4. Land

This section provides a summary of the assessments undertaken and the potential impacts identified in regards to land during construction and operation of the Project (Mine). The assessments were undertaken in accordance with the requirements of the Terms of Reference (ToR) and a table cross-referencing these requirements is provided in Volume 4 Appendix C ToR Cross Reference Table. The land assessment incorporates the results from a number of separate studies, which are included in Volume 4 Appendix K Landscape and Visual Assessment, Appendix L Soils Assessment and Appendix M Land Use Report.

4.1 Scenic Amenity and Lighting

4.1.1 Introduction

A landscape and visual impact assessment has been conducted as part of the Project (Mine) Environmental Impact Statement (EIS). The assessment is reported in Volume 4 Appendix K Mine Landscape and Visual Assessment. The following summarises the findings of the assessment.

The landscape and visual assessment considers impacts on the following:

- Landscape character i.e. the distinct, recognisable and consistent pattern of elements which differentiate between landscape types. A landscape can include prominent or eye-catching features, such as rocky outcrops or may alternatively comprise large consistent expanses of homogenous areas
- Scenic amenity i.e. the value of a particular area or view in terms of what is seen

4.1.2 Methodology

In the absence of any landscape and visual impact assessment methodology specific to Queensland, the study followed the UK Guidance for Landscape and Visual Impact Assessment (LI, 2002). The subsections below set out the stages through which the assessment was carried out.

4.1.2.1 Baseline Study

Baseline information to define the existing landscape character and scenic amenity was collected through a desktop study and a site visit to survey the Project (Mine) and surrounding areas. This information was used to identify sensitive landscape and amenity receptors. Key information collected included:

- the context and composition of the existing landscape, including the extent of existing man-made modifications
- the visual catchment (i.e. zone of theoretical visibility) of a particular area or view
- the sensitivity of a particular area and view to change

The sensitivity of a particular area or view was determined according to the four-point scale presented in Table 4-1 below.

Table 4-1 Visual Sensitivity Definitions

Sensitivity	Definition
High	Occupiers of residential properties with long viewing periods, within close proximity to the proposed development. Communities that place value upon the landscape and enjoyment of views of their landscape setting.
Medium	Outdoor workers who have a key focus on their work who may also have intermittent views of the Project (Mine) area. Viewers at outdoor recreation areas located within close proximity but where viewing periods are limited. Occupiers of residential properties with long viewing periods, at a distance from or screened / filtered views of the Project (Mine) area.
Low	Road users in motor vehicles, trains or on transport routes that are passing through or adjacent to the study area and have short term / transient views. Viewers indoor at their place of work, or similar.
Neutral	Viewers from locations where there is screening by vegetation or structures where only occasional views are available and viewing times are short.

4.1.2.2 Prediction of Change

Information regarding the description of the Project (Mine) was then reviewed to determine the nature and extent of potential changes on the existing landscape and value of particular areas or views. In particular, this considered:

- the direction of change (negative or positive)
- the duration of change (temporary, short, medium, long term or permanent)
- the magnitude of change

The magnitude of change was determined according to the definitions presented in Table 4-2. These changes could theoretically be negative or positive i.e. detrimental or enhancing to the existing environment.

Table 4-2 Visual Change Definitions

Level of Change	Definition
Large reduction or improvement	A substantial / obvious change to the landscape due to total loss of, or change to, elements, features or characteristics of the landscape. Would cause a landscape to be permanently changed and its quality diminished.
Moderate reduction or improvement	Discernible changes in the landscape due to partial loss of, or change to the elements, features or characteristics of the landscape. May be partly mitigated. The change would be out of scale with the landscape, and at odds with the local pattern and landform and will leave an adverse impact on the landscape.

Level of Change	Definition
Small reduction or improvement	Minor loss or alteration to one or more key landscape elements, features, or characteristics, or the introduction of elements that may be visible but may not be uncharacteristic within the existing landscape.
No perceivable reduction or improvement	Almost imperceptible or no change in the view as there is little or no loss of / or change to the elements, features or characteristics of the landscape.

Source:

Landscape Institute and Institute for Environmental Management and Assessment (2002)

4.1.2.3 Determining Impact Significance

The significance of impacts was determined based on the matrix presented in Table 4-3 which compares the magnitude of change against the visual sensitivity of a particular area or view.

Table 4-3 Significance of Impacts

		Change			
		Large	**Moderate**	**Small**	**Negligible**
Visual Sensitivity	**High**	Major significance	High significance	Moderate significance	Minor significance
	Medium	High significance	Moderate significance	Minor significance	Not significant
	Low	Moderate significance	Minor significance	Not significant	Not significant
	Negligible	Minor significance	Not significant	Not significant	Not significant

4.1.2.4 Mitigation

Mitigation was applied according to the following hierarchy to reduce the significance of impacts:

- **Avoidance** – avoid negative impacts through the consideration of the Project (Mine) layout and location of components in relation to the existing environment
- **Reduction** – reduce negative impacts that cannot be avoided by limiting impact duration through modified working practices or installing barriers to screen impacts from receptors

Residual impacts were then determined based on the likely success of mitigation measures to reduce the significance of impacts. In the event that any residual impacts were found to be significant, then measures to compensate for these impacts were proposed, as required.

4.1.3 Description of Environmental Values

4.1.3.1 Existing Landscape Character

The existing landscape character is rural with the dominant land use activity being low intensity cattle grazing. The vegetation elements of the landscape comprise scattered patches of open eucalypt woodlands with shrubby understoreys and expanses of cleared grasslands used for grazing (refer to Plate 4-1). Given the rural character of the area, artificial night lighting levels are expected to be very low, if present at all.

Plate 4-1 Landscape Character

Cleared grazing land

Open woodland north of Project (Mine)

Topography across the Project (Mine) slopes towards the east and north-east from a north-west to south-east trending ridge line. The highest regions of landform occur outside the Project (Mine) approximately 3 km west, and reach 396 m at its highest point (refer to Figure 4-1). The topographic gradient flattens out east of EPC1080.

The Carmichael River, Cabbage Tree Creek, Eight Mile Creek and various other unnamed creeks also traverse the Project (Mine) site, with Carmichael River/Cabbage Tree Creek bisecting the Project (Mine).

The Bygana West Nature Refuge occurs over part of the southern extent of the Study Area, south of the Carmichael River. The nature refuge covers an area of approximately 1,487 ha and is approximately 6 km long. It supports a composite of open grassy woodland and shrubland habitats. Doongmabulla Mound Springs Nature Refuge is approximately 10 km west and Wilandspey Conservation Park approximately 30 km north-east of the Project (Mine).

Within the Project (Mine) a number of existing modifications occur including a homestead, air strip, cattle yards, farm dams and bores. Figure 4-1 indicates the area surrounding the Project (Mine) is sparsely populated with very few homesteads being within 10 km of the Project (Mine). Due to land access restrictions at the time of the study, only one homestead has been accessed as part of the assessment to establish viewpoints i.e. Doongmabulla homestead. This homestead is located 6.2 km west of the Project (Mine) separated from it by a ridge. Remaining homesteads in the vicinity of the

Project (Mine) are screened from the development area due to topographical features and views are expected to be limited.

Dirt roads and access tracks, fence-lines and stock watering infrastructure comprise the other dominant features of the landscape's character.

4.1.3.2 Views from Publically Accessible Areas

Use of the Project (Mine) and surrounding area by the public is largely restricted to existing local roads. These locations therefore provide the key views to the Project (Mine). In particular, views from the Moray Carmichael Boundary Road are most likely to be affected given this road traverses the Project (Mine) site.

The Gregory Developmental Road is a significant tourist route for Isaac Region. This road is located approximately 64 km east of the Project (Mine). Given this large separation distance, the Project (Mine) will not be visible from the Gregory Developmental Road. Views from this road are therefore not considered further within this assessment.

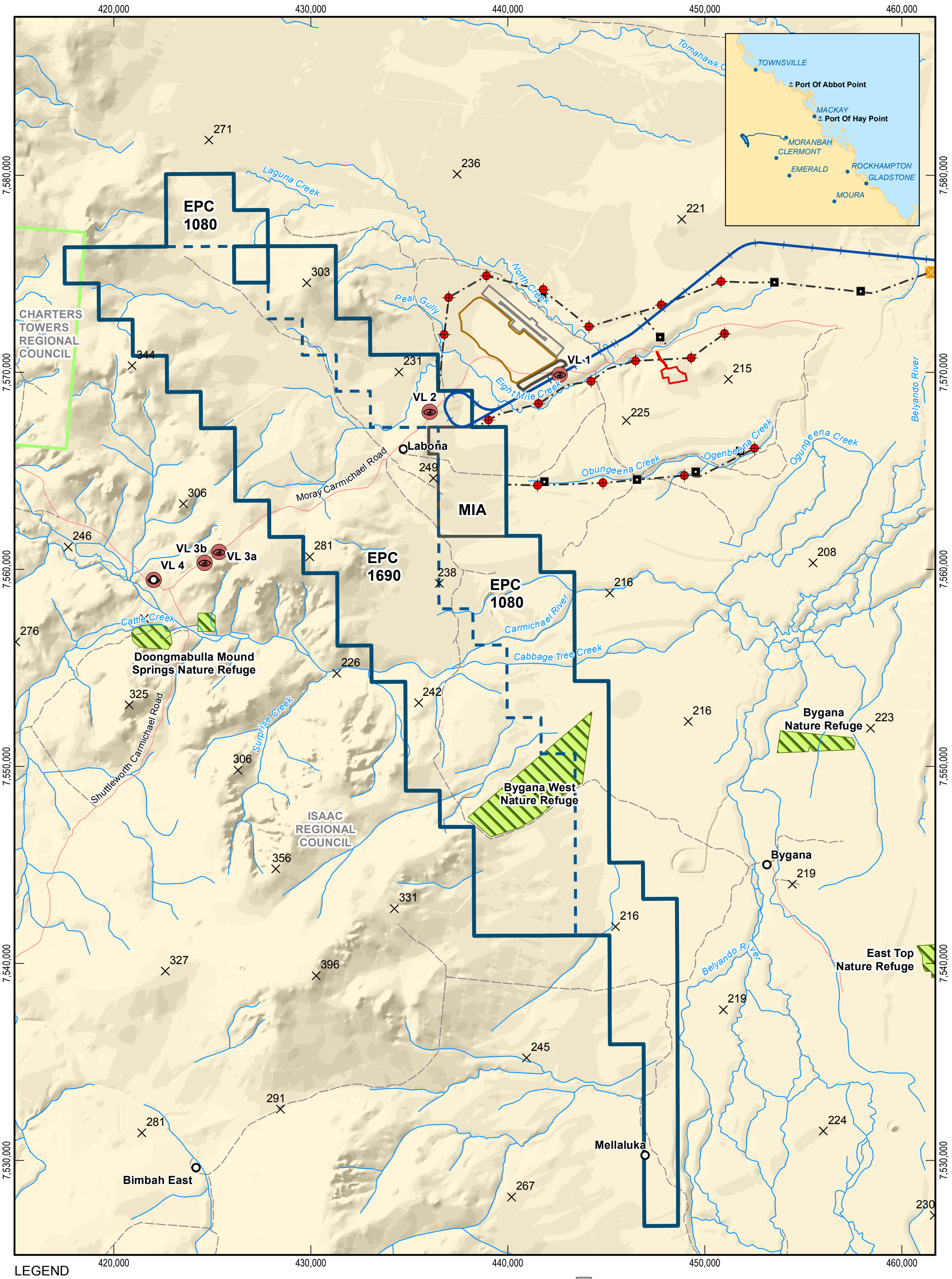
Moray Carmichael Road

The Moray Carmichael Road bisects the Project (Mine) site east to west. This is a minor road, used for local access only. No traffic count data was available for this road (refer section 11 Transport), however, it is understood to carry relatively low traffic volumes.

A description of the existing scenic environment is provided for four locations along the Moray Carmichael Road (Figure 4-1):

- One location east of the Project (Mine) – Viewing Location 1
- One location within the Project (Mine) – Viewing Location 2
- Two locations west of the Project (Mine) where the road traverses a ridge. The locations are on top and at the bottom of the ridge respectively – Viewing Location 3A and 3B.

Table 4-4 describes these viewing locations in more detail.



LEGEND

- Homestead
- Spot Height
- Viewing Location
- Local Road
- Track
- Watercourse
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Local Government Area Boundary
- Nature Refuge

Mine (Offsite)

- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

1:275,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision D
Date 10-10-2012

Viewing Locations

Figure: 4-1

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Data Source: DERM: Nature Refuge, Elevation, LGA Boundaries (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Homesteads, Watercourses, Spot Height (2007); DME: EPC 1690 (2010)/EPC 1080 (2011); GHD: Visual Impact Assessment (2011); Gassman/Hyder: Mine (Offsite) (2012); Adani: Alignment Opt9 Rev3 (2012). Created by: BW, CA

Table 4-4 Description of Public Viewing Locations

Viewing Location 1: View west along Moray Carmichael Boundary Road, towards the Project (Mine) site

Location	Moray Carmichael Boundary Road, approximately 7 km from the Project (Mine)
Landform and Significant Landscape Features	Topography is flat
Vegetation	Open paddocks of native grassland with scattered/ clumped trees and shrubs
Water	Low lying plains, may be flooded in wet season
Land Use	Primarily agricultural for cattle grazing
Visual Context	Views from this viewpoint are characterised by: ◗ Flat topography and sparse vegetation allowing open, long views over broad pastures to low woodlands ◗ Some short, intermediate vistas to nearby shrubs Views are experienced by local road users
Visual Sensitivity	Low

Viewing Location 2: View south-west-west along Moray Carmichael Boundary Road, towards proposed Project site

Location	Moray Carmichael Boundary Road, approximately 1.6 km within the Project (Mine) boundary
Landform and Significant Landscape Features	Topography is flat
Vegetation	Scattered/ clumped trees and shrubs, surrounded by native grassland.
Water	Low lying plains, may be flooded in wet season
Land Use	Primarily agricultural for cattle grazing
Visual Context	Views from this viewpoint are characterised by: ◗ Flat topography and sparse vegetation allowing open, long, background views over broad pastures to woodlands ◗ Some short, intermediate vistas to nearby shrubs Views are experienced by local road users
Visual Sensitivity	Low

Viewing Location 3A: Top of ridge line, west of Project (Mine) site, looking south-west

Location	Moray Carmichael Road, west of the Project (Mine)
Landform and Significant Landscape Features	Topography is undulating
Vegetation	Scattered/ clumped trees and shrubs, surrounded by native grassland
Water	Water erosion may occur in wet season
Land Use	Primarily agricultural for cattle grazing
Visual Context	Views from this viewpoint are characterised by: ◗ Flat topography and sparse vegetation allows open, long, background views over broad pastures to woodlands. ◗ Some short, intermediate vistas to nearby shrubs. Views are experienced by local road users
Visual Sensitivity	Low

Viewing Location 3B: View north-north-east towards the ridge line west of Project (Mine) site

Location	Moray Carmichael Road, approximately 3.5 km from the Project (Mine)
Landform and Significant Landscape Features	Sloping topography in a north-easterly direction towards the Project (Mine) site
Vegetation	Mixed shrubby woodland and native grassland
Water	Water erosion may occur in wet season
Land Use	Predominantly agricultural land uses
Visual Context	Views from this viewpoint are characterised by views towards the top of the ridge line, with short and intermediate views to vegetation Views are experienced by local road users
Visual Sensitivity	Low

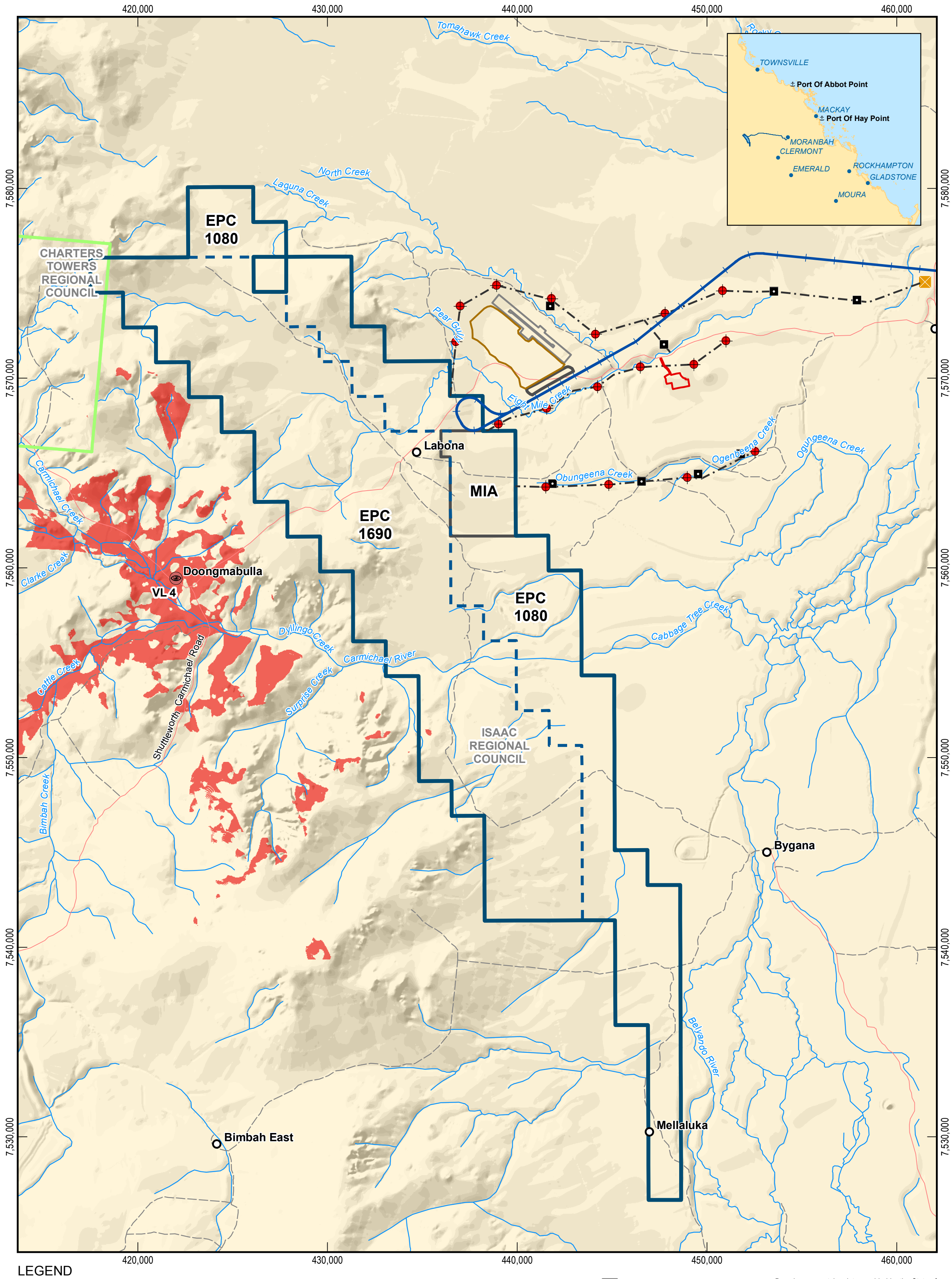
4.1.3.3 Views from Private/ Residential Property

Doongmabulla homestead is located approximately 6 km from the Project (Mine) Site. This site is identified as Viewing Location 4. Figure 4-2 presents the visual catchment for this Viewing Location. Further details of this Viewing Location are summarised in Table 4-5. No other homesteads could be accessed at the time of the field surveys. No assessment has therefore been undertaken for these sites within this report.

Table 4-5 Description of Private Viewing Locations

Viewing Location 4: Doongmabulla Homestead, facing east towards the Project (Mine) site.

Location	The homestead is located approximately 6 km from the Project (Mine). It is located on a minor road (Receptor 4)
Landform and Significant Landscape Features	The homestead is situated at an elevation of 250 m. The topography rises to the north and east directions to a ridge line, which at its nearest highest point is approximately 3 km from the homestead at an elevation of 310 m
Vegetation	Mixed shrubby woodland and native grassland
Water	Water erosion may occur in wet season
Land Use	Residential (surrounded by grazing land)
Visual Context	The existing visual context consists of a predominantly rural agricultural and natural landscape, with a ridge line dominating the north and eastern views. Views are experienced by occupants of the homestead
Visual Sensitivity	Low



LEGEND

- Homestead
- Viewing Location
- Local Road
- Track
- Watercourse
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Local Government Area Boundary
- Zone of Theoretical Visibility (View from Doongmabulla Homestead)

Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

1:285,000 (at A4)
0 2 4 6 8 10
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

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Carmichael Coal Mine and Rail Project

Zone of Theoretical Visibility
for Doongmabulla Homestead

Job Number | 41-25215
Revision | D
Date | 10-10-2012

Figure: 4-2

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Data Source: DERM: Elevation, LGA Boundaries (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Homesteads, Watercourses (2007); DME: EPC 1690 (2010)/EPC 1080 (2011); GHD: Visual Impact Assessment, Viewing Location (2011); Gassman/Hyder: Mine (Offsite) (2012); Adani: Alignment Opt9 Rev3 (2012). Created by: BW, CA

4.1.4 Key Landscape Changes as a Result of the Project (Mine) Onsite Infrastructure

The Project (Mine) will result in a large change to existing landscape character over a period of 90 years. The change will be progressive throughout the life of the Project (Mine) and will consist of conversion of 44,730 ha of land from low intensity cattle grazing character to a mining landscape character.

The substantial and permanent change in the landscape will result from:

- Progressive clearing of vegetation over the open cut mining footprint and out of pit spoil dump areas
- Creation of out of pit spoil dumps extending along much of the eastern length of the proposed mining lease. This will represent a permanent change in topography
- Creation of open cut pits and then partially backfilled residual voids. This will represent a permanent change in topography
- Some potential loss of trees from subsided areas over the proposed underground mines
- Installation of infrastructure, including a coal handling and preparation plant (CHPP) within the mine site and an industrial area, airport and workers accommodation village in the off-site infrastructure area. These features will be present for the life of the mine
- Creation of Run of Mine (ROM) and product stockpiles of coal. These features will be present for the life of the mine
- The change in land use resulting from the development of the Project (Mine). This will include the development of industrial infrastructure associated with the CHPP as well as mining operations, development of pits, haul roads and out-of-pit disposal areas

4.1.4.1 Assessment of Impacts on Viewing Locations from Public Areas

Potential Impacts

Viewing Location 1 (View west along Moray Carmichael Road towards the Project site) is approximately 7 km from the Project (Mine), surrounded by relatively flat terrain and scattered low vegetation. It is considered to be of low sensitivity. The development of the mine is unlikely to be visible from this point thus any change to the landscape is likely to be negligible. No significant impacts are predicted on this Viewing Location.

Viewing Location 2 (view south-west-west along Moray Carmichael Road, towards proposed Project site) is located 1.6 km within the Project (Mine) site and will therefore experience a greater impact from changes in the landscape. The change to the landscape is predicted to be moderate. The Viewing Location is used only by road users passing through the area, thus seeing only glimpses of the Project (Mine). The significance of the impact is therefore minor.

Viewing Location 3A is west of the Project (Mine) site and viewers driving east along the Moray Carmichael Road from this point will see the mine site. The sensitivity of this receptor is considered low due to the limited number of roads users in this area and the fact road users will only experience temporary views of the Project (Mine). The change in landscape character as a result of the Project (Mine) will be large. The significance of this change would be moderate on this Viewing Location.

Viewing Location 3B is approximately 3.5 km from the Project (Mine) site and is screened by a prominent ridge line. Therefore, it is unlikely that construction and operation of the mine will be visible from this point and no significant impact is predicted.

4.1.4.2 Assessment of Impacts on Viewing Locations from Private Property

Potential Impacts

Doongmabulla homestead (Viewing Location 4) is approximately six kilometres away from the Project (Mine) site and separated from it by a ridge. The zone of visibility analysis shown in Figure 4-2 shows that the mine site is not visible from the homestead due to this topographical feature. The sensitivity of this receptor is therefore negligible. Any change to the landscape as a result of the Project (Mine) would not be significant on this receptor.

