	0.5	Common canopy species on banks
Eucalyptus coolabah	Coolabah	0.8	Canopy species on flood plains
Eucalyptus populnea	poplar box	0.4	Canopy species found on flood plains
Eucalyptus tereticornis	forest red gum	0.8	Dominant canopy species on river banks
Lomandra longifolia	long-leaf mat rush	0.5	Herbaceous groundcover provides soil stability on banks
Lysiphyllum carronii	red bauhinia	0.6	Common midstorey species in riparian and floodplain communities
Lysiphyllum hookeri	white-flowered bauhinin	0.6	Common midstorey species in riparian and floodplain communities
Melaleuca bracteata	Black River tea tree	0.8	Common midstorey species on lower bank edges
Melaleuca linariifolia	snow in summer / flax-leaf paperbark	0.4	Common midstorey species on banks
Sorghum sp.	Sudax / Sudan grass	15	Temporary exotic sterile cover crop. Provides topsoil stability and biomass, loosens and aerates subsoils

5.5.6.5 Weed and Pest Management

The presence of weed species can significantly impact on revegetation and regeneration activities. Infestations of weeds will be managed with weed control focused primarily on rehabilitated areas during the first year of vegetation establishment, including areas impacted by subsidence. With regard to subsidence, weed management will be particularly important during the period between the installation of IMG management infrastructure, full subsidence occurring and subsequent final rehabilitation works. As described above, rehabilitation will be progressive with the specific scheduling of works to take into account the timing of subsidence, as well as the installation and subsequent removal of goaf drainage infrastructure.

Particular focus will also be on infestations of weed species declared under the *Land Protection (Pest and Stock Route Management) Act 2002* (LP Act) and Land Protection (Pest and Stock Route Management) Regulation 2003 (LP Regulation) and known to occur at the GRB mine complex. These species include *Harrisia martini* (harrisia cactus), *Parthenium hysterophorus* (parthenium), *Opuntia stricta v stricta* (prickly pear) and velvety *Opuntia tomentose* (tree pear).

Weeds will be managed across the project area through a series of control measures, including:

- hosing down equipment in an approved wash down area before entry to site;
- scalping weeds off topsoil stockpiles prior to re-spreading topsoil in a manner that minimises soil disturbance;
- regular inspections of rehabilitated areas to identify potential weed infestations; and
- weed control using chemical sprays (appropriate herbicides will be selected so as not to impact on waterways).

Records will be maintained of infestations and control measures taken. Weed control programs will be implemented according to best management practice for the species concerned. The annual audits will include a review of the effectiveness of weed control practices.

Weed control, if required, will be undertaken in a manner that will minimise soil disturbance. Any use of herbicides will be carried out in accordance with appropriate state and/or federal regulatory requirements to minimise potential environmental impacts. Records of weed infestations will be maintained and control programs will be implemented according to best management practice for the weed species concerned.

The presence or indications of use of rehabilitation reference sites on the mining lease by feral animals will be recorded opportunistically and as part of fauna monitoring. Pest species will be targeted for eradication where required under the LP Act and LP Regulation. It is acknowledged that feral pigs may become an issue due to the more permanent ponding predicted as a result of subsidence, and will therefore be targeted in the pest control program as indicated by monitoring.

5.5.6.6 Contaminated Land

At closure, a preliminary sampling and analysis program (Phase 1) will be implemented to determine whether an assessment (Phase 2 – detailed investigation of contamination involving drilling) is required to quantify the amount of contaminated material that requires management. If contaminants in excess of contaminated soil guidelines in place at the time of closure are detected, a contaminated soil management and remediation plan will be developed in compliance with guidelines in place at the time. If soil cannot be remediated *in situ*, the preference will be to remove the soil and place it within waste dumps on the adjacent GRM. Depending on the nature and level of contaminants, some level of encapsulation may be required, and placement may need to be above groundwater levels. Further details can be found in **Section 5.4**.

5.5.6.7 Progressive Rehabilitation

Progressive rehabilitation will follow the subsidence associated with each longwall panel.

Results of progressive rehabilitation against the criteria in **Table 5.5-3** will be used to refine rehabilitation methods for future application, such as the selection of appropriate drainage and erosion control measures and the selection of plant species for re-establishment. Progressive rehabilitation for the project will be consistent with existing rehabilitation on the GRB mine complex with respect to continuity and species composition, where possible. Areas available for progressive rehabilitation and the types of disturbance at those sites will be detailed in the plan of operations.

5.5.7 Monitoring

Regular monitoring of rehabilitation will be required during the vegetation establishment period, to demonstrate that the objectives of the rehabilitation strategy are being achieved and whether a sustainable landform has been provided. This will be undertaken consistent with the existing GRB mine complex Rehabilitation Management Plan (BMA 2011) and the One BMA Rehabilitation Monitoring Methodology (Emmerton 2010). Specific monitoring of key parameters such as sediment control and water quality will be carried out as discussed in **Section 7.3.9**.