Mitigation Measures

The impacts of the Project (Mine) upon the existing landscape character and its visual amenity are an avoidable consequence of the Project (Mine). The Project (Mine) is located at the coal deposit.

Notwithstanding this, while permanent changes to topography will occur, disturbed areas will be rehabilitated. On closure of the mine, all structures will be decommissioning and removed. Section 13 EMP provides further details of decommissioning and rehabilitation.

The Project would aim to achieve construction without causing undue visual disruption to existing receptors. The following mitigation measures are recommended in regard to changes in the landscape character for the Project (Mine):

- Removal of hoardings, barriers and traffic management signage when no longer required
- Minimisation of dust emissions onto retained areas outside the Project (Mine) footprint
- Limiting vegetation clearance to required areas only

4.1.4.3 Summary of Impact Assessment of Project (Mine) Onsite Infrastructure

The change in land use and resultant change in landscape character is described as a significant modification having a permanent impact. A moderate significant impact is predicted on Viewing Location 2. Importantly, whilst this significant impact is an unavoidable consequence of the Project (Mine) off-site infrastructure, this Viewing Location is used by very low numbers of people. No other significant impacts are predicted.

4.1.5 Key Landscape Changes as a Result of the Project (Mine) Offsite Infrastructure

The development of the workers accommodation village, airstrip and associated infrastructure will occupy approximately 1,416 ha. This change will occur within the first construction year of the Project (Mine).

4.1.5.1 Assessment of Impacts on Viewing Locations from Public Areas

Viewing Location 1 is immediately south of the industrial area and airstrip and west of the workers accommodation village. This location is surrounded by relatively flat terrain and scattered low vegetation. It is of low sensitivity. The workers accommodation village and airstrip will be visible from this point and the magnitude of the change is considered to be large. The Project (Mine) Offsite infrastructure will have a moderate significant impact on this Viewing Location. Views from this point are limited in duration and are also limited due to the short-term views afforded to local road users.

Viewing Location 2 is located approximately 12 km from the workers accommodation village. This location is of negligible sensitivity. The magnitude of the change is considered to be low due to the distance from the workers accommodation village and airstrip. No significant impacts are predicted on this Viewing Location.

Viewing Location 3A and 3B are located on the western side of the proposed mine, separated from it by a ridge. The off-site infrastructure will not be visible from these locations.

4.1.5.2 Assessment of Impacts on Viewing Locations from Private Property

Doongmabulla homestead (Viewing Location 4) is also on the western side of the mine and will not be able to view the off-site infrastructure. No significant impacts are predicted on this homestead.

Mitigation Measures

Mitigation in regard to the development of the workers accommodation village and airstrip relates to retention and maintenance of vegetation or revegetation along the Carmichael Moray Road and the boundary of the off-site infrastructure to mitigate the impact of this aspect of the Project (Mine).

4.1.5.3 Summary of Impact Assessment of Project (Mine) Off-site Infrastructure

The change in land use and resultant change in landscape character is described as a significant modification having a permanent impact. A moderate significant impact is predicted on Viewing Location 2. Importantly, whilst this impact is significant this Viewing Location is used by very low numbers of people and, furthermore, is an unavoidable consequence of the Project (Mine) off-site infrastructure. No other significant impacts are predicted.

4.1.6 Light Spill from Mine Operations and Off-site Infrastructure

4.1.6.1 Potential Impacts

Development of the Project (Mine) onsite and off-site infrastructure will necessitate the installation of lighting for safety and security of operations as the proposed mine will operate 24 hours per day. Impacts from lighting will involve the following:

- Static floodlights associated with mine operations
- Lighting around the mine infrastructure area, workshops and ancillary buildings
- Vehicle lights moving around the site
- Lighting from the workers accommodation village, industrial area, rail siding and airstrip

Taken together, and in the absence of mitigation, lighting emissions will result in a bright glow which would be visible from surrounding areas. This change is expected to be moderate. At present, artificial night lighting levels are expected to be very low, if present at all and this is considered to be an impact of minor significance.

4.1.6.2 Mitigation Measures

The Project (Mine) would aim to achieve construction and operation without causing undue visual disruption to existing receptors. The following mitigation measures are recommended in regard to lighting for the Project (Mine):

- Use luminaires which reduce light spill, sky glow and glare
- Utilise direction lighting wherever possible to reduce light spill
- Minimise security lighting, where practicable, to reduce additional sky glow during night operations

4.1.6.3 Summary of Lighting Impact Assessment

It is expected that the Project (Mine) will result in the moderate illumination of the night sky when viewed from Viewing Locations. All of the receptors are of low sensitivity. It is predicted that night lighting impacts will be of minor significance. No further mitigation is required.

4.2 Topography, Geology and Soils

4.2.1 Introduction

Technical studies have been conducted for the purposes of establishing the existing land values of the Project Area and to enable an impact assessment of the Project (Mine) during construction and operation. In accordance with Section 4.1.2 of the Project ToR these studies assessed topography, geology and soils, mineral resources, resource utilisation and subsidence of the Project Area. Key findings of the following studies have been summarised as part of this section:

- Soils, Pre-mining Land Suitability and Stripping Recommendations report prepared by North Queensland Soils Assessment (NQSA, 2011)
- Mine Waste Acid and Metalliferous Drainage and Dispersive Materials Desktop Assessment prepared by SRK Consulting (2012) including the Initial Laboratory Results Memorandum prepared in February 2012
- Linc Energy, Galilee Project – MDLa 372 In-situ Coal Resource Estimate (November, 2009)

The above studies focussed on the EPC1690 component of the Project (Mine) onsite infrastructure area. Additional studies incorporating the EPC1080 and the Project (Mine) offsite infrastructure area will be undertaken as part of the detailed design of the Project (Mine). Additional soil surveys will be undertaken on these areas prior to commencement of spoil placement and will inform topsoil stripping and management, land suitability and GQAL status. Notwithstanding this, a desktop review of soil types on EPC1080 was carried out and is reported below. EPC1080 and the Project (Mine) offsite infrastructure area have been assessed at a desktop level in this section.

4.2.2 Methodology

To enable an understanding of the existing environment and identify potential Project (Mine) impacts upon topography, geology, soils and mineral resources present within the Project Area, the following methodology was employed:

- Review of the Land System mapping at a scale of 1: 500,000 as contained within the *CSIRO Report, Land Systems of Nogoa – Belyando Area* (Gunn et al, 1967) and the land management units described in the *Desert Uplands: An overview of the Strategic Land Resource Assessment Project, Technical Report* (Lorimer, MS, 2005)

- Undertaking a soil survey in accordance with the Land Suitability Assessment Techniques in the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 2010). The survey consisted of 146 ground observation sites and was undertaken from 15 August 2011 to 22 September 2011 on only the EPC1690 component of the Project Area. No soil survey has been undertaken as yet on the EPC1080 component of the Project Area, however additional surveys will be undertaken as part of the detailed design of the Project (Mine). Additional soil surveys will be undertaken on these areas prior to commencement of spoil placement and will inform topsoil stripping and management, land suitability and GQAL status. Notwithstanding this, a desktop review of soil types on EPC1080 was carried out and is reported below.
- Analysis and description of soil profiles in accordance with the *Australian Soils and Land Survey Field Handbook* (CSIRO, 2009) and grouped in accordance with the *Australian Soil Classification* (CSIRO, 2002)
- Drilling a total of 24 exploration holes within the MDL372 from June 2009 to October 2009. These results were then used to complete a structural geological model and to prepare an in-situ Coal Resource Estimate in accordance with the Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves 2004 (JORC, 2004 Edition) for the Project (Mine)
- The independent Resource estimate based on the drilling up to 2009 as outlined above is the most up to date assessment of Coal Resources within MDL372 (formerly located over the areas of MLA70441). However progressive exploration programs have been conducted in 2010, 2011 and exploration is currently in progress for 2012. The intent of this progressive exploration is to increase overall geological definition and understanding, increase the coal resource base, and provide for sufficient Indicated and Measured JORC compliant Resources suitable for the development of a Bankable Feasibility Study (BFS). Various specialist boreholes have also been drilled to provide relevant mining, geotechnical and hydrogeological information (Table 4-6).
- Review of relevant literature to provide an understanding of the regional geology and undertake an initial assessment of the potential for excavated materials to be dispersive and/or have the potential to produce acid and metalliferous drainage

Table 4-6 Details of Drilling Surveys during 2011 and 2012

Type of Drilling	Number of Holes
2011 Field Season	
Rotary chip holes	67
Partially cored holes	18
Gas content and composition assessment holes	7
Full cored geotechnical holes	10
Piezometer holes	29
Total	**131**

Type of Drilling	Number of Holes
2012 Field Season	
Roatary chip holes	166
Partially cored holes	93
Full cored geotechnical holes	5
Large diameter coal quality holes	1
Line of oxidation holes	39
Piezometer holes	4
Water bores	3
Total	**131**

The methodology employed for the EPC1080 section of the Project (Mine) and the offsite infrastructure area was a desktop assessment of the landscape features in the area including a review of published information regarding soils, geology, topography and agricultural resources within EPC1080 and the offsite infrastructure area that may be impacted by the Project (Mine). This desktop assessment seeks to assist in the identification of soils that have adverse or limiting physical and chemical properties in the topsoil or subsoil profiles.

A review was undertaken of available 1: 100,000 geological maps relevant to the EPC1080 Project (Mine) area. Only half of the north western boundary, of the EPC1080 Project (Mine), essentially the area north of Moray Carmichael Road, has been surveyed at 1: 100,000 scale for geology and the source assessed was the Mount Tutah Geological Map 8154, 1: 100,000 Geological Series (2008).

The review of the local geology assisted in the identification of the soil parent material which is one of the primary drivers of soil type. Contour maps identified the soil type's location in the landscape and associated landform features. A review of existing soil mapping sought to identify the soil types at a district, broad scale level.

A review of available information for the geology of the offsite infrastructure area was undertaken. The resources assessed included:

- Bulliwallah Geological Map 8254, 1: 100,000 Geological Series (2008)
- Mount Tutah Geological Map 8154, 1: 100,000 Geological Series (2008)
- Epping Forest 8253, 1: 100,000 Geological Series (2008)

4.2.3 Description of Environmental Values

4.2.3.1 Topography

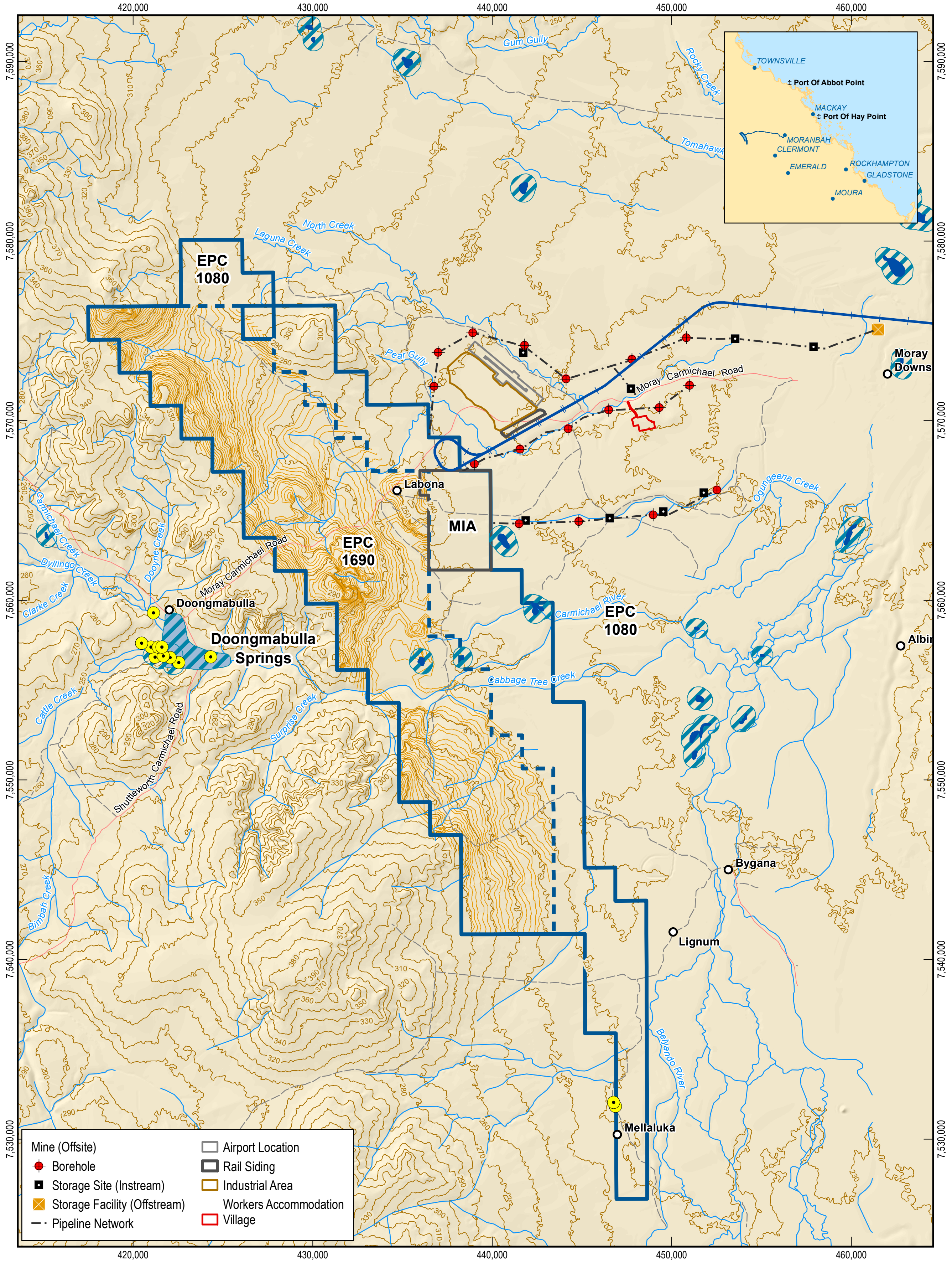
Topography across the EPC1690 section of the Project (Mine) typically slopes towards the east and north-east from a north-west to south-east trending ridge line, west of the EPC1690 boundary and running parallel to it (refer to Figure 4-3). The topographic gradient flattens out in the vicinity of the Carmichael River and in eastern parts of the Project (Mine). Topographically the land traversed by the Project (Mine) over EPC1080 is considered gently undulating with elevation ranging between 270 m to 300 m Australian Height Datum (AHD). In general, the majority of the Project (Mine) EPC1080 area is present in a slope less than 3%. In areas near the crest i.e. 9 km south of the western boundary of the Project (Mine) and along the Carmichael River and other creeks, the slope is greater than 10 per cent, and sometimes records greater than 56 per cent based on the LIDAR information.

The EPC1690 ridge line is bisected by the Carmichael River, which flows west to east through the southern half of the Project (Mine). The natural levee of Carmichael River is about 1 km wide on either side of the river course. The area to the south of the Carmichael River levee is generally flatter compared to the area to the north. A number of tributaries to the west of EPC1690 feed into the Carmichael River including: Surprise Creek, Carmichael Creek, Dingo Creek, Cattle Creek and Dooyne Creek. The river also receives discharge from the Doongmabulla Spring complex. Other ephemeral drainage lines also cross EPC1690, north and south of the Carmichael River, and typically flow towards the east. The Carmichael River is a tributary of the Belyando River, which flows south to north approximately 8 to 10 km to the east of the Project (Mine). Refer to Figure 4-3 for a presentation of the topography plotted at 10 and 20 m contours.

The north-western end of EPC1080 lies at an elevation of 270 m AHD. Elevation increases to the south of the Project (Mine) area, reaching a crest of 300 m AHD before gradually sloping east to 220 m AHD.

The land traversed by the offsite infrastructure area lies within the slope range of 1-3 per cent except for the pockets of land on the western portion of the Project (Mine) area which has a slope greater than 10 per cent. Slope greater than 10 per cent was also observed in areas near creeks and rivers. The slope of the river banks along the Carmichael River is particularly high, ranging from 50-100 per cent.

Elevations at the offsite infrastructure area range between 210 and 230 m AHD. The Project (Mine)'s industrial precinct and airport lie at an elevation of 230 m AHD at the western extent and the topography gently slopes down to 220 m AHD at the eastern extent. The workers accommodation village lies on a flatter plain at 220 m AHD. The water infrastructure traverses a gently sloping landscape extending from 230 m AHD on the western extent to 210 m AHD at the eastern end of the Moray Carmichael road (Figure 4-3).



LEGEND

- Homestead
- Springs
- Local Road
- Track
- Watercourse
- Contour - 2m
- Contour - 10m
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Directory of Important Wetlands
- Great Barrier Reef Wetland Protection Trigger Area
- Great Barrier Reef Wetland Protection Area

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1:300,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Project (Mine) Topography and Key Features

Job Number	41-25215
Revision	B
Date	05-09-2012

Figure: 4-3

G:\41\25215\GIS\Maps\MXD\300_Hydrogeology\41-25215_329_rev_b.mxd Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: Elevation (2011). GBR WPA (2009), DOI Wetlands (2011); DME: EPC 1690 (2010)/EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); EPA - Springs (2005); GHD: Hydrogeology Study Area (2011); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW.

4.2.3.2 Regional Geology

The Project (Mine) is located within the Galilee Basin, which is a Late Carboniferous to Mid-Triassic extensional intracratonic terrestrial basin of predominantly fluvial sediment infill (SRK Consulting, 2012). Galilee Basin covers an area of 247,000 m^2 and is separated from the Bowen Basin to the east by the north-south trending Anakie Inlier (refer to Figure 4-4). In the southern portion of the Galilee Basin, the Late Permian and Triassic sequences merge with the Bowen Basin sequences across the Nebine Ridge, which essentially separates the two basins.

According to SRK Consulting (2012), the Galilee Basin is bisected by the east to west trending Barcaldine Ridge as follows:

- To the north of the ridge the Galilee Basin is further subdivided by the Maneroo Platform and the Beryl Ridge which resulted in the development of a western depression (the Lovelle Depression) and an eastern depression (the Koburra Trough)
- To the south of the ridge the Galilee Basin is subdivided by the Pleasant Creek Arch, into the western Powell Depression and the Springsure Shelf

The dominant structural feature is the Koburra Trough, which on seismic evidence is about 300 km long and reaches depths of approximately 3,000 m (refer to Figure 4-4). SRK Consulting (2012) reports that the maximum known drilled stratigraphic thickness of the Koburra Trough is 2,818 m. , This is the deepest point of the Galilee Basin.

At its north eastern margin, the Galilee Basin adjuncts the older Devonian-Carboniferous Drummond Basin. An outcrop of the Galilee Basin sequences is confined to a linear belt expressed at the surface by a topographic high. This reflects the underlying control of the Mingobar monocline. To the west of this structure, the down-warped sequences towards the axis of the Koburra Trough are obscured beneath extensive cover of the Jurassic-Cretaceous Eromanga Basin. Post-sedimentation inversion of the Mingobar structure is also responsible for the broad shallow westerly dip of the sequences along this margin. The eastern rim on-laps the older Devonian Carboniferous Drummond Basin and is connected to the Bowen Basin in the south east by the Springsure Self, along the north to south trending Nebine Ridge (SRK Consulting, 2012).

The structural style of the Galilee Basin is dominated by a series of inversion structures, which is related to the Hunter-Bowen Orogenic event. The structures of the Galilee Basin are of similar style and orientation to the ones found in the Bowen Basin, although on a much smaller scale (SRK Consulting 2012).

The stratigraphic units which are relevant to the Project (Mine) are the conformable interval between the coal-bearing Colinlea Sandstone-Bandanna Formation and the overlying Rewan Formation with an unconformable and variable veneer of Tertiary sediments, which covers the deposit.

The two geological maps encompassing the offsite infrastructure area and EPC1080 area are Buchanan Sheet SF 55-6 (Olgers, 1970) and Galilee Sheet SF 56-10 (Vine and Doutch, 1972). Most of the area lies across two main tectonic elements i.e. the Drummond Basin and Galilee Basin. Further details are provided on these basins below:

- The Drummond Basin is a large intracratonic basin which developed in Central Queensland between the Late Devonian and the Early Carboniferous. The Drummond Basin in and around the Project (Mine) is characterised by the formations of Bulliwallah, Star of Hope, Raymond and some

- Mount Hall formations consisting largely of the coarse-grained thickly bedded conglomerate quartz sandstone sequence (Olgers, 1970)
- The Galilee Basin is a meridional depression that developed west of the Drummond Basin and received about 8,000 feet of sediment from the Upper Carboniferous to the end of the Triassic. The major feature observed within the Galilee Basin is the Belyando feature which comprises a major lineament along the straight course of Belyando River (Vine and Doutch, 1972). The feature generally separates the Galilee Basin from Drummond Basin rocks and is marked by steep gravity gradients along the Belyando River

Colinlea Sandstone

This sequence comprises of dominantly quartz sandstone and conglomerate with minor shale and a number of low rank sub-bituminous and sub-hydrous coal seams. The Colinlea Sandstone sequence represents fluvial deposition with sandy braided channel and flood plain deposits associated with mire and coal seam development. Three coal seams, namely seams D to F are laterally persistent and correlated regionally.

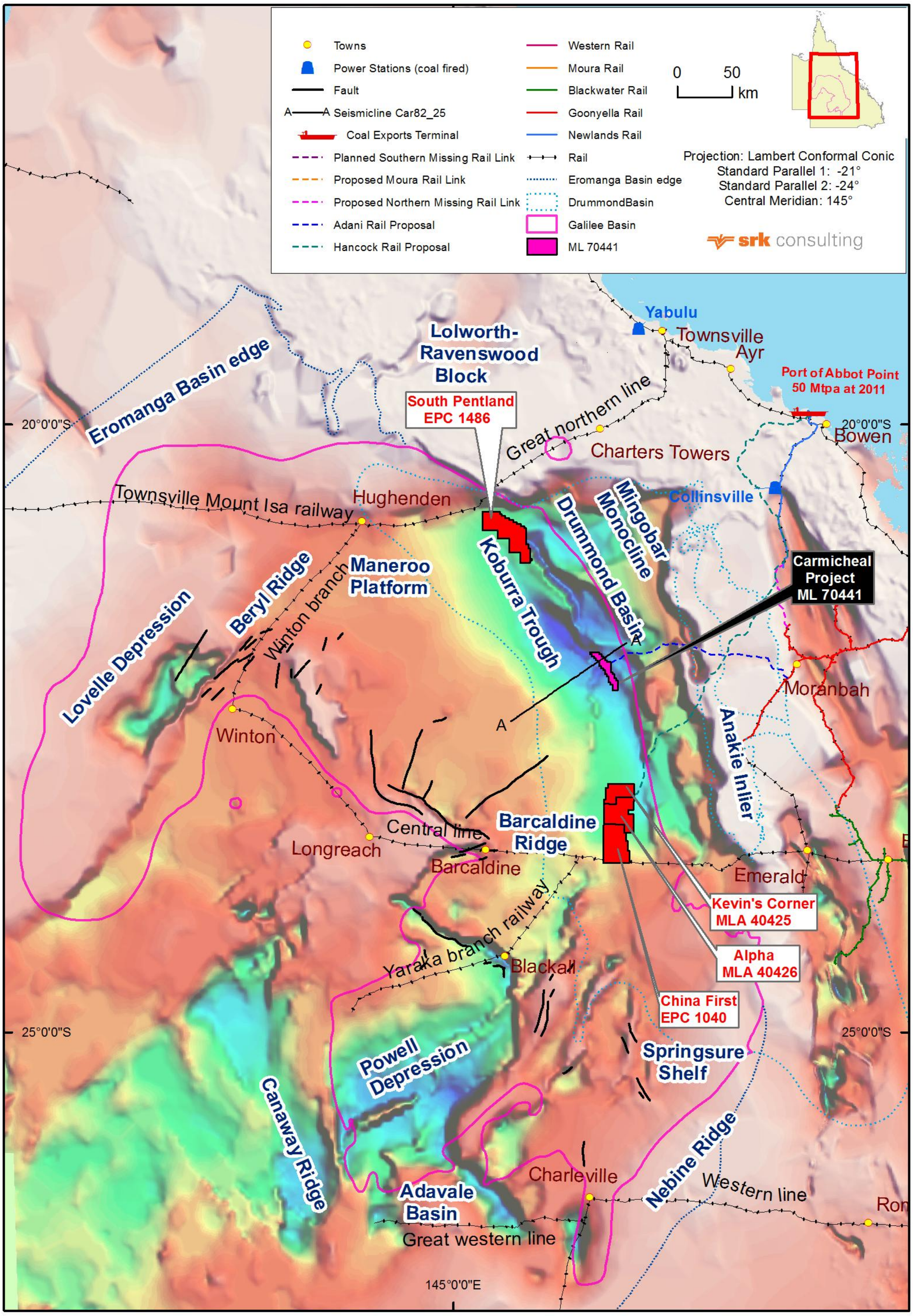
Bandanna Formation

The Bandanna Formation comprises of calcareous, lithic sandstone, siltstone and a number of low rank sub-bituminous and sub-hydrous coal seams. This sequence represents fluvial deposition with sandy braided channel and flood plain deposits associated with mire and coal seam development. Three coal seams, namely seems A, B and C, are laterally present and correlated regionally.

The Rewan Formation

The Rewan Formation comprises of monotonous sequence labile sandstones and multi-coloured argillaceous sediments, which are continuous across the Nebine Ridge and extensive throughout the Bowen and Surat Basins.

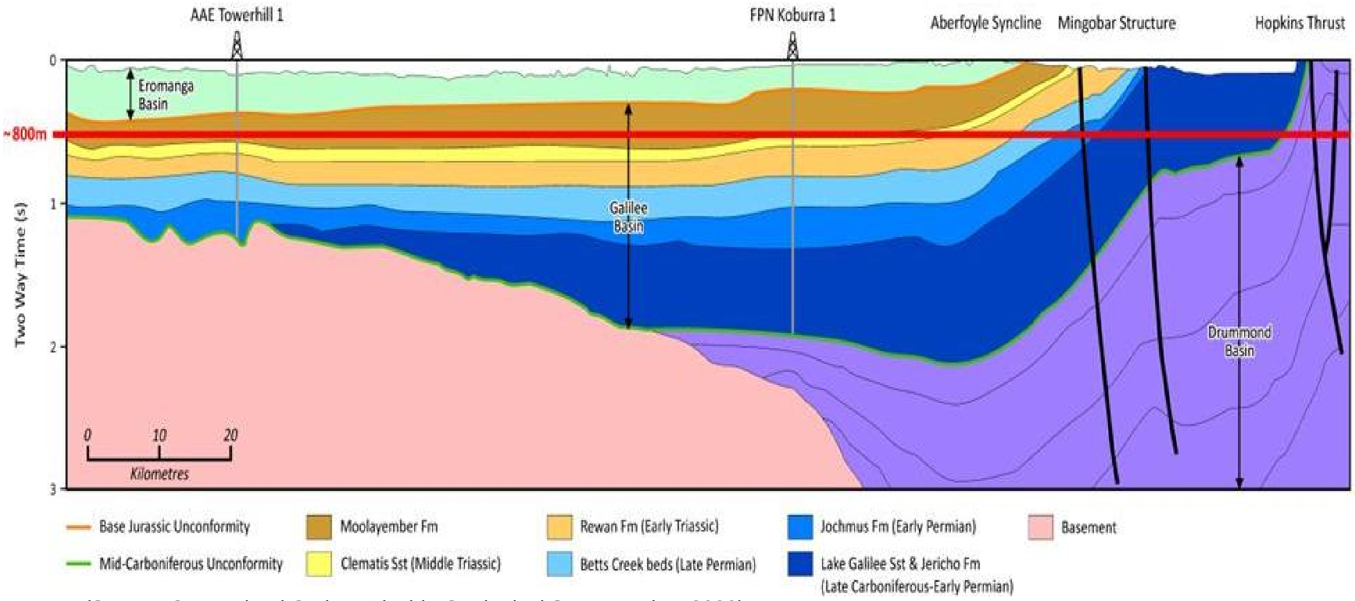
Figure 4-4 Structural Features of the Galilee Basin



Source: SRK Consulting, 2012

According to SRK Consulting (2012) along the eastern margin of the northern Galilee Basin (refer to Figure 4-5), this conformable sequence of stratigraphic units has a consistent regional expression, which means that the paleaogeographic characteristics extend over broad areas. Furthermore, a number of key economic coal seams with similar coal properties, which are hosted within the Colinlea Sandstone/Bandanna Formation interval, can be correlated along the eastern margin of the northern Galilee Basin between a number of deposits. A number of mining projects target this seam group for potential open-cut and underground coal extraction.

Figure 4-5 Schematic of the North Eastern Margin of the Galilee basin



(Source: Queensland Carbon Dioxide Geological Storage Atlas, 2009).

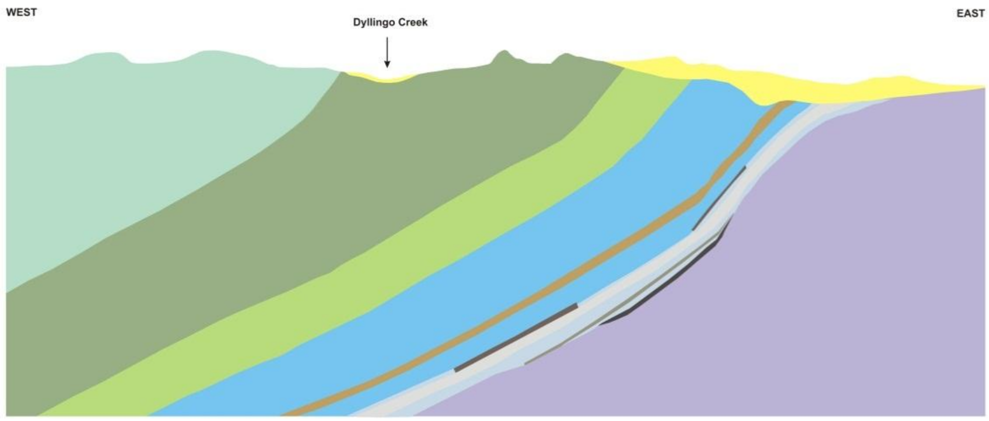
4.2.3.3 Local Geology

Within the area of the proposed Project (Mine), including on- and off-site infrastructure, Tertiary-age strata (i.e. sandstones, mudstones and conglomerates) are mapped at outcrop over much of EPC1690 and are typically in the range 45 to 100 m thick (Xenith Consulting, 2009). Along the Carmichael River and over much of the Belyando River system to the east of EPC1690, these strata are indicated to be overlain by Quaternary-aged floodplain alluvium (i.e. sands, silts, gravels and clays). Beneath much of EPC1690 an unconformity defines the boundary between the Tertiary-age strata and the underlying Late Permian-age coal bearing strata (a sequence of siltstones, mudstones, sandstones, shales and coal of the Bandana Formation and Colinlea Sandstone). Geological cross sections (Geological Survey of Queensland) and modelled cross sections of the geology (GHD, 2010) indicate that the Late Permian-age strata dip at approximately 2-4° to the west, steepening slightly in the southern half of the lease.

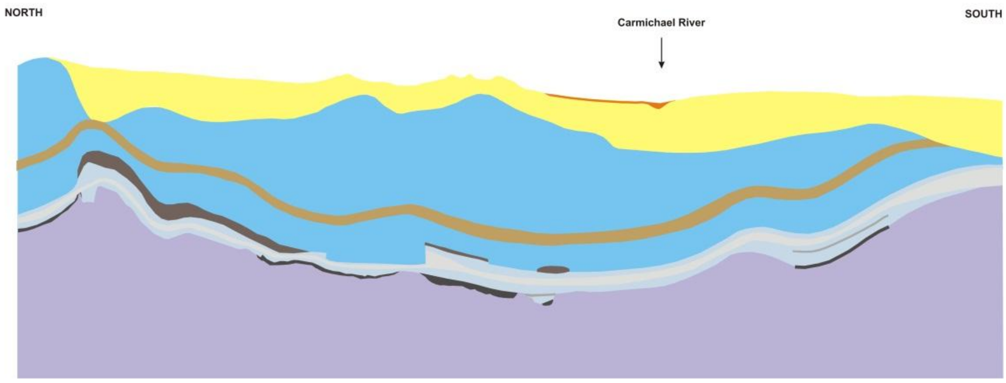
Along the western margins of EPC1690, a sequence of Triassic-age strata forms an angular unconformity with the overlying Tertiary-age strata and is mapped at outcrop as the Dunda Beds (predominantly sandstone). The Rewan Group (mudstone and sandstone) underlies the Dunda Beds, as shown in Figure 4-6, (developed based on the Xenith geological model dated 26 October 2011) and overlies the Late Permian-age strata. It has been reported that a fault has been interpreted through the middle of the lease but requires further drilling to confirm (Xenith Consulting, 2009).

The stratigraphic column (excluding the Triassic-age strata) is summarised in Figure 4-7, from the Carmichael Macro-Conceptual Mine Study (Runge, 2011). A cross section of the solid geology of the Project (Mine) is depicted in Figure 4-6. Published 1: 250,000 scale geological mapping is shown in Figure 4-8. Available digital geological mapping is shown in Figure 4-9 and Figure 4-10. Figure 4-11 provides further information on each of the units mapped at outcrop.

Figure 4-6 Cross-section of Project Area Geology



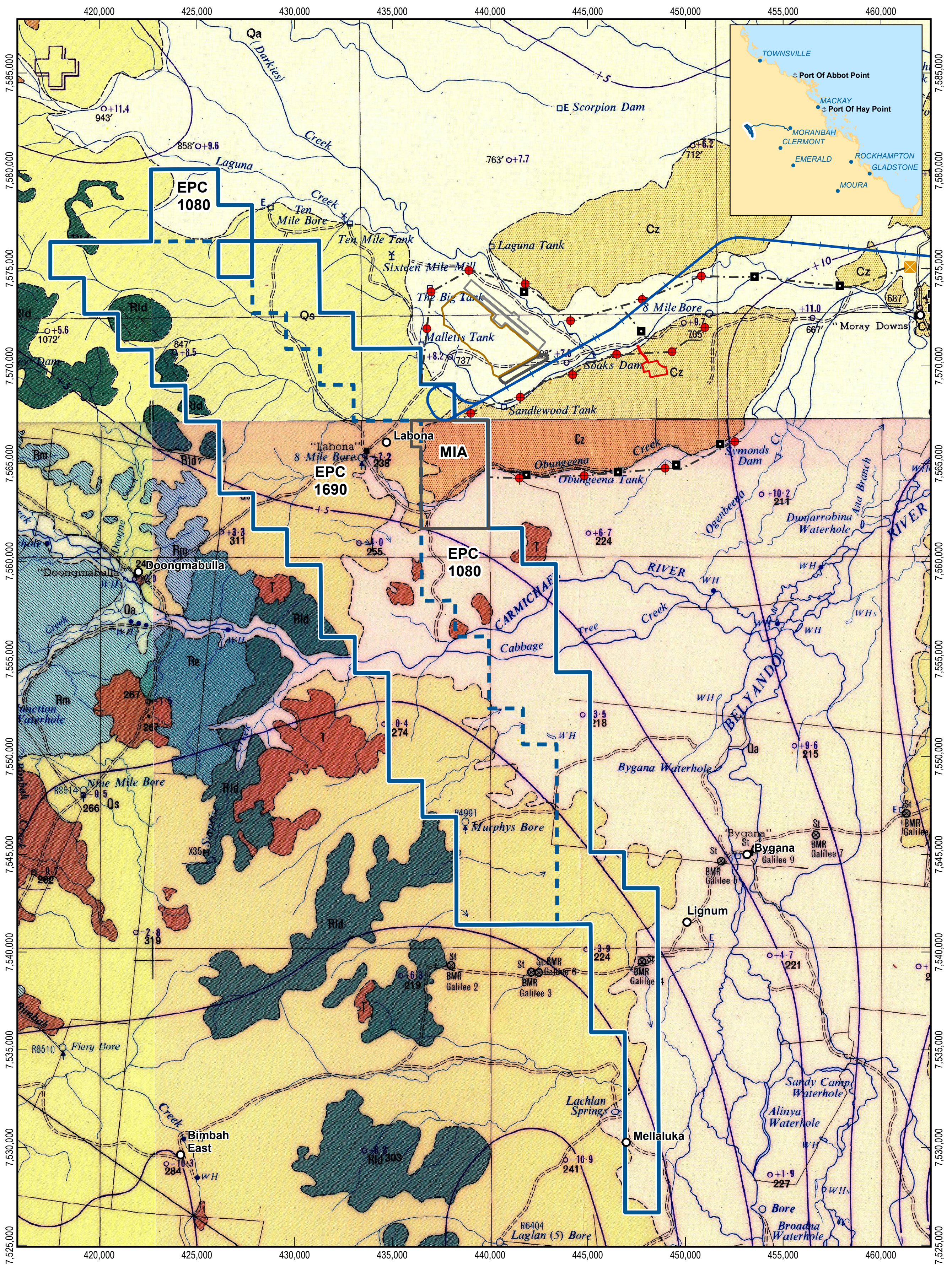
The west-east section, cut through EPC1690 and part of EPC1080



The north-south section, cut through EPC1690

Figure 4-7 Stratigraphic Column

Age		Lithology	Stratigraphy	Thickness
Tertiary		Clays / Mudstones		40 - 100m
Triassic		Mudstone / Siltstone	Rewan Formation	
Late Permian		Sandstone	Bandanna Formation	
		COAL - AB Seam		12 - 18m Resource Seam
		Sandstone / Siltstone		10m
		COAL - B splits		1 - 2m
		Siltstone / Mudstone		60 - 70m
		COAL - C Seam (carbonaceous)		3 - 4m
		Siltstone / Sandstone	Colinlea Sandstone	2 - 20m
		COAL - D1 Seam		4 - 6m Resource Seam
		Sandstone		5 - 30m
		COAL D2/D3 Seam		8 - 10m Resource Seam
		Siltstone / Mudstone		10 - 20m
		COAL - E Seam		1 - 3m Resource Seam
		Sandstone / Siltstone		5 - 10m
		COAL - F Seam		1 - 5m Resource Seam
Early Permian		Sandstone		



LEGEND

- Homestead
- Local Road
- Track
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area

Mine (Offsite)

- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

Refer to Figure 4-5 for the legend to the geology mapping

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1:275,000 (at A4)

0 1 2 3 4 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Mapped Geology
(1:250,000)

Job Number	41-25215
Revision	B
Date	05-09-2012

Figure 4-8

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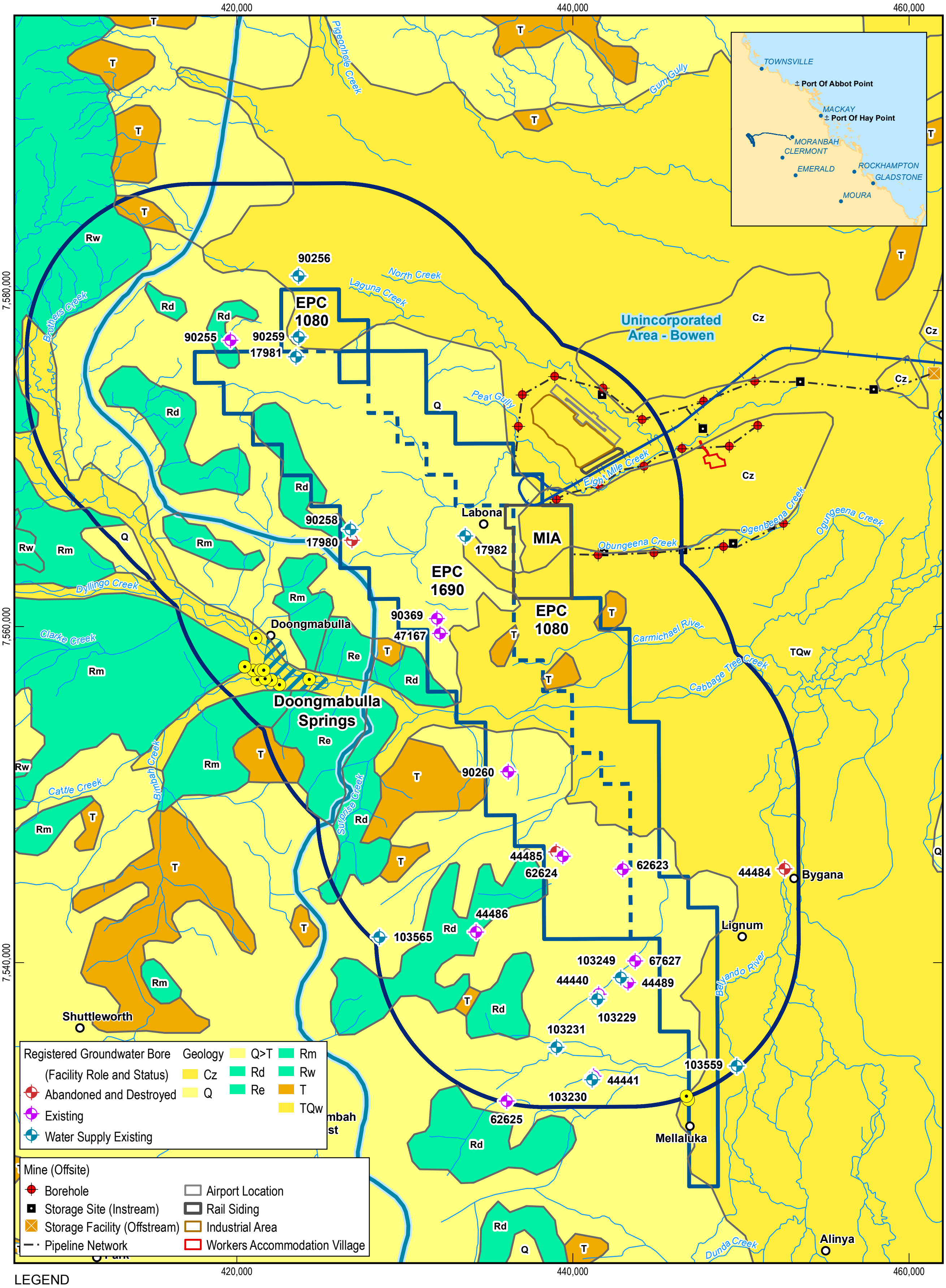
Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: Mapped Geology 250k (2008),EPC 1690 (2010)/EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA



LEGEND

- Homestead
- Springs
- Watercourse

Structure
- Anticline
- Fault
- Geological Boundary

- Joint Pattern
- Monocline
- Syncline
- Trend Line

- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area

- Hydrogeology Study Area
- Groundwater Management Unit boundary
- Directory of Important Wetlands

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Refer to Figure 4-5 for the legend to the geology mapping

1:325,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision B
Date 05-09-2012

Published Digital Mapped Geology and Registered Groundwater Bores

Figure 4-9

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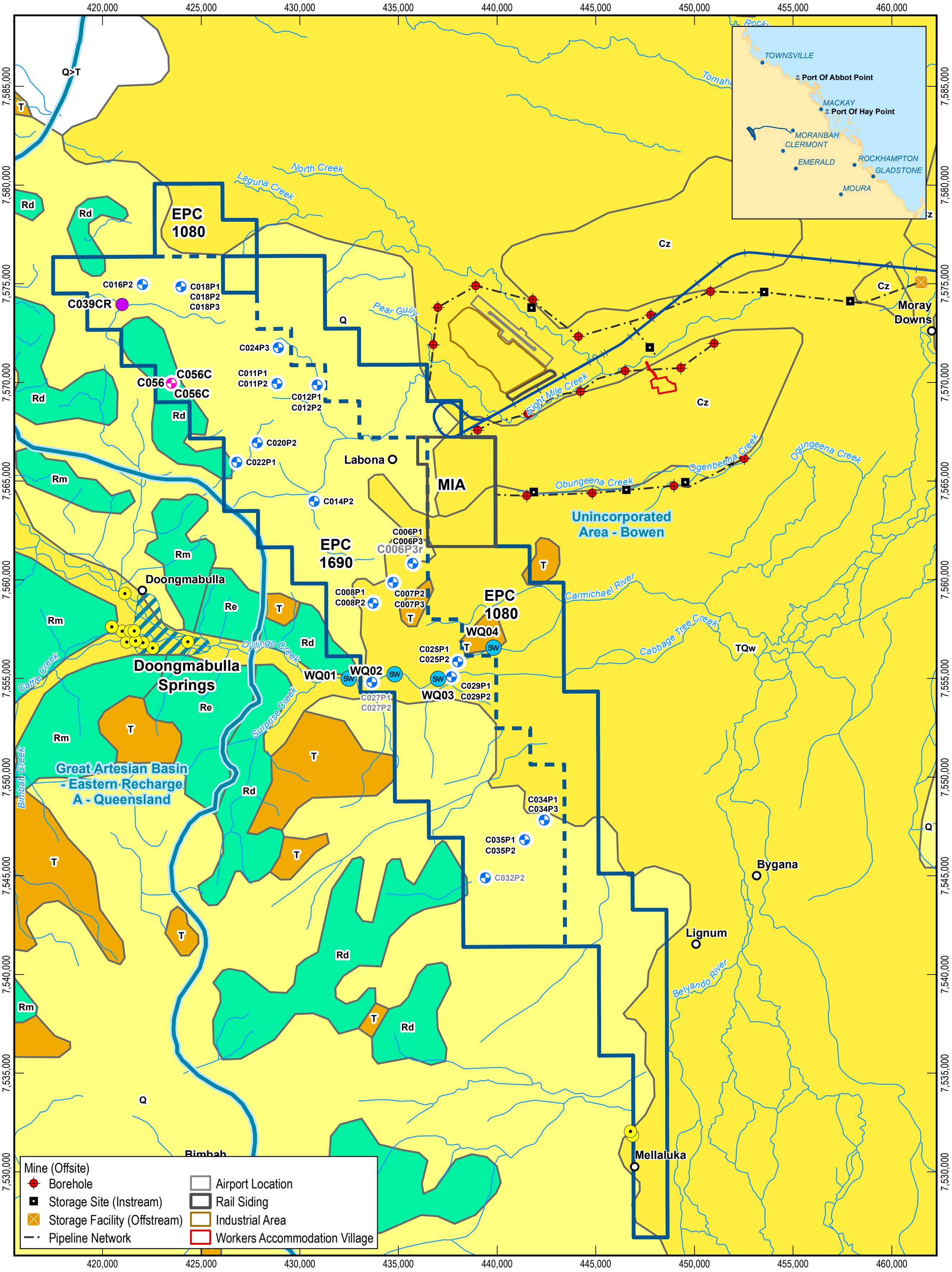
Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: Registered Groundwater Bores (2010), DOI Wetlands (2011); DME: Regional Geology 1:1000000 (2004), EPC 1690 (2010),EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Watercourse (2007); BRS: Groundwater Management Unit Boundary (2009); EPA - Springs (2005); GHD: Hydrogeology Study Area (2011); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA



LEGEND

- Homestead
- Surface Water Quality Monitoring
- Groundwater Monitoring Bore (Surveyed)
- Groundwater Monitoring Bore (GPS Survey Only)
- Vibrating Wire Piezometer, Packer Testing
- Packer Testing
- Springs
- Watercourse
- Rail (West)
- Directory of Important Wetlands
- Mine (Onsite)
- Mine Infrastructure Area

Structure: Anticline, Fault, Geological Boundary, Joint Pattern, Monocline, Syncline, Trend Line

Geology: Cz, Q, Rd, Re, Rm, T, TQw

Refer to Figure 4-5 for the legend to the geology mapping

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1:275,000 (at A4)

0 1 2 3 4 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Published Digital Mapped Geology and Monitoring/Test Locations