Monitoring will be conducted periodically by suitably skilled and qualified persons at locations that will be representative of the range of conditions on the rehabilitating areas. Annual reviews of monitoring data will be conducted in order to assess trends and monitoring program effectiveness.

In addition to rehabilitated areas, reference sites will be monitored to allow a comparison of the development and success of the rehabilitation against a control. This allows factors such as weather conditions to be taken into account when considering rehabilitation success rates. Reference sites indicate the condition of surrounding un-mined areas that the rehabilitated disturbance area must match. Currently, 11 reference sites are monitored annually for the GRB mine complex. These were selected in 2002 with the assistance of a local landowner. The sites are located adjacent to the current mine leases and represent surrounding land types that are exposed to cattle grazing. Additional reference sites will be selected as required to represent the post mining land use proposed and may include riparian sites.

Components of the rehabilitation to be monitored include:

- geotechnical stability of landforms;
- erosion and soil characteristics;
- surface and groundwater quality and flow parameters; and
- ecosystem establishment including vegetation structure and floristics, habitat and fauna.

Monitoring of specific parameters will be undertaken to determine the level of achievement of success criteria, in accordance with the elements included in **Table 5.5–7**.

Table 5.5-7 Key Elements of the Rehabilitation Monitoring Program

Aspect of Rehabilitation	Elements to be monitored
Geotechnical stability	
	Stability of batter and surface settlements, in particular where these features could impact on the performance of any surface water management system. Surface integrity of landform cover/capping (measurement of extent of integrity failure). Landform slumping (distance of material movement and extent).
Erosion and soil characteristics	
Erosion	Extent of bare areas with potential to erode. Location and extent of sheet wash. Location and extent of rill and gully erosion including measurements of depth, width and length. Sediment movement and runoff.
Soils	Surface condition (e.g. hard set, friable, self mulching). Basic fertility – NPK and trace elements. Electrical conductivity, as a measure of salinity. pH. Soil ESP. Stability, infiltration and nutrient cycling using landscape function analysis (LFA) methodology.
Subsidence	
	Baseline elevation and condition of areas predicted to be impacted by subsidence. Subsidence affects (landscape and ecological changes) including vertical drop, slope of failures, dimensions and frequency of cracking, signs and extent of ponding, signs of saline discharge/scalding, changes to channel and flow parameters.
Surface water and groundwater	
	Groundwater quality and level. Efficiency of landform surface water drainage systems. Presence and quality of any surface water and seepage at selected locations at the lower part of potentially acid producing landforms such as reject dumps. Water quality including pH, electrical conductivity and total suspended solids of water in water storages, ramps and pits, and sediment basins on site. Water quality including pH, salinity and turbidity of water entering creek/river systems on site.
Ecosystem establishment	
Groundcover	Details of ground cover (including bare lengths and obstructions) for use in landscape function analysis.
Fauna	General observations of vertebrate and invertebrate species. Detailed fauna surveys focusing on species of conservation significance and areas of habitat in rehabilitation works).
Weeds and pests	Species identity and approximate numbers/level of infestation. Observations of impact on rehabilitation (if any).

Aspect of Rehabilitation	Elements to be monitored
Vegetation and habitat	Height class. Crown cover. Relative abundance of species present. Stems count. Diameter at breast height (DBH) for all stems above 2 m height. Foliage projection cover (FPC %) of ground cover species. Pasture grass health (as determined by density, ground cover and pasture species composition). Detail of habitat components (e.g. stags, logs/rocks, free water, nests, food sources). Evidence of reproduction/regeneration. Assessment of plant health (healthy, sick or dead). Annual monitoring of the direct tree seeding and tube stock trials.

5.5.8 Maintenance

Maintenance of rehabilitated areas will be undertaken where necessary and in response to results of the monitoring program, to ensure success criteria are met, or in the case of progressive rehabilitation, are projected to be met at the time of mine closure. Depending on the criteria to be achieved, examples of maintenance works include: re-seeding or planting vegetation species (in-filling) to meet required parameters, implementation of erosion protection measures to reduce erosion and sedimentation rates or application of fertiliser. Where significant failure to meet indicators is identified, new strategies may need to be developed for particular areas. This is consistent with the adaptive management approach being undertaken in relation to subsidence impacts.

Responsibility for the maintenance of rehabilitation will lie with BMA, as owner/operator of the project. Post-subsidence and post-mining surveys of the rehabilitation will be undertaken across the proposed EIS study area to determine whether the site meets success criteria, and whether this result is being maintained over time. Once this occurs and the site is relinquished, the land will be returned to the relevant stakeholders and maintenance of the rehabilitation beyond what is typical for similar unmined lands in the area will no longer be required.

5.5.9 Post Closure and Monitoring

Following closure of the mine, the monitoring program described above in **Section 5.5.7** will be maintained until all decommissioning and rehabilitation works have been completed to the satisfaction of BMA and the regulatory authority. Notwithstanding this, there may be the need to establish some additional monitoring sites depending on the nature of the decommissioning works, and also in response to finding possible sources of pollutants to the environment as part of the monitoring program.

The type and location of this monitoring will be determined further during the site decommissioning phase.