Job Number	41-25215
Revision	B
Date	05-09-2012

Figure 4-10

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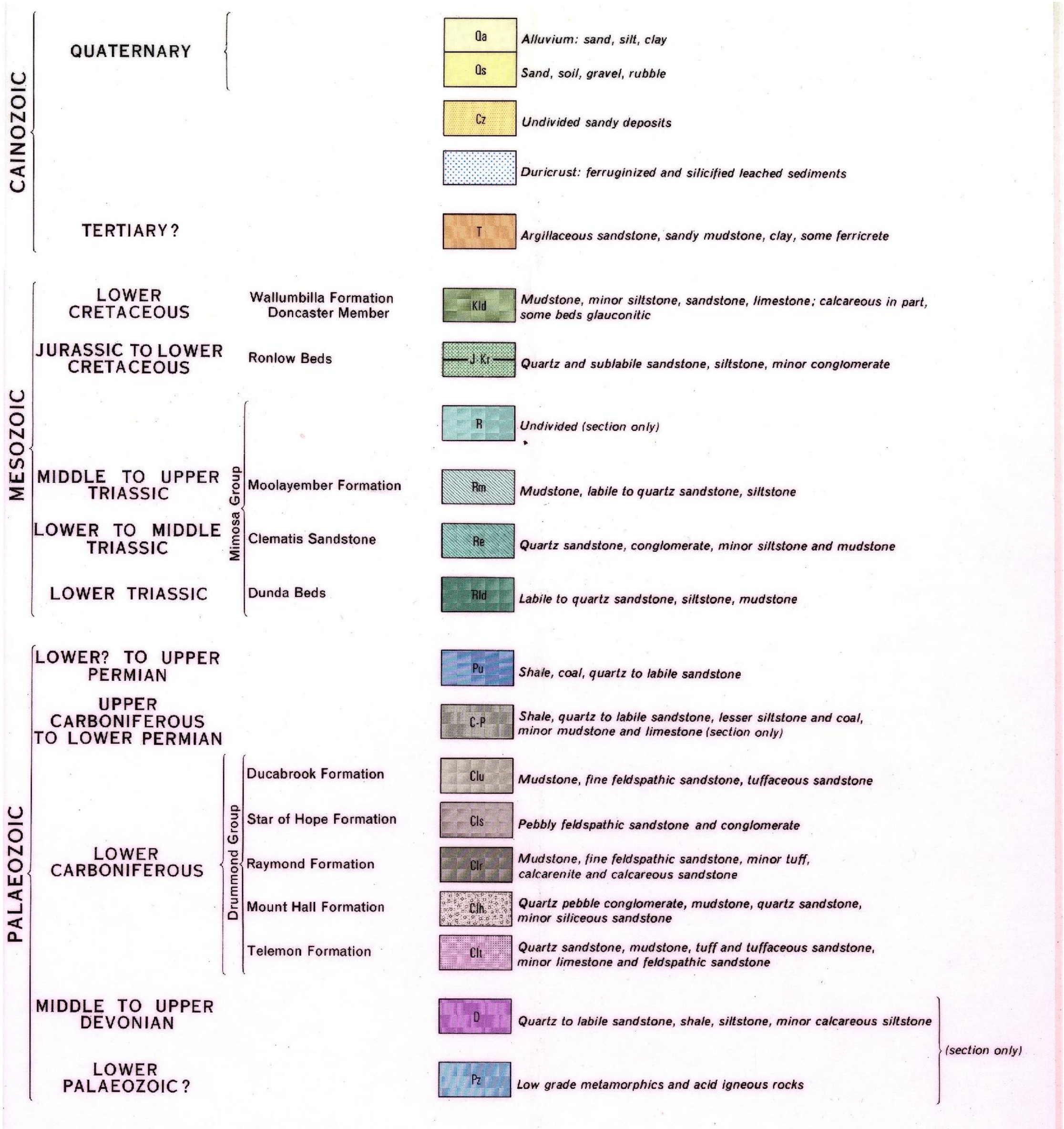
Data Source: DERM: Registered Groundwater Bores (2010),DOI Wetlands (2011); DME: EPC1690 (2010)/EPC1080 (2011), Regional Geology 1:1,000,000 (2004); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Watercourse (2007); BRS: GMU Boundary (2009); EPA - Springs (2005); GHD: Hydrogeology Study Area, Groundwater Monitoring Bores,Test Locations (2011); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

1:250,000 North Eromanga Regional Geology Symbol Key

Geology Unit	Formation	Age	Lithology Summary
Cz		CAINOZOIC	Sand, silt, gravel: alluvial, colluvial and residual
Q		QUATERNARY	Alluvium of older flood plains, sand, gravel, soil
Q>Rw	Warang Sandstone	QUATERNARY	Alluvium of older flood plains, sand, gravel, soil
Q>T		QUATERNARY	Alluvium of older flood plains, sand, gravel, soil
TQw	Woondoola beds	TERTIARY - QUATERNARY	Silt, clay, sandy clay; minor sand and gravel; fluvial
T		TERTIARY	Quartzose sandstone, conglomerate, siltstone
Rw	Warang Sandstone	TRIASSIC	Kaolinitic quartz sandstone, conglomerate, variegated mudstone and siltstone
Rm	Moolayember Formation	TRIASSIC	Micaceous lithic sandstone, micaceous siltstone
Re	Clematis Sandstone	TRIASSIC	Medium to coarse-grained quartzose to sublabile, micaceous sandstone, siltstone, mudstone and granule to pebble conglomerate
Rd	Dunda beds	EARLY TRIASSIC	Lithic to quartzose sandstone, siltstone, mudstone
Cb	Bulliwallah Formation	CARBONIFEROUS	Fine to medium feldspathic quartz sandstone; minor olive mudstone, pebbly feldspathic quartz sandstone and algal limestone; poorly preserved plant fossils
Cu	Ducabrook Formation	CARBONIFEROUS	Feldspatholithic sandstone, mudstone, siltstone (commonly tuffaceous), minor algal and oolitic limestone
Cs	Star of Hope Formation	CARBONIFEROUS	Lithic conglomerate, feldspatholithic sandstone, rhyolitic to dacitic ignimbrite and flows, tuffaceous siltstone and rare sinter
Cr	Raymond Sandstone	CARBONIFEROUS	Flaggy quartzose sandstone, siltstone and minor limestone
Ch	Mount Hall Formation	CARBONIFEROUS	Quartzose to feldspathic sublabile sandstone, quartz-pebble conglomerate, mudstone and red siltstone
Cn	Natal Formation	CARBONIFEROUS	Alternating fine feldspathic quartz sandstone and olive siltstone; poorly preserved plant fossils

1:250,000 Mapped Geology Symbol Key



NOTE

Geological unit descriptions are limited to those shown in the map extent.
Additional geological units not described here may be present in surrounding areas.

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GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision B
Date 05-09-2012

Geology Index Sheet

Figure 4-11

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Data Source: DME: Regional Geology 250K (2007). Created by: BW, CA

4.2.3.4 Soils

Overview

A review of the existing land system and land unit data of the Nogoa-Belyando Area (Gunn et al, 1967) and land management units identified within Lorimer, MS 2005, *The Desert Uplands: An Overview of the Strategic Land Resource Assessment Project, Technical Report* was undertaken for EPC1690, EPC1080 and the offsite infrastructure area.

In accordance with Section 4.1.2 of the Project ToR, a soil survey for EPC1690 has been undertaken at a scale of 1:100 000 following the standards of the *Land Suitability Assessment Techniques in the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 2010).* The key findings are presented in the following paragraphs. Refer to Volume 4 Appendix L for the full Mine Soils Assessment Report.

The field survey was undertaken from August 2011 to September 2011 and did not include the EPC1080 component of the Project (Mine) onsite infrastructure area or the Project (Mine) offsite infrastructure area. Additional soil surveys will be undertaken on these areas prior to commencement of spoil placement and will inform topsoil stripping and management, land suitability and GQAL status. Notwithstanding this, a desk top review of soil types on EPC1080 was carried out and is reported below.

Existing Soils Mapping - EPC1690

The *Land Systems of Nogoa – Belyando area* (Gunn et al, 1967) shows ten Land Systems within the EPC1690 area. These are:

- Durrandella (Du), Lenox (Le), Ronlow (Rn) and Tichbourne (Ti) which are described as hills, uplands, scarps or breakaways; shallow rocky soils and red and yellow earths; with bendee, lancewood scrub, silver-leafed ironbark woodland or yellow-jack woodland over eastern spinifex and /or eastern min-height grass or arid scrub grass
- Degulla (De) described as extensive, stabilised low-gradient fans; uniform coarse-textured soils and yellow earths
- Humboldt (Hu), Islay (I) and Blackwater (Bl) which are described as brigalow, gidgee and blackwood scrubs on plains and lowlands; acid to alkaline clay and cracking clay soils with minor texture-contrast soils
- Alpha (Al) described as higher alluvial plains and terraces, not extensively flooded - alluvial soils, red earths, texture-contrast soils and cracking clay soils; poplar box woodland over eastern mid-height grass

The review also indicated the following:

- Carmichael River levee within the EPC1690 area as deep, texture contrast soils with thick, sandy surface soils
- Areas to the north of Carmichael River as dominantly Yellow earths. On the western edge deep, texture-contrast soils with thin sandy or loamy surface occur, while on the eastern edge shallow, rocky soils occur. There is also an area of uniform coarse-textured soils mapped in the north-eastern corner

- Areas to the south of Carmichael River mapped as dominantly Yellow earths with deep texture contrast soils with thin sandy or loamy surface soils. There are also areas of Red Earths

Results of the medium intensity survey undertaken for the EPC1690 area are in general agreement with the Land Systems and Soils map of Gunn et al (1967) mentioned above.

The majority of the EPC1690 area is occupied by Yellow Earths (using the older soils terminology to be consistent with the Gunn et al 1967 report or Yellow or Brown Kandosols and Yellow-Orthic and Brown-Orthic Tenosols using the ASC (Isbell, 2002)) with the Carmichael River levee dominated by soils with thick sandy surfaces. There are some differences between both soil maps, given the differences in map scales.

The Desert Uplands: An Overview of the Strategic Land Resource Assessment Project, Technical Report (Lorimer MS, 2005) was also reviewed. The Lorimer (2005) report has defined a second set of Land Systems, unique to that report. Four of these Land Systems have been mapped at the medium intensity 1: 100,000 scale over the EPC1690 area. The following briefly describes the land systems, detailed in the Lorimer (2005) report, that are mapped within EPC1690.

Beenboona Land System (BB) occupies the majority of the EPC1690 area both north and south of Carmichael River. The geomorphology is described as alluvial fans formed by creeks emerging from the Peneplain of the Desert Uplands. This alluvium has very high fine sand content due to its source and weathered sandstone underlies the lateritic hardpan. A range of alluvial soils characterise this land system. Silver-leaved ironbark and Reid River box communities dominate this land system.

The Land units of the BB Land System mapped within the area include BB1, BB2, BB3 and BB4.

Very large contiguous units of BB1 are mapped in the south and north of the EPC1690 area, with minor areas of BB2 and BB3, while BB4 occupies the entire area of the Carmichael River levee. BB1 has a generalised soil description of a texture-contrast soil profile with medium, non-gravelly, sandy loam topsoil overlying yellow, sandy clay and an ironstone hardpan between 0.5–1.0 m. It is correctly classified as a Yellow Chromosol (using ASC terminology).

Generalised soil description of BB2 is a reddish yellow, sandy clay loam gradually increasing in clay content to yellow, light clay. It was classified as a Red Kandosol but the soil description indicated more likely to be a Yellow or Brown Kandosol. Land Unit BB3 has a generalised soil description as a deep, uniform sand profile, with loose sandy topsoil and classified as a Tenosol but the soil description indicated a Red Kandosol. Generalised soil description of BB4 is a uniform sandy profile with minimal profile development other than an accumulation of organic matter in the sandy loam topsoil. It is classified as a Tenosol but the soil description provided would be better classified as a Rudosol.

Plain Creek Land System (Pk) represents the steep hill landform and folded bedrock normally found in the adjacent Brigalow bioregion. Vegetation is described as Narrow-leaved and Silver-leaved Ironbark, Ghost Gum and Reid River box. One Land Unit, Pk3 of the Pk Land System protrudes into the area around Labona Homestead and smaller areas to the south along the eastern boundary of EPC1690. Generalised soil description of Unit Pk3 is a texture-contrast soil profile with a thick dark brown sandy clay loam topsoil and bleached A2 horizon overlying brown light medium clay. It is classified as a brown Sodosol, but no data is provided on the level of sodicity or salinity within the soil profile. This mapping is at odds with the CSIRO Land Systems mapping and the results of the medium intensity soil survey undertaken as part of this EIS.

Northern Plateau Land System (NP) represents an undulating landscape of low rises, moderate slopes and drainage depressions located in the central part of the Desert Uplands bioregion.

Vegetation on NP includes Silver-leaved Ironbark, scrubland of acacia-melaleuca species including isolated Applejack, Lancewood, Normanton Box, Reid River box and River red gum. Three Land Units NP1, NP2 and NP3 are mapped over the EPC1690 area.

Generalised soil description of NP1 is a shallow, texture-contrast soil profile with medium sandy loam topsoil over brown, sodic sandy clay with a hardpan at depth of approximately 0.5 m. It is classified as a Brown Chromosol, but this classification does not match the soil description provided. No information is provided on the level of sodicity or salinity in the subsoil. Land Unit NP2 has a generalised soil description as a dark reddish brown sandy clay loam topsoil gradually increasing in clay content to red, light clay subsoil. It is correctly classified as a Red Kandosol. Generalised soil description of NP3 is a texture-contrast soil profile with thick sandy loam topsoil over brownish yellow, sodic clay with an ironstone hardpan at approximately 2 m depth. It is classified as a Yellow Chromosol, which does not appear to match the soil description. No information is provided on the level of sodicity or salinity in the subsoil.

Willandspey Land System (Wy) is characterised by an extensive plain of deep, grey and red-brown clay soils, part of the Brigalow belt bioregion. The deep clay soils have developed from the fine colloidal sediment deposited on the bed of an extensive lake system. Vegetation includes Ironbark, Box and Ghost Gum on the crests and upper hillslopes and Brigalow and Gidgee on the gentle slopes and plains. One Land Unit WY4 protrudes into the eastern boundary of the EPC1690 area to the south of Labona homestead and extends to the levee of Carmichael River. Generalised soil description of WY4 is young sandy deposits, of variable depth, overlie uniform clay soils. Soil classification was not provided, but the soil description most likely is within the range of a Rudosol. The special features noted with WY4 include constantly changing channel systems and active processes of deposition and erosion which occur on this seasonally flooded landscape.

One very minor unit of Land Unit DT2 from the Desert Land System is found in the north-western corner of the EPC1690 area. There is some broad agreement between the description of some Land Types from the Lorimer (2005) report and the soils identified during the medium intensity soil survey conducted during this investigation. Both Lorimer (2005) and this report note the high fine sand content of most soils of the EPC1690 area.

However, there are only minor similarities between the mapped distribution of soils and Land Types from the Lorimer (2005) report and the soils mapped in this report. The correlation between both soil maps is far less than what is expected between soil maps of the same or similar scales.

Review of Soils Mapping EPC1080 and Offsite Infrastructure Area

The Desert Uplands Strategic Land Resource Assessment Database (Lorimer, M.S. 2005) has defined six land systems mapped at the medium intensity 1: 100 000 scale predominantly representing the EPC1080 mine area and the three offsite infrastructure areas except for certain parts of the workers accommodation village and water infrastructure which is captured within the Gunn et al (1967) report. The land systems for the EPC1080 mine area and the offsite infrastructure are identified in Table 4-7 and Table 4-8 respectively and brief descriptions have been extracted from the Lorimer (2005) report and detailed below. The extent of the Land systems is shown in Figure 4-12.

Table 4-7 EPC1080 Section –Lorimer MS (2005) Mapped Land Systems

Land System	Land Unit
Willandspey	WY1, WY2, WY3, WY4
Beenboona	BB1, BB2, BB3, BB4
Plain Creek	PK3, PK4
Belyando River	BR1
Northern Plateau	NP2, NP3
Badlands	BD1, BD2

A general discussion on the additional land units present within the EPC1080, not present within the EPC1690 is provided below.

The Badlands land system represents the central section of 'actively eroding' escarpments in the Desert Uplands bioregion. The eastern and western escarpments, together with numerous "jump-ups" throughout the intervening area, are, on a geological time scale, actively eroding. There is a clear sequence of soil vegetation associations beginning at the narrow rim of the scarp, where shallow, red gradational soils support a sparse vegetation of Normanton box, bush house paperbark and spinifex (BD1). The steep scarps, with exposed laterite and numerous boulders, associate with dense woodlands of lancewood and bendee (BD2), whereas the foot slopes have a mixture of soil types ranging from shallow gradational profiles to deep uniform sandy profiles. The seasonal flood regime and presence of waterholes adds to the importance of these riparian zones for biodiversity and habitat values.

In general the soils of the land system is characterised by shallow, red gradational and texture-contrast soils, with an ironstone hardpan within 0.5 m of the surface. The soils are also described to be deep uniform sandy profiles; and shallow, reddish-brown, gradational soils with or without structured clay subsoils. Yellowish-brown, texture-contrast profiles with sodic subsoils. Uniform sandy and silty loam profiles of variable depth.

This Belyando land system represents the Belyando River floodplain between "Forrester" and "Bulliwallah" - a distance of approximately 140 km. Within the broad riparian zone, four land units are apparent, one of these land units is traversed by the proposed Mine corridor being the actual streambeds and channels (BR1). This land unit represents the clayey backplains of the Belyando river. Brown or grey Vertosols (uniform-textured cracking-clay profiles) predominate and support woodlands dominated by Acacia harpophylla (brigalow), with some Eucalyptus coolabah (coolabah) and E. cambageana (blackbutt). After big floods these areas can remain inundated with water for extended periods of time. The same land units within EPC1690 and EPC1080 are also mapped as present within offside infrastructure area.

Table 4-8 Offsite Infrastructure Area Lorimer MS (2005) Mapped Land Systems

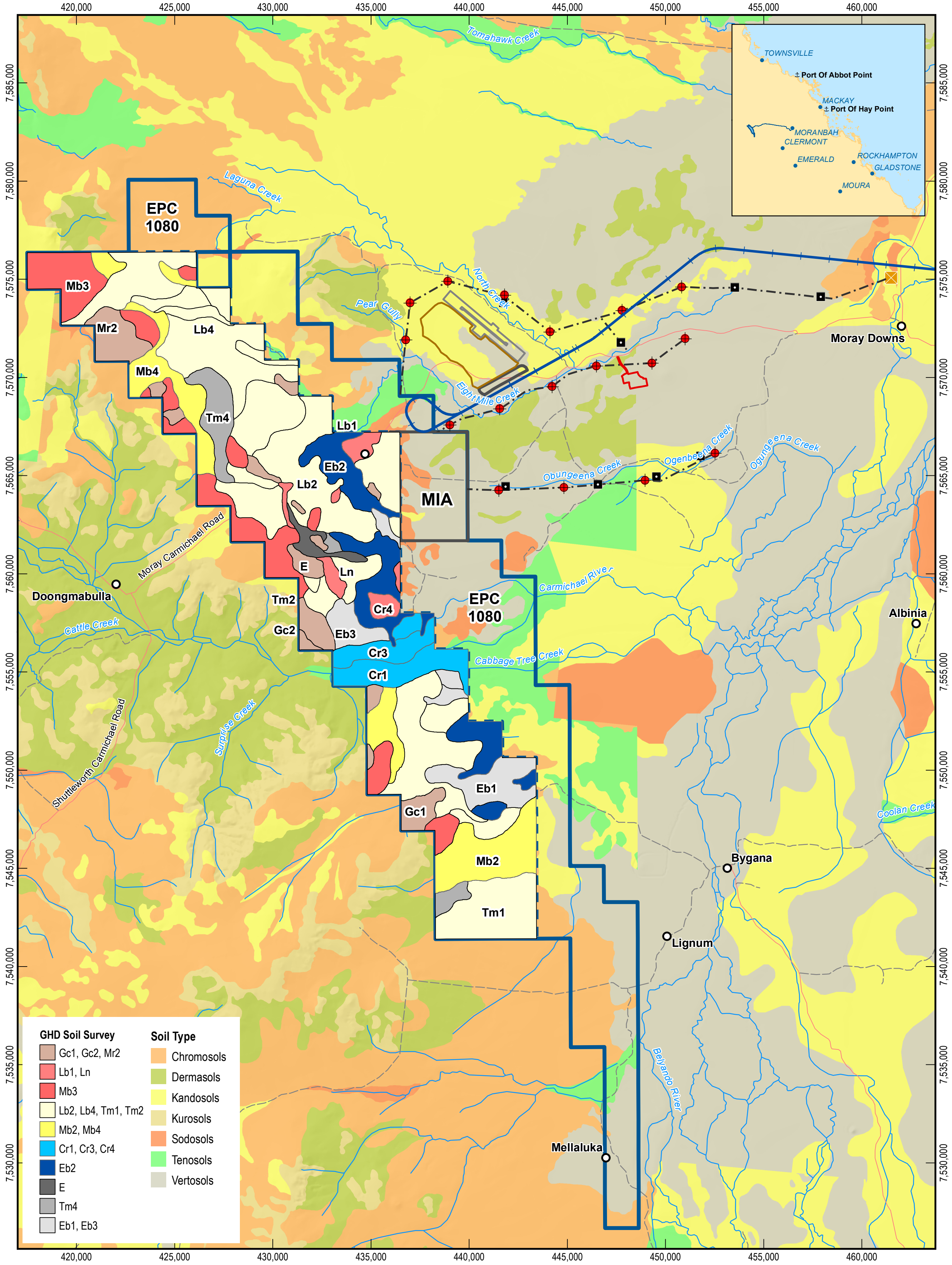
Offsite Infrastructure	Land System	Land Unit
Workers accommodation village	Willandspey	WY1, WY2

Offsite Infrastructure	Land System	Land Unit
Industrial precinct and airport	Willandspey	WY3
	Beenboona	BB2
Water supply infrastructure	Willandspey	WY1, WY2, WY3, WY4
	Beenboona	BB3
	Plain Creek	PK3
	Bulliwallah	BH1, BH2
	Belyando River	BR4

Dominant Soil Orders EPC1080 and Offsite Infrastructure Area

A review of available broad scale soil types, and available literature, has identified the soil types mapped as present within the vicinity of the Project (Mine) and shown in Figure 4-12. These are described below using the Australian Soil Classification (ASC) (Isbell, 2002) and are based on the findings from review of the Lorimer (2005) report (published at a scale of 1: 100,000).

- Vertosols - Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates. Although many soils exhibit gilgai microrelief, this feature is not used in their definition. Vertosols are mapped as dominating the landscape in the Project (Mine) area
- Kandosols – The Kandosols soil order accommodates soils with weak or massive sub-soil structure, a clay content of greater than 15 per cent in the B horizon, no strong texture contrast and no carbonate throughout the profile
- Dermosols – Distinguished by their moderate to strong structured B2 (sub – soil) horizon and the lack of a strong texture contrast between the A and B horizons. These soils are not high in free iron (<5 per cent), nor are they calcareous throughout the profile. Dermosols are a diverse order, bringing together a wide range of soils with some common important properties
- Chromosols – The essential feature of Chromosols is the strong texture contrast between the A and B horizons. They are distinguished from other texture contrast soils by not being strongly acidic (Kurosols) or sodic (Sodosols) in their upper B horizon. In their natural condition, these soils may have favourable physical and chemical properties but many now have hardsetting surface layers with structural degradation caused by long term cultivation
- Sodosols – Sodosols are soils with a strong texture contrast between A horizons and sodic B horizons and which are not strongly acid
- Kurosols – Kurosols are soils with strong texture contrast between A horizons and strongly acid B horizons. Many of these soils have some unusual subsoil chemical features such as high in magnesium, sodium and aluminium
- Tenosols – Tenosols include soils that are generally with weak pedologic organisation apart from the A horizons. It encompasses a rather diverse range of soils, which are nevertheless widespread in many parts of Australia



LEGEND

Homestead	Rail (West)	Mine (Offsite)	Airport Location
Local Road	Mine (Onsite)	Borehole	Rail Siding
Track	Mine Infrastructure Area	Storage Site (Instream)	Industrial Area
Watercourse		Storage Facility (Offstream)	Workers Accommodation Village
		Pipeline Network	

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision B
Date 17-10-2012

Soil Types

Figure: 4-12

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Data Source: DERM: Combined Soils (2010); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007);
GHD: Disturbance Footprint, Soil Survey (2011); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, MS

Soil Survey Findings EPC1690

The medium intensity scale soil survey involved recording of soil and land features at 146 ground observation sites, excavation of 122 soil cores to the depth of underlying rock or pan and excavation of soil profiles via soil-coring equipment. Sampling at 146 ground observation sites within the 26,015 ha of the EPC1690 or 1 per 178 ha is well within the standards required for a 1: 100 000 scale mapping project (Reid, 1988).

The number of extracted soil cores formed 84 per cent of the total number of ground observation sites, with 10 "check sites"' where soil and land features as well as brief soil notes were recorded (6 per cent of the total). The soil cores were 50 mm in diameter, with most profiles examined to the depth of 1.8 m or underlying rock or hardpan. The soil profile was described from pits or exposures at 8 ground observation sites (4 per cent of total) and from 6 hand auger excavations (6 per cent of the total) where the soil was rocky and obviously very shallow or where vehicle access was difficult. These statistics are well within the standards for a medium intensity (1: 100 000 scale) soil survey (Reid, 1988). Some soil profiles were recorded from fresh pits recently excavated for geological sampling purposes.

A total of 19 soils have been identified within EPC1690, based on geology, landform, native vegetation and soil profile features. Soil profile morphology such as depth to underlying rock, texture, colour and structure were used to delineate and classify the soils based on ASC. These soils could not be directly correlated with the soils defined within the CSIRO Land Systems (Gunn et al, 1967) as these earlier descriptions are too broad to define the soil differences identified and mapped.

Soils were given a symbol based on two letters representing major topographical features of the EPC1690 area, followed by a number to delineate the soils identified. For example, the symbol *Cr* represents soils formed on the recent alluvium from Carmichael River, and the numbers 1, 3 and 4 delineate the three soils identified and mapped within that alluvium. Other symbols used include Gc (Gregors Corner), Tm (Ten mile bore), Lb (Labona), Ln (Lignum road), Eb (Boundary Road) and Mb (Murphies bore). The physical extent of the soils, as mapped at the medium intensity 1: 100 000 scale, is depicted in Figure 4-13 with a description including Vegetation and ASC provided in Table 4-9.

Table 4-9 Soil Types

Soil Types	Vegetation	Australian Soil Classification	Area
Soils with sandstone < 1.5 m on Dunda beds (Geology Rld)			
Gc1 Very shallow (<0.25 m), gravelly, acid to neutral, brown loam to clay loam	Eucalypts	Leptic Rudosol	849
Gc2 Shallow to moderately deep (0.25–1.0 m), gravelly, acid to neutral, bleached loam to clay loam	Eucalypts	Bleached-Leptic Tenosol	353
Lb1 Moderately deep (0.5–1.0 m) acid to neutral soil with moderately thick loamy surface grading to red,	Eucalypts	Red Kandosol	423

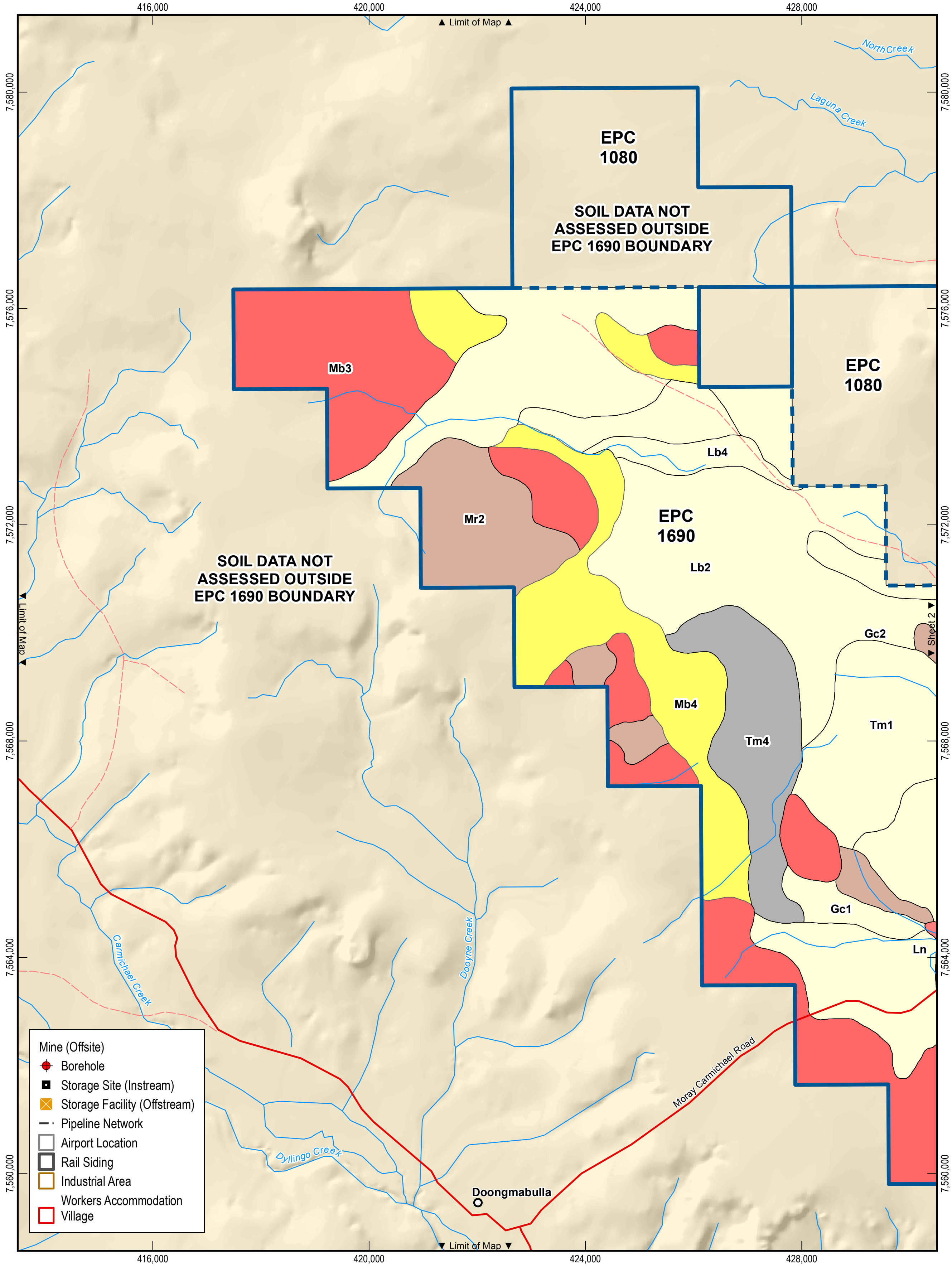
Soil Types	Vegetation	Australian Soil Classification	Area
massive fine sandy clay subsoil			
Lb2 Moderately deep (0.5–1.0 m) acid to neutral soil with medium to thick loamy surface grading to yellow-brown massive fine sandy clay subsoil	Eucalypts	Yellow or brown Kandosol	7521
Lb4 Moderately deep (0.5 – 1.0 m), acid to neutral, yellow-brown, massive sand to loam.	Eucalypts	Yellow-Orthic or brown-orthic Tenosol	482
Ln Shallow to moderately deep (< 0.75 m), slightly gravelly, acid to neutral, red well-structured clay.	Eucalypts	Red Dermosol	214
Tm1 Deep (0.9 – 1.2 m) texture contrast soil with thick sandy surface over acid to neutral, massive, yellow-brown fine sandy clay subsoil	Eucalypts	Yellow or brown Chromosol	3037
Tm2 Deep (> 1.0 m) texture contrast soil with thick loamy surface over acid to neutral, well structured, yellow-brown fine sandy clay subsoil.	Eucalypts	Yellow or brown Chromosol	188
Tm4 Deep (> 1.0 m) texture contrast soil with thick, bleached, sandy to loamy surface over alkaline, mottled, yellow-brown fine sandy clay subsoil.	Eucalypts	Yellow or brown Sodosol or Chromosol	903
Soils of older alluvium (Qs and T Geology units)			
Moderately deep soils (0.5 – 1.0 m to rock)			
Mr2 Moderately deep, gravelly, acid to neutral bleached sand to loam	Eucalypts	Bleached-Leptic Tenosol	695
Deep to very deep soils (> 1.0 m to rock)			
Eb1 Texture contrast soil with thick, bleached sandy to loamy surface over alkaline, mottled, yellow-brown fine sandy clay subsoil.	Eucalypts	Yellow or brown Sodosol	951
Eb2 Grey, brown or red cracking clay with hard-setting surface and moderate to strong gilgai or melon holes.	Brigalow / Gidgee	Red, brown or grey Vertosol	2199
Eb3 Texture contrast soil with moderately thick, bleached loamy surface over alkaline, mottled, yellow-brown medium clay subsoil.	Brigalow/ Gidgee	Yellow or brown Chromosol or Sodosol	639

Soil Types	Vegetation	Australian Soil Classification	Area
Mb2 Yellow-brown, acid to neutral, massive, bleached sand to loam.	Eucalypts	Bleached-Orthic Tenosol	1347
Mb3 Red, acid, massive sand to loam.	Shrubs	Red-Orthic Tenosol	2795
Mb4 Yellow to brown, acid, massive sand to loam.	Shrubs	Yellow-Orthic and Brown-Orthic Tenosol	1653
Very deep soils of recent alluvium (Qa Geology unit)			
Cr1 Acid to neutral, yellow-brown, massive and loose, sand to loam	Eucalypts	Yellow-Orthic and Brown-Orthic Tenosol	849
Cr3 Texture contrast soil with moderately thick loamy surface over alkaline red, well-structured light medium clay subsoil.	Eucalypts	Red Chromosol	531
Cr4 Texture contrast soil with moderately thick sandy to loamy surface over acid to neutral, brown, massive to weakly structured light medium clay subsoil.	Eucalypts	Brown Chromosol	129

* Australian Soil Classification (Isbell, 2002) Classification given only to most common Order and Suborder

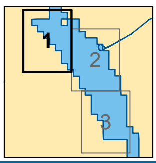
A total of 51 soil samples from 10 soil profiles were collected for chemical analyses. These samples were analysed in a NATA accredited Laboratory for chemical properties that are important in assessing grazing suitability and topsoil stripping suitability. For full results refer to Volume 4 Appendix L – Appendix III. The results are assumed to represent the chemical properties of each soil analysed. The surface of most soils contains moderate to high proportions of fine sand, which due to its lack of structure will form 'bulldust' when disturbed. Plate 4-2 shows the very fine 'bulldust' surface of soil Mb4.

Plate 4-2 Bulldust Surface Soil Mb3



LEGEND

Homestead	Rail (West)	GHD Soil Survey	Lb2, Lb4, Tm1, Tm2	E
Local Road	Mine (Onsite)	Gc1, Gc2, Mr2	Mb2, Mb4	Tm4
Track	Mine Infrastructure Area	Lb1, Ln	Cr1, Cr3, Cr4	Eb1, Eb3
Watercourse		Mb3	Eb2	



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Map Projection: Universal Transverse Mercator
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Soil Survey Results
for EPC1690

Job Number 41-25215
Revision C
Date 17-10-2012

Figure 4-13
Sheet 1 of 3

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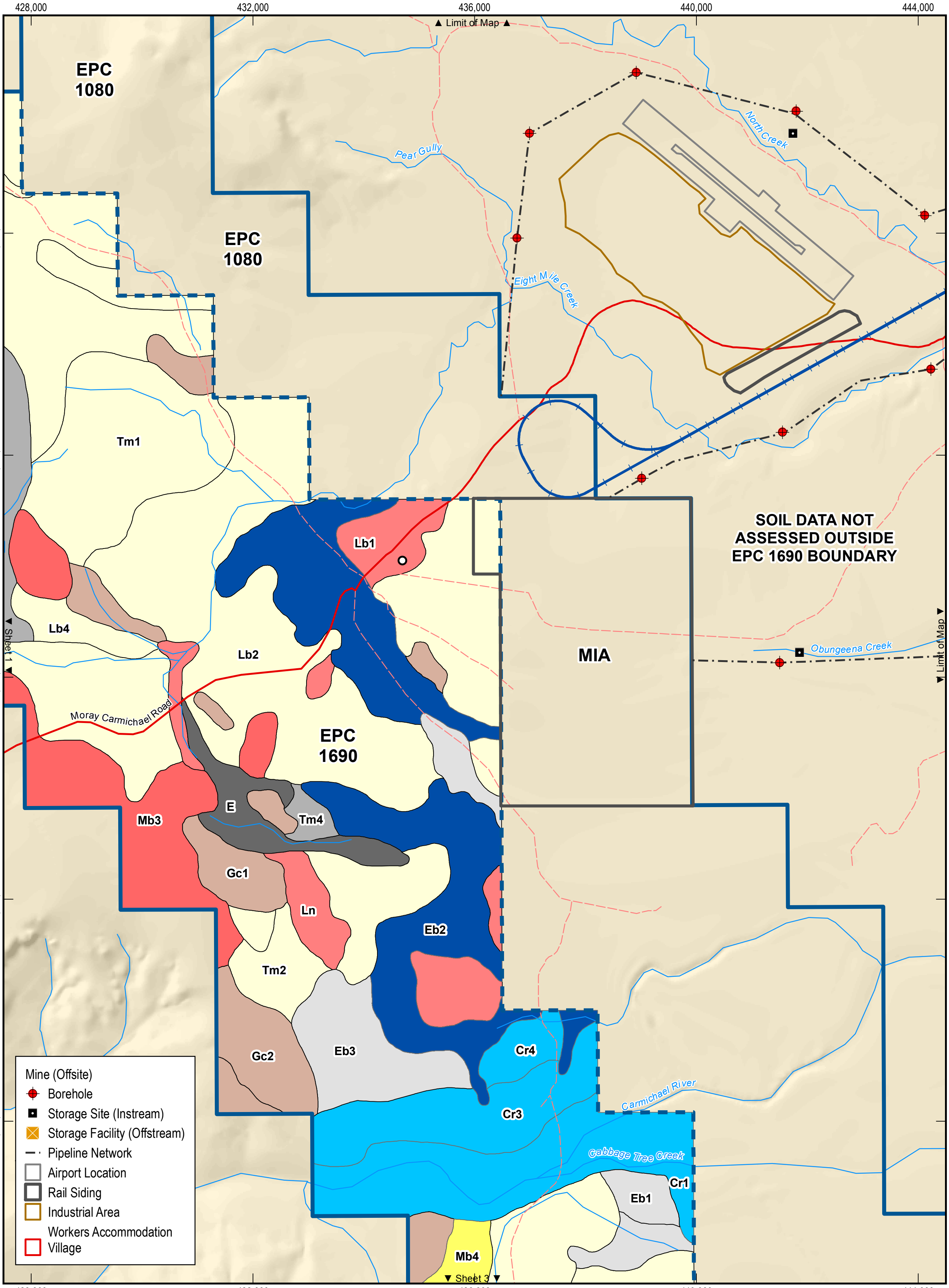
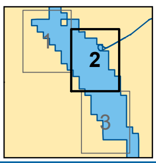


LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area

GHD Soil Survey
- Gc1, Gc2, Mr2
- Lb1, Ln
- Mb3
- Lb2, Lb4, Tm1, Tm2
- Mb2, Mb4
- Cr1, Cr3, Cr4
- Eb2
- E
- Tm4
- Eb1, Eb3



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Soil Survey Results for EPC1690

Job Number	41-25215
Revision	C
Date	17-10-2012

Figure 4-13
Sheet 2 of 3

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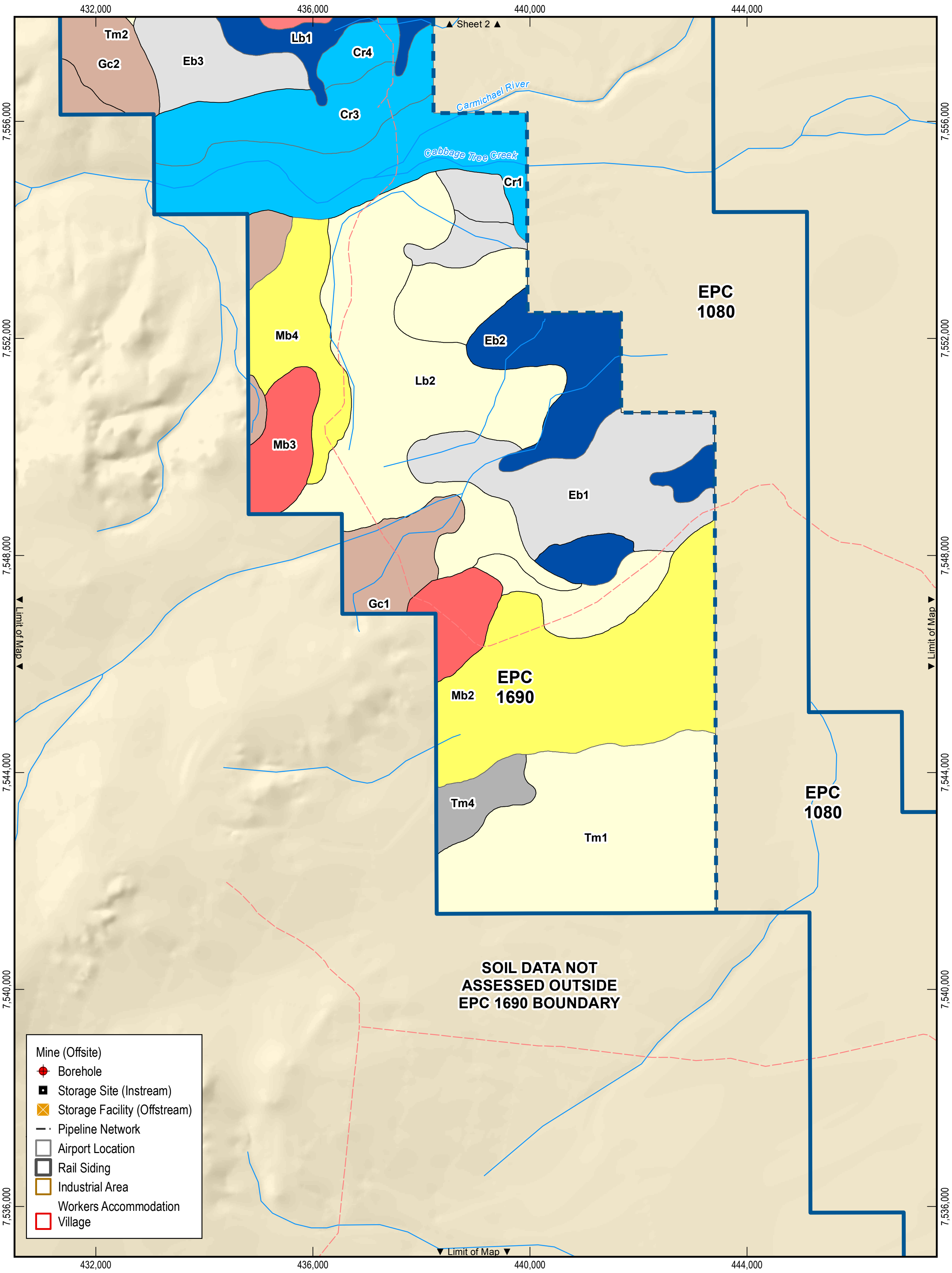
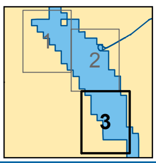


LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area

GHD Soil Survey

- Gc1, Gc2, Mr2
- Lb1, Ln
- Mb3
- Lb2, Lb4, Tm1, Tm2
- Mb2, Mb4
- Cr1, Cr3, Cr4
- Eb2
- E
- Tm4
- Eb1, Eb3



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
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Carmichael Coal Mine and Rail Project

Soil Survey Results for EPC1690

Job Number	41-25215
Revision	C
Date	17-10-2012

Figure 4-13
Sheet 3 of 3

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GHD: Carmichael Soil Survey (2011); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); GHD: Soil Survey Results (2011). Created by: BW.

Areas of each soil unit mapped within the boundaries of EPC1690 are given in Table 4-10, while Table 4-11 lists the areas of each soil classified to Order and Suborder of the ASC. In terms of the highest mapped areas of soils, Lb2 is the highest with 7, 500 ha, Tm1 occupies the next largest area with just over 3, 000 ha while Eb2 is third largest occupying almost 2,200 ha. Sandy red or yellow-brown Tenosols, Mb2, Mb3 and Mb4, together occupy almost 6,000 ha of the EPC1690 area. Most of these soils have thick shrub vegetation.

Table 4-10 Areas of Each Soil Unit and Number of Mapped Units within EPC1690

Soil	Area mapped (Ha)	Number of Unique Mapped Areas (UMA)
Gc1	849	9
Gc2	353	2
Lb1	423	4
Lb2	7,521	9
Lb4	482	4
Ln	214	2
Tm1	3,037	5
Tm2	188	1
Tm4	903	3
Mr2	695	3
Eb1	951	2
Eb2	2,199	6
Eb3	639	3
Mb2	1,347	1
Mb3	2,795	11
Mb4	1,653	4
Cr1	849	1
Cr3	531	1
Cr4	129	1
Erosion	257	1
Totals	**26,015**	**73**

Note: Areas calculated assuming dominant soil occupies 100 per cent of each UMA and does not take into account minor areas of each soil within other UMAs.

Table 4-11 Areas of soils that are classified to the Order and Suborder of the Australian Soil Classification

Soil Order (and Suborder)	Area (Ha)
Chromosol	3,885
Dermosol	214
Red Kandosol	423
Yellow or Brown Kandosol	7,521
Rudosol & Leptic Tenosol	1,897
Sodosol	2,493
Red-Orthic Tenosol	2,795
Yellow and Brown-Orthic Tenosol	4,331
Vertosol	2,199
Erosion	257
Total area of EPC1690	**26,015**

Sandy or loamy yellow-brown or red Kandosols or Tenosols, consistent with the CSIRO Land System report (Gunn et al, 1967) of red or yellow earths, occupy just over 15,000 ha of the total EPC1690 area (or 58 per cent). This result is similar to the mapping over the area by Gunn *et al* 1967.

Chromosols occupy 15 per cent while Sodosols occupy almost 10 per cent of the total EPC1690 area. Vertosols occupy 8 per cent while shallow soils (Rudosols and Leptic Tenosols) occupy 7 per cent of the total area. The Vertosols of Eb2 have high salinity levels close to the soil surface. This salt can be seen in a soil profile exposure caused by small localised erosion where water flow was concentrated by the direction and depth of melonholes. This salt can be seen in Plate 4-4.

Many soils formed on Dunda beds (Geology unit Rld) and soil Mr2 formed on Geology unit T are shallow to moderately deep over hard sandstone or manganese pan. In some localities this pan is exposed on the surface. Plate 4-5 below shows examples of the underlying or exposed manganese pan, while the hard sandstone can be seen in Plate 4-6.

The characteristics and limitations of each of the identified soils within EPC1690 is detailed below in Table 4-12.

Table 4-12 Soil Types, Classifications and Limitations

Soil Type	Description
Gc1	The soil occurs on rocky hillcrests, mainly associated with Red Hill and also near Gregors Corner. Pasture growth is poor due to the shallow, rocky soil which is likely to be very low in fertility. Control of wattle regrowth is a problem on this soil. Topsoil stripping is not recommended due to shallow soil depth and the amount of surface cobbles, stones and rock outcrop.

Soil Type	Description
Gc2	The soil occurs on hillcrests and mid to upper hillslopes. Pasture growth is poor due to the shallow, sandy soil. Control of wattles and woody weeds such as flannel weed is a problem on this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Lb1	The soil occurs on hillcrests and mid to upper hillslopes. Pasture growth is poor due to the shallow to moderately deep, sandy soil. Control of currant bush may be difficult in some locations of this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Lb2	The soil occurs on gentle lower hillslopes. Pasture growth is poor due to low soil water holding capacity. Currant bush may be hard to control on this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Lb4	The soil occurs as relatively small areas within lower hillslopes, broad flats or pediments. Pasture growth is poor due to the sandy soil which is expected to be low to very low in fertility. Control of wattle regrowth and woody weeds such as currant bush may be difficult on this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Ln	The soil occurs on a broad low rise and edge of creek line. Cleared with evidence of Eucalypt vegetation. Buffel grass is growing well but wire grass and black spear grass also occur. However plant available water capacity (PAWC) and hence pasture growth will be limited by shallow depth to underlying rock. Some currant bush is present which may be hard to control on this soil. Subsoil sodicity, sodicity and dispersion are expected to be low in this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.

Soil Type	Description
Tm1	The soil occurs on gentle lower hillslopes to broad flats. Pasture growth is poor due to the thick sandy topsoil. Wattle and currant bush will be hard to control on most areas of this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes. Stripping below 0.90 m is not recommended to minimise capture of sodic soil material.
Tm2	The soil occurs on a lower hillslope or pediment. Pasture growth is reasonable. Control of currant bush may be difficult on this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Tm4	The soil occurs on gentle lower hillslopes and broad flats. Pasture growth is poor due to alkaline, sodic and/or saline subsoil. Currant bush may be hard to control in some localities of this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Mr2	The soil occurs on hillcrests and mid to upper hillslopes. Pasture growth is very poor due to the shallow, sandy soil which is very low in fertility. Control of wattles and other shrubs will be difficult on this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Eb1	The soil occurs on rises and upper hillslopes. Pasture growth is poor due to alkaline, sodic and/or saline subsoil. Currant bush will be hard to control on most of the area of this soil. This soil will become bulldust upon disturbance. Salinity and sodicity levels in the subsoil are variable, with some profiles highly saline and sodic from 0.60 m. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to very high fine sand content and is therefore recommended for reuse only on very gentle slopes. Reuse of material below 0.60 m should be avoided to minimise highly sodic layers in the final mix.

Soil Type	Description
Eb2	This soil occurs on generally low-lying broad alluvial flats, usually with melon holes. Pasture growth is mostly good, especially as a result of the last few wet seasons, but weeds such as currant bush and Parthenium as well as patches of Sodosols (Eb3) may limit productivity in some locations. Shallow effective rooting depth due to high to extreme salinity and sodicity will limit PAWC. Soil reuse should be restricted to less than 0.30 m to avoid material with high salt, sodium and therefore dispersion. Achieving this will be difficult over most of the area of this soil due to the depth and frequency of melonholes. Therefore reuse of this soil material is not recommended, unless in areas of less prominent melonholes.
Eb3	The soil occurs within gentle lower hillslopes and broad brigalow/gidgee flats. Soil Eb2 is usually associated as a minor soil, which has high EC levels and dispersible subsoil. Soil pH, field salinity and possible sodicity levels vary between profiles of this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes. Any reuse of soil material below 0.30 m should be restricted to avoid media with high sodium or salinity It is recommended that further testing of this soil unit is undertaken prior to disturbance due to the variable depth to material with adverse chemical
Mb2	The soil occurs on lower hillslopes and broad flats. Pasture growth is poor due to the rapidly drained sandy soil which is low in fertility. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Mb3	This soil occurs on broad rises and upper hillslopes. Pasture growth is poor due to the rapidly drained sandy soil which is likely to be very low in fertility. Thick wattles and other shrubs will be hard to control on this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes
Mb2	Yellow-brown, acid to neutral, massive, bleached sand to loam.
Mb3	Red, acid, massive sand to loam
Mb4	Yellow to brown, acid, massive sand to loam

Soil Type	Description
Cr1	The soil occurs on the levee of Carmichael River. Pasture growth is poor due to low estimated PAWC. This soil will become deep bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Cr3	The soil occurs on a small backplain associated with Carmichael River. Currant bush will be hard to control on this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Cr4	The soil occurs on a small backplain associated with Carmichael River. Currant bush will be hard to control on this soil. This soil will become bulldust upon disturbance. Any salvaged material from this soil is likely to be subject to slaking, sealing and have poor physical properties due to the very high fine sand content and is therefore recommended for reuse only on very gentle slopes.
Eb1	Texture contrast soil with thick, bleached sandy to loamy surface over alkaline, mottled, yellow-brown fine sandy clay subsoil
Eb2	Grey, brown or red cracking clay with hard-setting surface and moderate to strong gilgai or melon holes.
Eb3	Texture contrast soil with moderately thick, bleached loamy surface over alkaline, mottled, yellow-brown medium clay subsoil.

The main limitation to soil reuse for most of the soils within the EPC1690 area is the variable depth to hard sandstone or manganese pan. Depth to saline or sodic subsoil will limit depth of useable material from Tm1, Tm4, Eb1 and Eb3 soils while depth to strongly alkaline soil will limit the depth of useable material from soil Cr3. All soils have high fine sand contents throughout the recommended maximum depth for reuse. Any salvaged material is likely to be subject to slaking, sealing and have poor physical properties due to this very high fine sand content and is therefore recommended for reuse only on level to very low slopes. Design of stockpiles must consider this soil property to ensure side-slope stability and minimise susceptibility to failure due to erosion risk.

Plate 4-3 Very fine bulldust surface soil Mb3

Plate 4-4 Subsoil salinity in a soil profile exposure within area mapped as Eb2 soil

Plate 4-5 Manganese pan often associated with soils formed on Dunda beds

Plate 4-6 Soil Lb4 formed on Sandstone of the Dunda beds

Detailed descriptions of each soil including geology, landform, vegetation, ASC and suitability are included within Volume 4 Appendix L (refer to Section 2.4). Chemical and physical data including fertility from analysed profiles are included where appropriate as well as a summary of soil properties and management issues for soil reuse within mine rehabilitation processes.

Careful identification of the limitations and undesirable attributes associated with inferior soil resources is essential to ensure only the least hostile and therefore most appropriate media are selected, and that such materials are used in accordance with their capability (i.e. capable of sustaining the end use to which they are put).

For most rehabilitation situations, subsoil clays with elevated levels of soluble salts (e.g., soluble chloride contents >300-600 ppm or EC1:5 >0.6 dS/m), such as areas of soil Eb2, are not recommended for salvage. Reinstatement of such materials, particularly as surface materials, will typically be subject to poor physical behaviour (sodicity, dispersion and coarse/dense structure) and limited plant establishment. Cumulatively, these effects restrict the development of ground and canopy cover and slow water relations and structural recovery in the surface soil. Such effects impact significantly on rehabilitation outcomes at a site by increasing both erosion risk and the potential for localized rehab failure.

Where available soil mapping indicates high levels of subsoil salinity or sodicity may be present or significant spatial variability in salinity or sodicity levels exists, localized field testing of materials prior to salvage is recommended.

4.2.3.5 Agricultural Suitability

Grazing Suitability Assessment

A grazing suitability assessment was undertaken based on classifications developed by the Department of Mines and Energy, Land Suitability Assessment Techniques 1995, and Land evaluation methodology for determining pre-mining dryland cropping and grazing suitability in the Bowen Basin, Burgess 2011. Most of the soils of the EPC1690 area are classified as Class 4 or 5, which is marginal to unsuitable land for production of export quality cattle but suitable to marginal for cattle breeding. This class of land is often referred to as Breeding Country. Class 5 land is typically only utilised for cattle breeding over the wet season and destocked over the dry season, unless it is utilised with other land in the same paddock.

Classification of the land as Class 4 or 5 is based on poor water availability (m) due to low estimated plant available water capacity (PAWC) and water entry, nutrient deficiency (nd) for soils such as the deep massive sandy soils, and vegetation management (vm) for soils with significant wattles or other shrubs or currant bush growth. Soil Eb2 has limitations of salinity (sa), and pH which also places it in Class 4. Areas of Class 3 land – suitable for production of export cattle in good seasons - are mostly restricted to better soils associated with Carmichael River levee. These soils have higher estimated PAWC and good fertility. Their extent over the area is minimal. Table 4-13 identifies the results of grazing suitability assessment, with further detail contained within Volume 4 Appendix L Mine Soils Assessment.

Table 4-13 Grazing Suitability Analysis Results – EPC1690

Results of Grazing Suitability analysis	
Class 1 - Land suitable for the production of 2 year old, grassfed, export quality cattle in all seasons	0 ha
Class 2 - Land suitable for the production of 2-3 year old, grassfed, export quality cattle in most seasons	0 ha
Class 3 – Suitable land for the production of 2-3 year old, grassfed, export quality cattle, but only in good seasons	964 ha
Class 4 - Marginal land for production of export quality cattle, but suitable as breeding country all year round	18,502 ha
Class 5 Unsuitable land for production of export quality cattle and marginal as breeding country all year round	6,549 ha
Total Area	**26,015 ha**

Similar results are expected for EPC1080 and the off-site infrastructure area.

Assessment of Land Condition

As the Project Area is located within the Burdekin Dry Tropics Rangelands an assessment of Land Condition for each soil and UMA was undertaken using the standards for the Burdekin Dry Tropics

(Karfs et al, 2009). Land Condition assessment is based on the ability of the land to respond to rain and produce useful forage for beef cattle grazing. Assessment of land condition is based on a combination of factors including but not limited to pasture density, pasture type, ground cover, soil condition and presence and density of introduced weeds.

There are 4 land condition classes in the Land Condition Suitability Framework, using an A, B, C, D system (refer to Table 4-14 for a general description of Land Condition Classes). Note that the land condition classifications do not correspond to agricultural potential of the land, but rather to additional constraints to productivity over and above the criteria used for land suitability assessment.

Most of the EPC1690 area is assessed as Land Condition C (16 713 Ha or 64 per cent of the total area). This land class has high proportions of black spear grass and a moderate proportion of non-preferred grasses such as wire grasses or soft spinifex. The presence of currant bush in many localities also contributes to this lower the land condition class. A total of 3 668 ha or 14 per cent of the EPC1690 area was classified as Land Condition D due to thick wattles and shrubs with little grass cover on areas of deep, red or yellow sandy soils and shallow rocky areas.

Soils Eb2 and Eb3 with black spear grass cover and some buffel grass with weeds such as currant bush or Parthenium weed (Eb2 only), often with Brigalow regrowth, are assessed as Land Condition Class B, (5,112 ha or 20 per cent of the total EPC1690 area). Only some areas of soil Eb2 without weeds or brigalow regrowth is assessed as Land Condition A (522 ha or 2 per cent of the total EPC1690 area). Refer to detailed soil descriptions given in Section 2.4 of Volume 4 Appendix L Mine Soils Assessment for further detail.

Table 4-14 Land Condition Classes for the Burdekin Dry Tropics Rangelands

Condition rating	General description
A	High density and coverage of preferred grasses
B	Moderate density of preferred or high density of intermediate grasses
C	Moderate to low density of preferred grasses or moderate density of intermediate grasses. Higher numbers of annual grasses and forbs, some woody thickening
D	General lack of any perennial grasses or forbs or severe erosion and large bare areas or high numbers of weeds/annuals or thickets of woody plants covering much of the area

Land condition classes and associated constraints are considered likely to be similar for EPC1080 and the off-site infrastructure area.

4.2.3.6 Mineral Resources

Exploration Drilling History and Key Findings

Two drilling campaigns have been undertaken within the Project (Mine) by the Queensland Government in late 1970s. A total of 23 boreholes were drilled in two phases generally in a straight line along the strike of the coal seam immediately down dip of the AB seam sub-crop line. Xenith (2009) reports that the exploration data was not used as part of the In-situ Coal Resource Estimate reporting and the associated geological model as the data was completed on a Float/Sink cut point of F1.90, which has been deemed as non-representative of the potential product coal characteristics.

From June 2009 to late October 2009, Linc Energy Ltd undertook a total of 24 exploration drill holes within the Project (Mine) area, on EPC1690. All holes were HQ core holes with some having an open hole pilot drilled first that allowed accurate starting core depths for the target coal seams. The seams that were intersected in the core holes were sampled into plies on site and were analysed by the Bureau Veritas laboratory in Emerald.

A Coal Resource Estimate (CRE) was also undertaken for the Project (Mine) (when the tenure was MLD 372 now expired) in November 2009 (Xenith, 2009). The CRE was prepared in accordance with the *Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, 2004* (JORC Code, 2004 Edition) with the key findings presented in the following paragraphs.

From a regional perspective coal seams are present in three Late Permian units of the Galilee Basin as follows:

- The Colinlea Sandstone and overlying Bandanna formation occurring in the southern and north western portion of the basin
- The lateral equivalent of these two units, the Betts Creek Beds which also exists at Pentland, approximately 180 km north west. According to Leblang (2005) individual seams are up to 20 m thick with an aggregate maximum thickness of 45 m developed in the western part of the Koburra Trough

The Late Permian coal seams are designated A to F (refer to Table 4-15), in the order of increasing age with most seams comprising dominantly dull, clean coal. The resource targeted by the Project (Mine) consists of the following coal seams:

- AB seam
- C and D seams
- E and F seams

Xenith (2009) defines these seams as per the following:

- The AB and D seams are the thickest seams in the Project Area, attaining a maximum cumulative coal thickness of approximately 19 m
- The C seam is generally highly banded with carbonaceous mudstones and attains a maximum thickness of approximately 4 m
- The E and F seams appear to vary in thickness across the MDL372 with thicknesses ranging from 0.5 m to 5 m for the F seam

The new geological model for the resource further divides the coal seams AB and D into 3 intervals so as to allow the limit parameters to be applied for the resource estimate, and to ensure that any parting stone bands are excluded from the coal seams. The intervals are:

- AB 1
- AB 2
- AB 3
- D1

- D2
- D3

Seam C, E and F have been modelled as single seams.

Table 4-15 Average Seam Thickness Results from Model

Coal Seam	Average Thickness (m)
AB1	6.76
AB2	2.13
AB3	4.47
D1	4.87
D2	3.51
D3	3.15
E	2.22
F	2.15

Structural Interpretation

The general structure of the resource shows a gradual gentle dip to the west with the seams sub-cropping along the eastern lease boundary. More drilling will be required to more accurately define the D, E and F seam subcrop lines with some evidence to suggest the Tertiary sequence is thinning in this direction as is evident in hole GLC013 which has a tertiary thickness of 50 m.

The seams are generally dipping at 2-4 degrees to the West with some slight steepening to the south and in the middle of the deposit where a fault has been interpreted. This fault has not been included in this geological model as it will require further definition drilling to accurately map. No evidence exists for any other significant structures in this deposit. The overburden cover of the AB seam varies from approximately 50 m near the eastern subcrop line to over 400 m in the western part of the deposit.

Hydrogeology

Based on the current understanding of the geology for Project (Mine) site and Study Area the following hydrogeological units are considered of relevance to the Project:

- Cainozoic, Quaternary and Tertiary-age unconsolidated alluvial and colluvial deposits associated with the Carmichael River and other local water courses (map symbols Cz, Q, Q>T, Q>Rw, and TQw)
- Consolidated Tertiary-age sandstones and siltstones (map symbol T)
- Numerous underlying Triassic-age units which form part of the Great Artesian Basin (**GAB**) including the Warang Sandstone (map symbol Rw), the Moolayember Formation (map symbol Rm), the Clematis Sandstone (Re), the Dunda Beds (Rd) and the Rewan Group (not mapped at outcrop)

- Permian-age siltstones, mudstones, sandstones and coals of the Bandanna Formation and the Colinlea Sandstone which form the target of the proposed mining operations (not mapped at outcrop)

Table 4-16 provides a summary of each hydrogeological unit.

Table 4-16 Summary of Hydrogeological Units Identified for the Study Area

Description	Map Symbol	Age	Type	Typical Thickness[1]	Comments
Alluvium (lenses of sand, sand and gravel, and clay)	Q, Cz	Quaternary/ Cainozoic	Unconfined local aquifer(s)	2 – 37 m (where present)	Predominantly in the vicinity of the Carmichael River within EPC1690 and the Belyando River to the east of the Study Area.
Weathered sandstones and siltstones (often weathered to clays and sandy clays, including yellow, red, orange colourations)	T, TQw	Tertiary	Unconfined local aquifer (s)	30 - 85 m	Thought to occur at outcrop over much of EPC1690 and the Study Area, except towards the western boundary.
Moolayember Formation (sandstone and siltstone) and Warang Sandstone (sandstone, conglomerate, mudstone and siltstone)	Rm	Triassic	Aquitard / limited resources	Not present	Mapped at outcrop approximately 2 km west of EPC1690.
Clematis Sandstone (sandstone)	Re	Triassic	Confined GAB artesian aquifer	Not present	Mapped at outcrop approximately 2 km west of EPC1690.

[1] Within EPC1690 lease area

Description	Map Symbol	Age	Type	Typical Thickness[1]	Comments
Dunda Beds (typically orange-brown and red-brown quartzose sandstone)	Rd	Lower Triassic	Confined local aquifer	Up to 100 m at western limit of lease	Mapped at outcrop in western parts of EPC1690, separated from the underlying Late Permian-age strata (bearing the coal) by the underlying Rewan Group
Rewan Group (typically red-brown and grey-green mudstone and green-grey sandstone)	NA	Lower Triassic	Aquitard	Up to 50 m at western limit of lease	Defined as the base of the Great Artesian Basin, separating the Dunda Beds (above) from the Permian-age (coal–bearing) strata below
Permian Coal Measures. Variable sequences of mudstone, siltstones, coals and sandstones including the target coal seams of the Bandanna Formation and Colinlea Sandstone.	NA	Late Permian	Variable. Aquitards/limited resources and confined local aquifers	90 to 180 m to base of target coals	Aquitard layers (typically siltstone, mudstone and clays) in central and western parts of EPC1690; Sandstone and coal seams yield estimates <0.1 to 1 L/s

Coal Quality Results

The coal samples retrieved through the exploration drilling program were analysed for proximate analysis, relative density, specific energy and total sulphur, with the results presented in Table 4-17. These results are raw coal results only and more detailed washability float sink analysis is yet to be undertaken. On the basis of these results it is evident that D3 seam has the lowest average ash of 21.5 per cent, with the AB1, D1 and D2 seams also showing low raw ash results. The seam with the highest raw ash results is the AB2 which is 38 per cent. Raw specific energy ranges from 17 Mj/Kg across the deposit. Total raw sulphur results are very consistent and appear to lie in a narrow range from 0.38 to 0.51 per cent.

Table 4-17 Coal Seam Average Quality Results

Coal Seam	Air Dried Moisture (%)	Average Raw Ash (%)	Raw Specific Energy (Mj/KG)	Raw Total Sulphur %	Raw Volatile Matter %
AB1	6.76	23.4	21.1	0.41	27.3
AB2	2.13	38.4	16.9	0.40	23.8
AB3	4.47	31.8	19.1	0.40	25.1
D1	4.87	22.2	21.8	0.44	27.5
D2	3.51	22.9	22.8	0.43	27.1
D3	3.15	21.5	23.0	0.51	26.2
E	2.22	25.4	19.7	0.38	24.5
F	2.15	28.6	20.1	0.38	23.9

Source: Xenith, 2009

Resource Estimates

The coal resource was estimated in accordance with the JORC Code and the associated 2003 edition of *Australian Guidelines for Estimating and Reporting of Inventory Coal, Coal Resources and Coal Reserves* (the Guidelines). Resource categories are defined as the following:

- Measured Coal Resource is a resource estimate in which the quantity and quality can be estimated with a high level of confidence. This estimate is based on high level of confidence to estimate coal extent, thickness, depth range, in-situ quality and quality
- Indicated Coal Resource is a resource estimate in which the quantity and quality can be estimated with reasonable levels of confidence. There are sufficient data points to reasonably estimate coal extent, thickness, depth range, in-situ quantity and quality
- Inferred Coal Resources are those estimates that can only be estimated with a low level of confidence

It is estimated conservatively that the Project (Mine) EPC1690 contains a coal resource of 7.8 billion tonnes, with majority of this resource contained within AB and D seams. The E and F seams combined contribute approximately 7 per cent of the total resource. This estimate excludes the C seams completely. As a result, the modelled coal volume exceeds that reported in the JORC resources.

The majority of the coal is contained in the depth range of 100 to 400 m, with approximately 0.3 billion tonnes contained at less than 100 m depth. As previously noted, it is not thought likely that significant coal reserves occur under the eastern portion of EPC 1080 forming part of the Project (Mine).

Table 4-18 Resource Estimate Summary Results

Resource Estimate	Quantity (billion tonnes)
Total Resource	7.8
Total Indicated	0.5
Total Inferred	7.3
Total < 100 m depth (<100 m)	0.3
Total between 100-200 m depth	2.2
Total between 200-300 m depth	2.3
Total between 300-400 m depth	2.0
Total between 400-500 m depth	0.9
Total AB Seam	3.4
Total D Seam	3.8
Total E Seam	0.4
Total Seam	0.2

4.2.4 Potential Impacts and Mitigation Measures

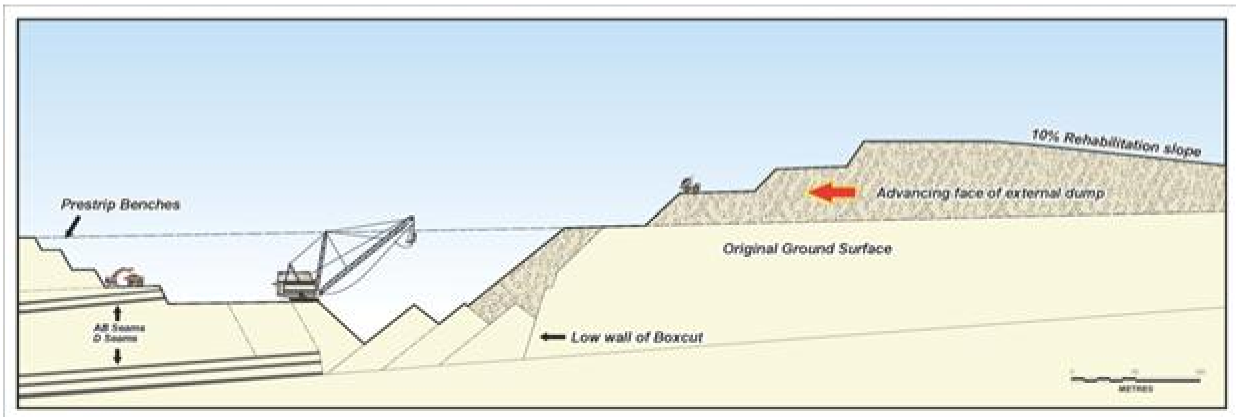
4.2.4.1 Change in Landform - Open-cut Mining

Potential Impacts

Open cut mining will involve excavation of pits to depths of up to 400 m on EPC1690. Mining will occur from the east to the west. Hence, the western edge of the open cut pits will be the steeper high-walls where the coal face is exposed, and the shallower low-wall will be created to the east as coal is removed. As mining progresses, overburden can be progressively dumped at the low-wall side of each pit (Figure 4-14).

As excavated soil and rock material becomes more bulky after it is removed, the overburden volume is estimated to increase by approximately 20 to 25 per cent. It is not possible to place all removed overburden into pits as there is insufficient volume available initially as each new pit is opened up. Further, placement of spoil against the low wall as mining progresses will result in elevation above the final surface due to the bulking effect.

Figure 4-14 Diagrammatic Layout of Out of Pit Disposal (west to east)



The height and slopes of the final landform cannot be determined without detailed geotechnical investigations which have not been completed. However, it is anticipated that the out-of-pit overburden dump will reach heights of up to 100 m and overburden placed against the low wall may raise the elevation by about 50 m above the natural ground surface. Where possible, overburden from new pits will be placed in adjacent pits but the original landform will not be able to be restored. The total area of disturbance and rehabilitation is estimated to be approximately 16,000 ha.

This change in landform will have a number of flow on impacts. If a stable landform cannot be created, slumping and collapse of slopes may present a safety hazard to humans and other animals in the area and may result in releases of sediment to surface waters. Potentially acid forming materials that have been strategically buried may also be exposed to oxidising conditions and release acidic drainage to groundwater and surface water. Similarly, saline materials may become exposed to overland flows. Management of acid forming and saline overburden is discussed in Volume 2 Section 10 Waste.

If a stable landform cannot be formed, rainfall will cause ongoing sediment mobilisation with associated impacts on surface water quality and aquatic ecosystems. Finally, without a stable landform, the site will remain unusable forever and the potential for the site to provide both both agricultural productivity and natural environmental values will be lost. The changed landform will change the landscape of the area and this is assessed in Section 4.1.4.

Several minor streams and a number of drainage lines will be diverted as part of the mining activity, particularly to prevent inflows into the open cuts. As it is not desirable to allow inflows into the final void, these diversions will be left in place after mining. Although these diversions will cause a localised change in hydrology, the overall direction of drainage will not change significantly (refer Section 6 Water Resources).

Mitigation Measures

The impact of open cut mining on landform will be mitigated through progressive rehabilitation. The overarching objectives for rehabilitation are:

- Creation of a stable and self-sustaining post-disturbance landform that is safe for human access and use, and safe for wildlife and cattle
- Preservation of surface water and groundwater quality and quantity such that environmental values and beneficial uses present pre-mining are maintained
- Achievement of post-mining land-uses over the open cut and out of pit spoil dump areas

The final landform will be achieved through placement of spoil and treatment of sides of the open cut to achieve slopes that are geotechnically stable. Completion criteria in relation to creation of safe and stable slopes will be developed once geotechnical information is available.

Overburden will be placed in the out of pit dumps and within the pit such that initial slopes are as close as possible to the desired final landform. As mining progresses, both the backfill areas and out-of-pit dumps will be profiled to create an elevated rolling landscape that is designed to be safe, stable and non-polluting. On completion of each open cut, the highwall and sides of each open cut will also be shaped through blasting and battering to form a safe and stable landform, with slopes to be determined. Progressive rehabilitation of the backfill will be at a rate of around 100 ha to 180 ha per year. As it is not possible to completely backfill the open cut pits, a final void will remain in each pit. Stormwater will be diverted around final voids so that the only inflows are groundwater and incident rainfall. More information on final voids is provided below.

Once the final landform has been achieved, topsoil will be replaced on disturbed areas and these areas revegetated. A rehabilitation framework has been developed and is presented in the EM Plan (Section 13). A water quality management process for water present in the final voids is also presented in Section 13.

At the completion of mining, an estimated 4,500 ha of area will be affected by final voids up to 400 m deep, of which approximately 2,500 ha will not be backfilled. The estimated surface area of total final void including the internal slopes is approximately 3,000 ha.

The final land use for the mined area has yet to be determined. Similarly to other large open cut operations in the Central Queensland area, it will probably be designated bushland and grazing area. If possible, areas that are suitable may be returned to pastoral use.

4.2.4.2 Topsoil Management

The methodologies for both topsoil stripping and Agricultural Land Suitability assessment were taken largely from QDME 1995, except where indicated. The following discussion is based on Burgess (2010) which is expanded from the Growth Media Management Section of QDME 1995.

Topsoil stripping recommendations are primarily determined by inherent soil characteristics and spatial soil variability within the landscape. Suitability of materials available for stripping depends not only on the presence or absence and severity of inherent limitations (such as salinity or dispersive behavior) but also on the landform design and final end uses of the material. Different landform designs and final end uses will change acceptable soil parameters and recommended stripping depths accordingly. Stripping recommendations where commitments are made to reinstate pre-mining cropping or grazing suitability to high agricultural potential, will be very different to those where final uses with no or limited agricultural potential are planned.

Stripping recommendations have been purposefully designed to maximize the salvage of soil resources (primary and secondary growth media) suitable for the establishment of functional native vegetation ecosystems capable of sustainably rehabilitating and stabilizing slopes designed according to the soil properties. Soil materials recommended for salvage have been selected to provide suitable growth media for the establishment and long term survival of selected/adapted native tree and groundcover species. Poor outcomes in terms of reduced productivity and excessive erosion risk could be expected where attempts to implement agricultural activities other than appropriately managed cattle breeding operations on rehabilitated land without revising the stripping recommendations in this report to ensure they were appropriate and purpose specific. Stripping recommendations presented in this report do not consider reinstating the land to a higher agricultural value than cattle grazing after the mining operation has ceased as most of the EPC1690 area is assessed in the pre-development state as ‘breeding country’ with limited agricultural potential. Revision of the findings and outcomes from this investigation would be required where end uses are envisaged other than the stabilization through the establishment of sustainable native vegetation cover of slopes designed according to the soil properties

The discussions outlined below are based on results from a medium intensity soil survey of 1: 100 000 scale and provide good general information on soil properties of the EPC1690 area that may affect suitability for reuse. Whilst this is a suitable level of assessment for the purposes of environment impact assessment, more detailed soil surveys will be undertaken on specific areas to be disturbed once these are finalised, to provide sufficient data for appropriate topsoil management plans for each area.

Potential Impacts

Poor topsoil management during both the stripping process and reapplication may result in poor rehabilitation results, and also have a negative impact on the required post-mining land use. This in turn may lead to high soil loss due to erosion across areas that have not been rehabilitated. Poor outcomes in terms of reduced productivity and excessive erosion risk could be expected where attempts to implement agricultural activities other than appropriately managed cattle breeding operations on rehabilitated land without revising the stripping recommendations in this report to ensure they were appropriate and purpose specific. Topsoil management will also be required in areas that are proposed for stockpiling of spoil material. These areas will be required to be assessed for suitable topsoil and subsoil materials for rehabilitation, and stripped and stockpiled in accordance with the below mitigation measures.

Topsoil Management and Planning

In any topsoil stripping, stockpiling and replacement operation, planned activities need to carefully follow actions outlined in a detailed topsoil management plan. The aim of any such plan should be to ensure optimal allocation of appropriate media reserves across all future rehabilitation activities proposed for the mine. It is important ongoing topsoil management planning is implemented during the normal operation of the mine to minimize shortfalls in rehabilitation media.

Selection of material to be stockpiled for planned activities must consider proposed landform designs, nature of the rehabilitated material and intended rehabilitation methods to be employed. A management plan should outline the intended depth and surface treatment of material to be reinstated and the intended type/nature of vegetative cover to be established. In practice, a detailed topsoil management plan should clearly outline:

- Areas to be disturbed
- Volumes/characteristics of suitable materials available from areas proposed for disturbance
- Methodology for optimal soil management during stockpiling
- Areas for reinstatement
- Physical conditions expected at each rehabilitation site (e.g. slope degree/length, spoil characteristics, proposed rehabilitation technique)
- Selection methodology to identify the most appropriate soil materials from available stockpiled resources for different rehabilitation scenarios; and volumes and characteristics of material (or other cover materials) required for stripping to meet rehabilitation requirements

In general:

- Soil material with poor physical properties (such as slaking and sealing) should only be utilized on very gentle slopes to minimise erosion risk
- Stockpiles containing soil material for reuse should ideally be formed no more than 1.5 m in height and should be ripped and seeded (with species selection based on the desired outcome of rehabilitation) as soon as practical following stockpile laydown
- Stripped materials should be segregated into stockpiles, which have similar reuse characteristics. Soils with good surface physical characteristics should not be stockpiled with soils with poorer physical attributes

It is proposed the suitable topsoil and subsoil will be salvaged via a single stage stripping approach, which involves the salvage of maximum quantities of useable soil material, irrespective of its source. Recommendations for single stage stripping outlining one-off salvage depths for the retrieval of all useable materials for each soil within the EPC1690 area are also included in the detailed soil descriptions in Appendix L.

The primary objective with single stage stripping is the one off salvage of maximum volumes of useable material, irrespective of original soil depth or origins (i.e. salvage of all suitable topsoil, subsoil and/or substrate material). Typically, surface soil and subsoil materials with differing characteristics are not kept segregated and are subject to significant mixing during stripping operations. As any of the stripped material, whether topsoil or subsoil, can potentially be exposed as final surface cover on reshaped spoil, all materials to be salvaged should have characteristics capable of supporting this use. For these reasons, generalised goals for single stage stripping are similar in many ways to those presented above for topsoil materials under two stage stripping.

Materials to be stripped during single stage operations should ideally conform to most, if not all, of the following characteristics:

- Have a particle size distribution that is dominated either by the coarse sand fraction; or alternatively the reactive clay fraction with limited fine sand and/or silt fractions
- Have a pH range appropriate for plant growth
- Be characterized by non-sodic/non-dispersive physical behaviour, particularly in the case of clay material
- Have very low levels of soluble salts
- Have fertility levels appropriate for the plant species to be grown

Materials conforming to these general principles would typically be considered appropriate for salvage during single stage stripping. Where materials are suitable except for elevated fine sand/silt fractions, as applies for most soils identified in the EPC1690 area, salvage may still be possible but reinstatement will be restricted to very low slope angles because of increased runoff and erosion risk.

Careful identification of the limitations and undesirable attributes associated with inferior soil resources is essential to ensure only the least hostile and therefore most appropriate media are selected, and that such materials are used in accordance with their capability (i.e. capable of sustaining the end use to which they are put).

For most rehabilitation situations, subsoil clays with elevated levels of soluble salts (e.g., soluble chloride contents >300-600 ppm or EC1:5 >0.6 dS/m), such as areas of soil Eb2, are not recommended for salvage. Reinstatement of such materials, particularly as surface materials, will typically be subject to poor physical behaviour (sodicity, dispersion and coarse/dense structure) and limited plant establishment. Cumulatively, these effects restrict the development of ground and canopy cover and slow water relations and structural recovery in the surface soil. Such effects impact significantly on rehabilitation outcomes at a site by increasing both erosion risk and the potential for localized rehab failure. Soil reuse recommendations for Project (Mine) onsite infrastructure are shown in (Table 4-19). Where available soil mapping indicates high levels of subsoil salinity or sodicity may be present or significant spatial variability in salinity or sodicity levels exists, localised field testing of materials prior to salvage is recommended.

Table 4-19 Soil reuse recommendations for Project (Mine) onsite infrastructure area, EPC1690

Soil	Recommended single stage stripping depth	Comments
Gc1		Not recommended for reuse due to shallow, rocky soil
Gc2	0.40 m	Not recommended for reuse > 0.40 m due to variable underlying rock.
Lb1	0.40 m	Not recommended for reuse > 0.40 m due to variable underlying rock.

Soil	Recommended	Comments
Lb2	0.40 m	Not recommended for reuse > 0.40 m due to variable underlying rock.
Lb4	0.70 m	Not recommended for reuse > 070 m due to variable underlying rock.
Ln	0.40 m	Not recommended for reuse > 0.40 m due to variable underlying rock.
Tm1	0.90m	Not recommended for reuse > 0.90 m due to sodic/dispersive subsoil or underlying rock.
Tm2	1.00 m	Not recommended for reuse > 1.00 m due to variable underlying rock.
Tm4	0.30 m	Not recommended for reuse > 0.30 m due to sodic/saline subsoil.
Mr2	0.60 m	Not recommended for reuse > 0.60 m due to variable underlying rock.
Eb1	0.40 m	Not recommended for reuse > 0.40 m due to sodic/saline subsoil.
Eb2		Not recommended for reuse due to shallow depth to saline/sodic subsoil and depth and frequency of melon holes.
Eb3	0.30 m	Not recommended for reuse > 0.30 m due to possible saline/sodic subsoil.
Mb2	0.90 m	Not recommended for reuse > 0.90 m due to high fine sand content.
Mb3	0.90 m	Not recommended for reuse > 0.90 m due to high fine sand content.
Mb4	0.90 m	Not recommended for reuse > 0.90 m due to high fine sand content.
Cr1	0.90 m	Not recommended for reuse > 0.90 m due to high fine sand content.
Cr3	0.70 m	Not recommended for reuse > 0.70 m to avoid strongly alkaline subsoil.
Cr4	0.90 m	Not recommended for reuse > 0.90 m due to high fine sand content.

4.2.4.3 Erosion

Potential Impacts

Construction of the off-site and on-site infrastructure will require clearing of vegetation and earthworks. This in turn will expose soils to erosive forces from overland flow of water and from wind. Erosion of soils has a range of impacts:

- Soil resources are lost. This affects the ability to rehabilitate disturbed areas and restore productivity to the land
- Release of sediment to surface waterways affects aquatic ecosystems. This is discussed further in Section 5

- Release of sediment to surface waterways may affect beneficial uses of water downstream of the site (see Section 6.3.3)
- Dust deposition may affect plant health in adjacent vegetated areas and cause nuisance to adjacent landholders. This is discussed further in Section 7
- Increased ambient concentrations in dust may be harmful to humans and animals. This is discussed further in Section 7

All of the soils within the Project (Mine) are likely to be highly erodible once disturbed due to high fines content and generally poor structural properties (Appendix L). Erosion risk will also be higher on slopes and along drainage lines.

The mine infrastructure area and off-lease infrastructure area are located on relatively flat terrain with no mapped drainage lines passing through these areas. These areas will be relatively low risk in terms of erosion due to the flat topography, however overland flow from a significant rain event may mobilise contaminants to downstream drainage lines, and ultimately the Belyando River. Erosion and sediment controls will be needed to manage erosion from overland flow.

Water supply infrastructure is also located in areas of relatively flat topography; however the nature of works requires works within streams and drainage lines where erosion risk can be higher because of the concentration of flow along drainage lines.

Haul roads and other mine transportation infrastructure will traverse a variety of terrains and cross drainage lines. Erosion risk will be higher on steeper slopes and at drainage line crossings during both construction and operation.

During the operation phase, overburden stockpiles will be subject to erosion from incident rainfall. As the stockpiles will have sloping sides, erosion risk is relatively high and erosion and sediment control will be required.

Mitigation Measures

General principles for erosion and sediment control will be drawn from the International Erosion Control Association (Australasia) Best Practice Erosion and Sediment Control (2008) and other guidelines that may be introduced over the life of the mine. Erosion and sediment control will be based on a hierarchy of controls as follows:

- Avoid disturbance of very steep slopes, drainage lines and watercourses wherever possible
- Avoiding works in watercourses in flow conditions wherever possible
- Divert surface flows around disturbed areas. This will include permanent diversion of minor watercourses that currently pass through the proposed open cut and overburden dump areas
- Minimise exposure of soils to erosive forces. This is largely achieved by clearing vegetation progressively with minimal time lag between clearing and construction or mining works, and stabilising and/or rehabilitating cleared areas and stockpiles as quickly as possible
- Detain sediment laden runoff using sediment fences, check dams and sediment dams to allow sediment to settle out
- For permanent or long term facilities, install permanent stormwater control works as quickly as possible

Selection of particular controls will then depend on the nature of works being undertaken and the erosion risk.

For the relatively flat workers accommodation village, airport, off-site industrial area and on-site infrastructure areas, erosion control will require capture of overland flow in sediment fences and, for larger areas, sediment basins. As these areas are to remain as permanent features of the proposed mine, stormwater collection systems will be installed as early as possible during construction to capture and control runoff.

For water supply infrastructure and access roads where works are required in watercourses, mitigation strategies will be based on compliance requirements of the riverine protection permit. .

Mitigation strategies will include:

- In-stream works to be undertaken in no or low flow conditions wherever possible
- Duration of in-stream works to be minimised through prior planning such that all equipment and materials are available to allow works to be completed as quickly as possible
- For dam raising, sediment control measures to be installed where in stream disturbance must be undertaken during flow conditions. This will most likely involve sediment weirs. If sediment weirs are installed, care will be taken to minimise effects of the sediment weirs on aquatic habitat
- Minimisation of disturbance area within streams and riparian areas. Equipment parking and laydown areas will be located outside these areas. The area of disturbance within streams and riparian zones will be the minimum area required for safe working and the area of disturbance for infrastructure installation clearly marked
- Prompt stabilisation of disturbed areas to prevent flow-related scouring of bed and banks of stream. Stabilisation is to use “soft” engineering solutions rather than concrete or similar

Water supply pipeline alignments will also need to be stabilised and revegetated after construction so that these do not become preferential flow paths. Topsoil will be replaced and the pipeline alignments will be sown with pasture species or small shrubs as larger plants cannot be placed directly over pipelines.

Haul roads and other roads will have drainage systems to capture and control runoff from the road surfaces.

Runoff from overburden stockpiles will be captured in sediment basins designed in accordance with IECA 2008 guidelines. This will allow sediment from these stockpiles to settle out before waters overflow to Carmichael and Belyando Rivers.

4.2.4.4 Subsidence

Potential Impacts

SCT Operation Pty Ltd conducted a preliminary assessment of the estimated vertical subsidence resulting from longwall extraction in the AB and D seams. The surface topography within the Project Area consists of low-lying gently sloping plains of generally less than 2 per cent gradient. The Carmichael River is the most significant watercourse traversing the mine site and the proposed longwalls have been set back from the Carmichael River such that the closest longwall is approximately 215 m from the river.

The lowest points on the surface above the proposed longwalls are at 225 m AHD, near the Carmichael River. The highest point is at approximately 315 m AHD above the proposed Longwall 109. The seams dip towards the west within the proposed mining area at approximately 2 to 4 degrees. The depth of cover to the AB1 seam varies within the proposed mining area from 150 metres in the north west corner of proposed Longwall 201 to 480 metres in the south east corner of proposed Longwall 210.

The target seams for the underground mines are the AB1 and D1 seams. It is planned to operate longwall extraction faces in both seams, however extraction of the D1 seam will not occur until after the extraction in the AB1 seam. The planned height of the longwall development roadways is 3.2 m and the planned extraction height of the longwall face is 4.5 m. Top coal caving is not being considered as an option due to coal quality constraints.

The planned longwall layout in the AB 1 seam has been overlaid on the D1 seam with superimposed main roadways and offset longwall panels to reduce the influence of vertical stresses caused by subsidence on longwall production. The proposed longwall face lengths will be nominally 300 m wide.

As underground mining progresses, coal extraction from each longwall leaves a void in the mined out areas. The roof of the longwall typically collapses and this then leads to subsidence above the mined out area. As the main heading and development drives have fixed roof support, which is not removed as mining progresses, these areas are subject to only minimal subsidence, and hence the surface expression of subsidence is expected to be a pattern of troughs following the longwall layout. The time lag between mining and subsidence depends on geotechnical and geological conditions but is typically in the order of months rather than years.

Figure 4-15 shows the longwall long section and the way that caving of the roof material and overburden occurs as the longwall mining proceeds. Figure 4-16 shows a cross section of subsidence demonstrating how surface troughs form over the longwall.

Due to stresses and tensions in the geological layers, there may be vertical sheering as shown in Figure 4-15. This can be expressed at the surface as cracks.

Figure 4-15 Underground Longwall Mine Operation – Section View

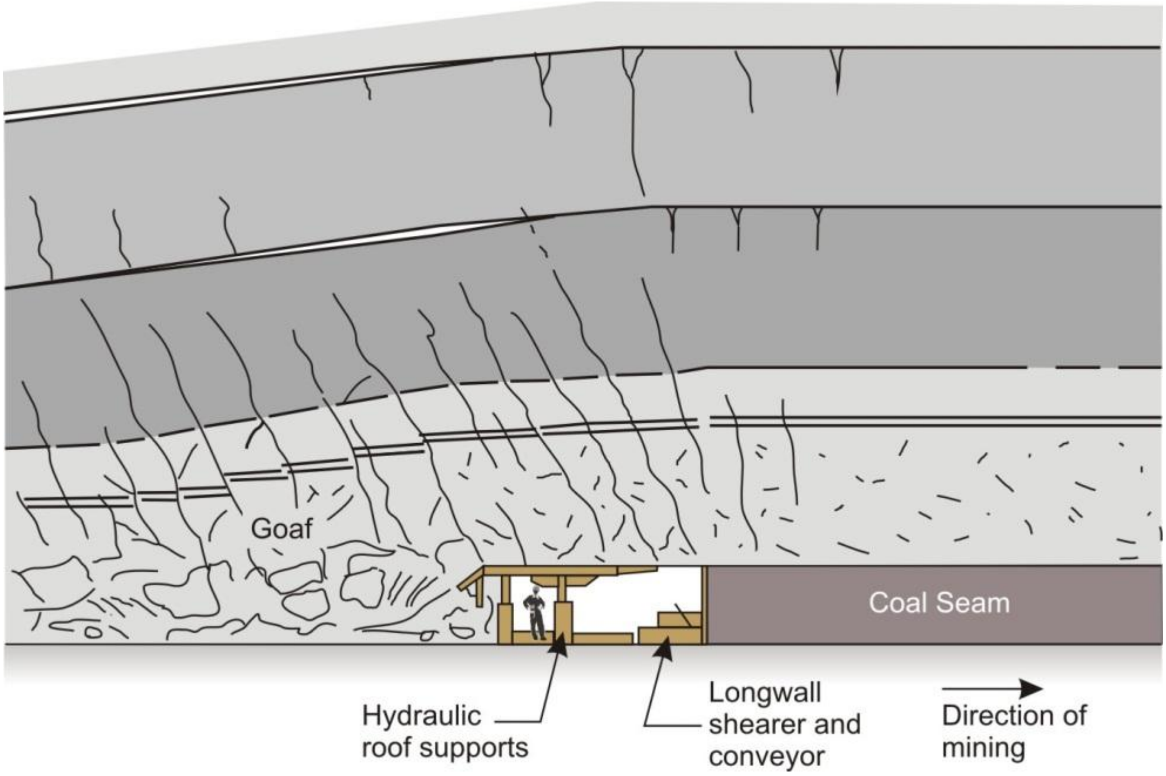
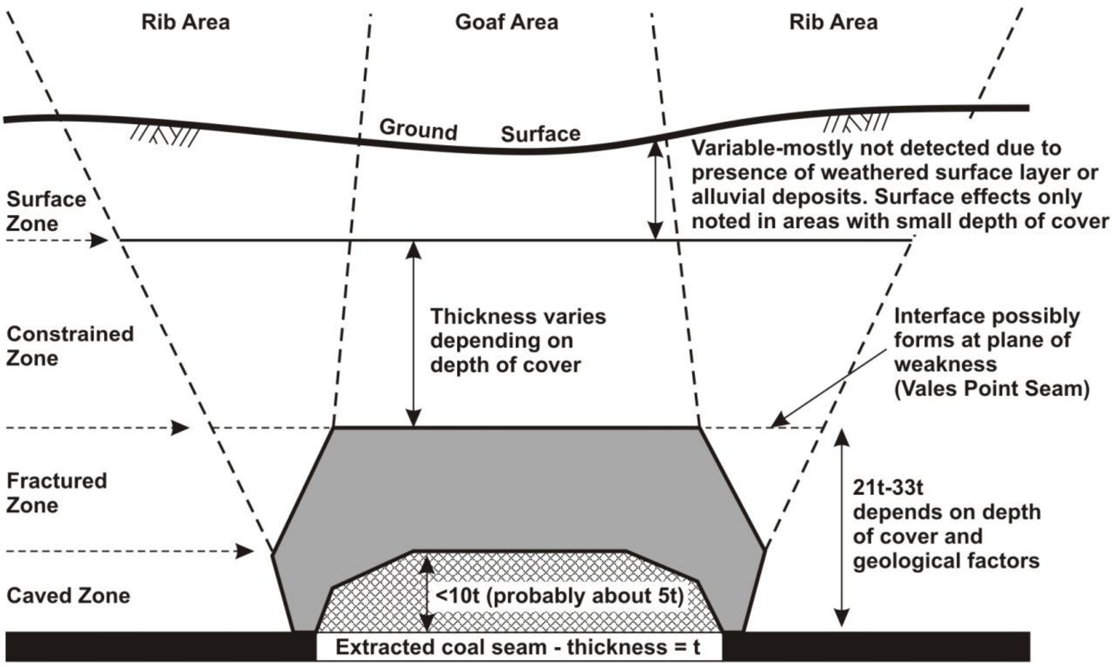


Figure 4-16 Zones in the Overburden (Foster 1995)



The underground mines are overlain by tertiary material which is predominantly clay (see Table 4-20). The lithology of the units indicates that the Tertiary is a very clay rich sequence with virtually no sand or sandstone units. On the rare occasion that sand or gravel units occur they are less that 1 m thick. This suggests that the Tertiary is of very low permeability and based on slug tests the hydraulic conductivity typically ranges from 1 x 10-7 m/s to 1 x 10-9 m/s. It is possible there will be little or no hydraulic connectivity between the surface and the underground.

Table 4-20 Classification of Tertiary Materials over Underground Mine

Unit	Lithology	Thickness(m)	Average Thickness(m)	Comments
Unit 1	Superficials	0 – 12		Includes Quaternary alluvium
Unit 2A	Tertiary Clay	0 – 29	16.9	
Unit 2B	Tertiary Claystone	0 – 29	16.2	
Unit 3	Tertiary Siltstone	0 – 35	13.5	
Unit 4	Mudstone CW - HW		24.3	Permian

Potential subsidence has been modelled based on known geological features and depth to the coal seam. As there has not been any underground coal mining operations conducted in the Galilee Basin, the empirical datasets used by SCT are derived from experience in other Australian coal basins. Initial assessment of the strength of the overburden sequence at the Carmichael Project shows these to be at the lower end of industry experience, indicating higher levels of subsidence. Due to the fact that this is a greenfield coal basin with no practical experience a conservative approach has been taken to derive the predicted subsidence, leading to potential over-prediction of subsidence depths.

The MSEC report predicts an average of 7.5 m of subsidence at the surface over the shallow longwalls with the total subsidence decreasing with depth. The final arrangement of overlying panels and pillars will act to locally modify strata response and result in potentially lower values of vertical subsidence than noted here. However, strains and tilts associated with panel edges and remnant chain pillars may be locally elevated.

The predicted subsidence that will occur is presented in Figure 4-17 predicted subsidence AB1 seam, and Figure 4-18 predicted subsidence AB1 and D1 seams.

Figure 4-17 Predicted Subsidence AB1 Seam (subsidence contours are in meters)

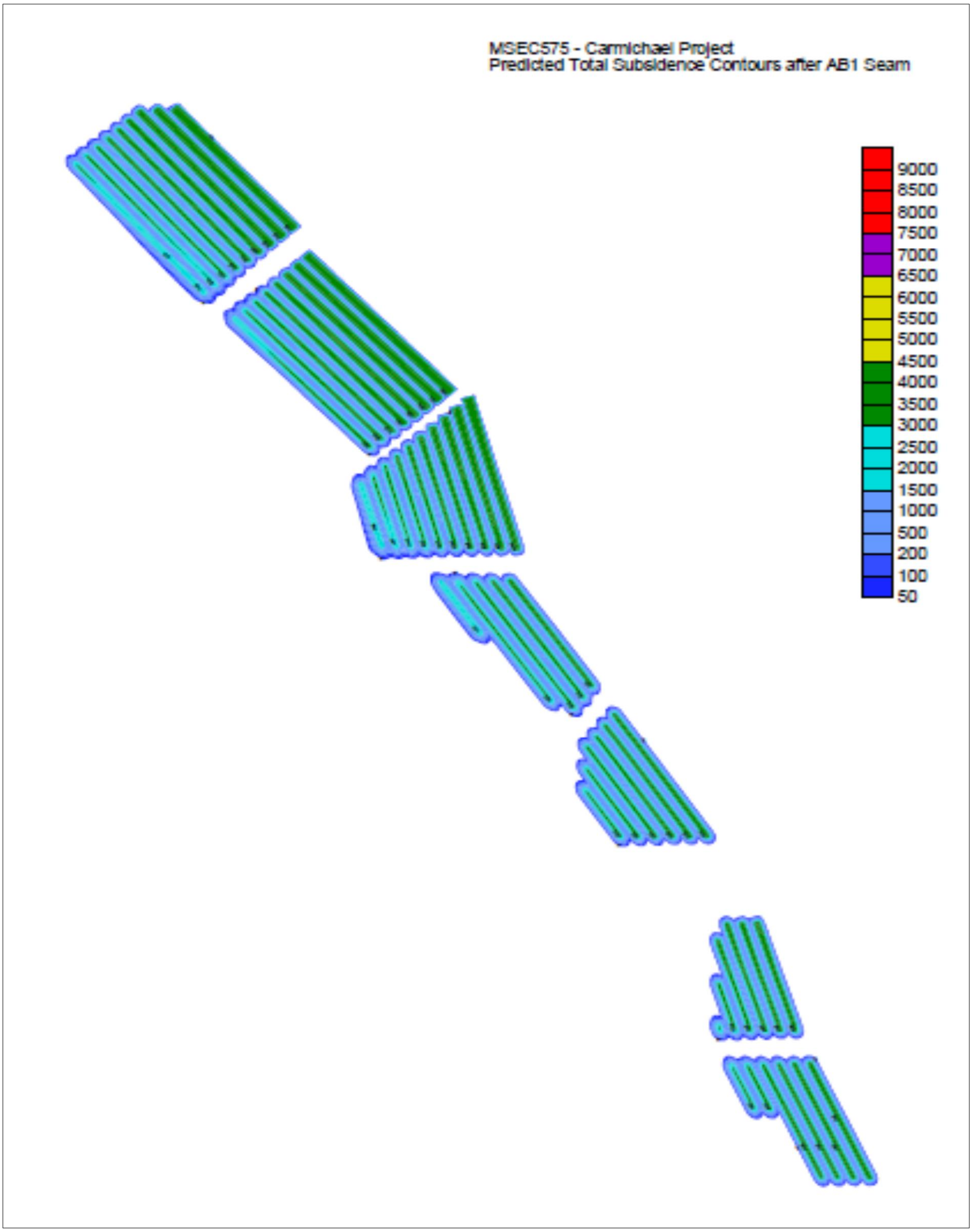
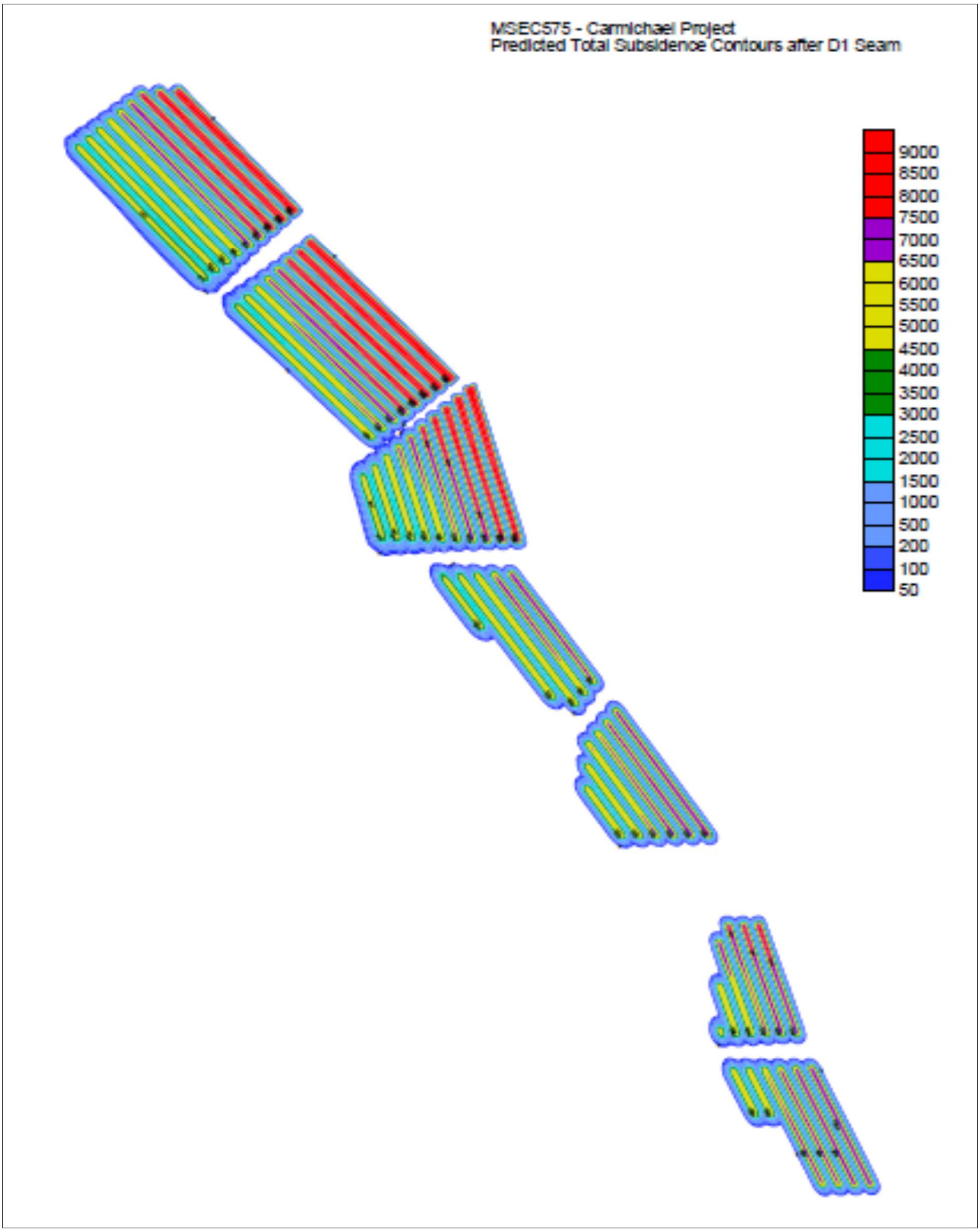


Figure 4-18 Predicted Subsidence AB1 and D1 Seams (subsidence contours in meters)



A number of small drainage lines in the Carmichael Creek and Eight Mile creek catchments traverse the mining footprint, mostly running roughly perpendicular to the longwall orientation. These are ephemeral creeks with small catchments. For the northern mining area (north of Carmichael River), a ridge line runs just west of the mining lease boundary and hence, watercourse catchments upstream of the underground mining area are small. Streams in this section drain largely towards Eight Mile Creek.

South of the Carmichael River, streams are somewhat discontinuous due to flatter topography and drain towards the Carmichael River and Belyando River.

Vertical tension cracks can lead to surface water infiltrating into subsurface layers, and may also create hydraulic connectivity between aquifers. As there is no experience with underground mining in the Galilee Basin, the extent to which surface cracking will occur is unknown. The width and depth of tension cracks will depend on the underlying geology and also the speed at which subsidence occurs. As subsidence will be staged, this may reduce the formation of tension cracking. Tension cracks can create a safety hazard for humans and other animals. In many underground mining cases, tension cracks fill in or close up naturally. This will need to be monitored for the Carmichael Coal underground mine.

Subsidence will also result in alteration in surface drainage patterns due to altered topography. Bed profiles of streams will be affected by the subsidence profile. Streams traversing the underground mining footprint are minor ephemeral streams with small sub-catchments. Most of these flow roughly perpendicular to the longwall panel and subsidence trough orientation. As these streams are quite small and ephemeral, when flowing, the streams will empty into the subsidence troughs and result in ponding in some of the troughs. Over time, channel deepening may occur at the upstream edge of the subsided area as stream flows cut back into the existing area unaffected by subsidence.

Effects of subsidence on vegetation are assessed in Section 5 Nature Conservation. Root zones of vegetation may be affected either by the relatively rapid change in ground surface or by tension cracks. Altered hydrology may also result in wetter or dryer conditions for plants. Affected vegetation may fall over, or become less able to withstand windy conditions or more gradual impacts may occur due to changes in water availability to root systems. Grasses and smaller shrubs are more likely to be unaffected by subsidence due to smaller, shallower root systems. Plants more tolerant to wet conditions may colonise in ponded areas within the subsidence troughs.

While drainage and vegetation changes may expose soils to erosive forces, flows will be into the middle of subsidence troughs, and hence sediment will be captured and downstream water quality impacts are not expected.

Apart from the Moray-Carmichael Road and a stock route, which are to be realigned, there is no existing infrastructure traversing the proposed underground footprint.

Subsidence Management and Monitoring

As the surface expression and flow on effects of subsidence are difficult to predict with accuracy, an reactive and adaptive management approach must be taken to subsidence. This approach involves monitoring the effects of subsidence and developing management controls to respond to observed effects. Effectiveness of controls is then evaluated and responses revised as required. Proactive management of subsidence is not warranted in this instance as there are no major watercourses and no infrastructure or other surface features to be protected.

A subsidence management plan will be developed, setting out

- Monitoring locations and methods
- Detailed baseline and performance criteria, drawing on baseline monitoring results
- Management responses to failure to meet performance criteria
- A system for recording monitoring data, required management responses and confirmation that management responses have been implemented effectively
- Rehabilitation success criteria for subsided areas

The post-mining land use for subsided areas is grazing on a mosaic of native pasture and woodland and wetland habitat. Preliminary rehabilitation criteria for subsided areas have been identified as follows:

- A safe and stable landform, as demonstrated by:
  - Stable slopes with no sign of slumping
  - No surface cracking that poses a risk to cattle or humans
  - No evidence of active rill, gully or sheet erosion as demonstrated by three years of monitoring
- A non-polluting landform whereby:
  - Subsided areas are not contributing excess sediment load to downstream watercourses when compared to a suitable reference site.
  - Subsidence has not caused connection between surface waters and groundwaters
  - A landform that can support grazing and native habitat with 70% cover of native grasses, shrubs and trees and weed infestation at similar or lower levels than pre-disturbance and in adjacent unmined areas.

Humans and cattle will be excluded from underground mining areas until subsidence has occurred and any cracks or other hazards are made safe.

The reactive and adaptive management approach requires a monitoring program to be implemented. A baseline monitoring program will be undertaken including:

- Stream monitoring points immediately upstream, at mid-point and immediately downstream of underground footprint on each mapped watercourse
- Vegetation characteristics and health monitoring transects and control points
- Habitat value transects
- Topographical survey transects
- Establishment of photo-monitoring points corresponding with each of the above monitoring locations

This will allow baseline conditions for stream characteristics, vegetation health and species composition, habitat features and values and topography to be established.

As subsidence occurs, subsided areas will be inspected for new and existing tension cracks. Where tension cracks do not close up within one to two years of subsidence, or there is evidence that water is preferentially flowing into cracks and underlying strata, cracks will be treated by grading and filling cracks with inert materials. The cracks will then be covered with topsoil and revegetated. Small scale equipment will be used to minimise damage to surrounding unaffected areas.

Vegetation health, species composition and habitat characteristics will also be monitored. Monitoring will include an assessment of whether changes to vegetation caused by subsidence mean that the regional ecosystem classification changes or that habitat values for threatened species have been lost. If this occurs, these areas will be added to the offsets strategy for offsetting outside of the mine footprint. Weed control will be undertaken as required and revegetation of areas where vegetation has not survived subsidence will also be undertaken so that the proposed post-mining land use can be achieved. Habitat values may also be enhanced by placement of logs, rocks or hollow trees removed from areas cleared for open cut mining or artificial habitat features such as roosts and nest boxes.

Stream condition will be monitored to identify whether significant erosion has occurred, or if channel deepening is occurring upstream or downstream of subsided areas. Management responses may include diversion or reforming of channels as well as stabilisation of bed and banks of channels. If significant “headcutting” is observed on subsided watercourses, pre-subsidence stabilisation can be undertaken on unsubsided streams as part of the adaptive management response.

While it is not expected that ponding will form to the extent that overflows occur, or that streams will enter subsurface strata, this will also be monitored, as will the water quality of ponded areas. If ponding is presenting an environmental or safety risk, ponds will either be drained by breaching the unsubsided development roads downstream of the ponded area, or by diverting upstream flows around the subsided area.

This approach to subsidence management maximises retention of natural features and natural stabilisation processes which in turn is likely to lead to a more stable and sustainable landform in the long term. Interference with natural processes will only occur where it appears that the final rehabilitation objectives cannot be achieved or an environmental or safety risk is apparent. As flows in the subsided areas will be towards the subsidence troughs, there is a low risk of downstream impacts occurring during this stabilisation process. Similarly, as an exclusion zone will be established over newly subsided areas, there is a low safety risk.

4.3 Land Contamination

4.3.1 Legislative Requirements

The legislative requirements covering contaminated land in Queensland are primarily contained in the *Environmental Protection Act 1994* (EP Act) and subordinate legislation and policies. The EP Act is administered by the Department of Environment and Heritage Protection (DEHP). Under the Act, owners and occupiers of land must notify DEHP if any of the potentially contaminating activities (notifiable activities) are being carried out on land. Such properties are then entered into an Environmental Management Register (EMR), maintained by DEHP. Entry onto the EMR means that land has potential to be contaminated. Where potentially contaminated land is investigated and found to be contaminated, DEHP enters the land onto a Contaminated Land Register (CLR).

The EP Act contains a number of provisions in relation to the investigation, management and remediation of contaminated land.

The extent to which contaminants may pose a risk to human health and the environment depends on the quantity and concentration of contaminants. Levels at which contaminants may be considered harmful have been set based on toxicity data and other hazardous properties. In Queensland, contaminant levels are set in:

- National Environment Protection (Assessment of Site Contamination) Measure 1999
- Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland 1998

It is an offence under the EP Act to remove soils from a site listed on the CLR or EMR without a permit.

Under the Sustainable Planning Act (SP Act), applications for development approval (material change of use) involving land on the EMR or CLR must be referred to DEHP for assessment. This assessment will focus on whether contamination levels are inconsistent with the proposed land use.

4.3.2 Methodology

Lots within the Project (Mine) area were searched for on the CLR and EMR. The study also identified potential sources, impacts and mitigation measures of land contamination during the Project (Mine)'s construction and operational phases. It was recognised that contaminated lots not registered or that are notifiable in the CLR or EMR may be identified during further investigations or construction phases of the Project (Mine).

A detailed survey of potentially contaminated land will be undertaken during the detailed design phase of the Project, when defined areas of impact are finalised. This section of the EIS responds to Section 3.2.3 of the Project ToR in relation to the mine. A detailed cross-reference of compliance with the ToR is provided in Volume 4 Appendix C.

The area of investigation was those lots directly impacted by the Project (Mine). This comprises five lots as described in Table 4-21. The study involved:

- A search and review of the CLR and EMR[2]
- A review of land uses in the study area
- Identification of potential offsite sources of contamination
- Identification of potential environmentally sensitive receptors

Table 4-21 Lot and Plan of Project (Mine) Area

Lot and Plan	Project (Mine) Component	Current Land Use
Lot 1 on AY35	Open cut and underground mining	Cattle grazing
Lot 1 on SP164918	Open cut and underground mining	Cattle grazing
Lot 662 on PH1491	Open cut and underground mining, stock piling area, airstrip, workers accommodation village	Cattle grazing
Lot 633 on SP228220	Open cut and underground mining	Cattle grazing
Lot 3 on DR17	Stockpiling area, mine infrastructure area	Cattle grazing

[2] Searches conducted 11 January 2012

4.3.3 Description of Environmental Values

Table 4-21 lists the land uses of the five lots in the study area. All subject land is currently utilised for low density cattle grazing. Infrastructure associated with this use includes stockyards and dams. None of the lots in the Study Area were recorded on the CLR or EMR, however this does not mean that there were no activities undertaken on the properties resulting in contamination. Current land practices may include storage of fuel and chemicals for rural usage however this is not considered to represent a high risk of contamination.

Livestock dips and spray races are notifiable activities and are potentially present on the Project (Mine) site. Potential contaminants of concern associated with livestock dips or spray races are presented in Table 4-22 (Kimber et al., 2002; McDougall and Macoun, 1996). Contamination by these and other agricultural chemicals may occur in localised areas associated with storage of the chemicals and the dip process itself. In general, contamination is restricted to localised areas of use but may become more widespread if chemicals reach the groundwater table or in highly permeable soils.

Sensitive receptors, relevant to land contamination, within the study area are major watercourses and groundwater resources. Major watercourses include the Carmichael River and Belyando River (refer to Volume 4 Appendix R Hydrology Report). Watercourses are used as sources of stock water, either directly during the wet season or indirectly from impoundments during the dry season.

Groundwater resources within the region are used for water extraction. Forty five bores within 10 km of the study area were identified from the relevant DEHP Groundwater Resource Information, of which 23 are currently utilised. Of the 23 bores still in use, nine are used to for water extraction and a further nine are unclassified. The remaining bores are used for mineral or coal exploration, sub-artesian monitoring and groundwater investigation.

Table 4-22 Potential Contaminants Associated with Livestock Dips or Spray Races

Pesticide	Period of Use
Arsenic (Trioxide)	Pre-1900s to 1955
DDT	1955 - 1962
BHC	1955 - 1962
Carbaryl	1663 - 1970
Caoumpahos	1962 - 1970
Carophenothion	1962
Bromos ethyl	1969 - 1974
Dioxothion	1969
Ethion	1962 - 1976
Chlordimeform	1973 - 1976
Amitraz	1976 - present

Pesticide	Period of Use
Promacy	1977 - 1992
Cypermethrin + Chlorfenvinphos	1979 - present
Flumethrin	1986 - present

4.3.4 Potential Impacts and Mitigation Measures

4.3.4.1 Overview

The potential impacts of land contamination may arise in two ways. First, construction and operation activities may increase human exposure to pre-existing contaminants, or mobilise contaminants to surface water or groundwater. Second, construction and operation activities may release contaminants into soils, causing soil contamination.

Soil contamination then has a number of flow-on effects, including:

- Acute or chronic toxicity effects on humans and animals that come into contact with the soil, including where contaminated soil becomes wind-blown. Contaminated soil guidelines generally focus on whether or not levels of particular contaminants might be high enough to cause toxic effects
- Inhibition of plant growth and death of existing plants in contaminated areas
- Mobilisation of contaminants by overland flows to surface watercourses. This in turn may lead to acute or chronic toxicity effects to aquatic organisms and to contamination of water supplies. (Impacts on aquatic habitats are addressed in Volume 2, Section 6.4.7 Water Resources).
- Contaminants in watercourses may be deposited in sediment on the bed of the watercourse, resulting in sediment contamination. Subsequent flow events may re-mobilise sediments into the water columns, and contaminated sediments may also inhibit aquatic plant growth.
- Mobilisation of contaminants to groundwater, which in turn may lead to contamination of groundwater supplies. (Impacts on groundwater and aquifers are addressed in Volume 2, Section 6.4.4 Water Resources.)
- In alluvial aquifers such as that occurring along the Carmichael River, and where aquifers discharge as springs, contaminants may also be released into surface waterways. (Impacts on springs are addressed in Volume 2, Section 6.4.5 Water Resources.)

With implementation of appropriate management and mitigation measures the potential for land contamination to occur during the operational phase is considered to be low. However it is intended that neither phase of the Project will lead to land contamination requiring registration in the CLR. Furthermore, any notifiable activities under Schedule 3 of the EP Act, such as the storage of hazardous material, will be reported to DEHP. Sites notified under this process will be registered on the EMR.

The following overarching mitigation measures will be implemented to manage the potential impacts of spills:

- An Site Management Plan will be prepared for all sites notified and for any notifiable activities under the EP Act

- A spill response plan will be prepared and incorporated into an incident response plan, including requirements for spills to be reported, contained and cleaned
- Procedures for storing, handling, refuelling and using fuels, oils and other chemicals will also be developed and all staff will be trained accordingly
- Spill response kits and personal protective equipment will be placed in readily available locations wherever spills may occur. Material Safety Data Sheets will be readily available

These measures will all be included in the Project environmental management plan.

4.3.5 Management of Existing Contaminated Sites

A review of the presence and potential for land contamination within the Study Area did not identify any lots registered on the CLR and EMR. However, if site contamination is incidentally found to occur or a previously existing contaminated site is encountered, then the site will be assessed and managed in accordance with the contaminated land provisions of the EP Act, National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM, 1999) and Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland (DoE, 1998; now administered by DEHP). Specific measures include:

- A site contamination assessment (SCA) will be undertaken in accordance with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM, 1999)
- Management and remediation will adhere to a Site Management Plan or Remediation Action Plan approved by DEHP
- Validation sampling will be conducted to verify that remediation is successful
- Any required long term monitoring will be provided for in the EM Plan (Mine) and EMP (off-site infrastructure)

4.3.6 Management of Contamination During Operation of the Project (Mine)

4.3.6.1 Runoff

Potential Impacts

Weathering of overburden and interburden stockpiles may result in the release of contaminated runoff, in particular if these materials are potentially acid forming (PAF). Emissions from the stockpile could consequently contaminate surrounding soils, groundwater or surface water. Land contamination resulting from acid and heavy metal generation from overburden is considered in Volume 4 Appendix V.

Mitigation Measures

Contaminated materials should be placed within waste landforms the likelihood of contacting runoff water would be reduced. Stormwater should be diverted away from disturbed areas. Sediment laden water should be treated on site.

The storage of overburden is a notifiable activity under the Schedule 3 of the EP Act and will be reported to DEHP for registration on the EMR.

4.3.6.2 Process Waste

Potential Impacts

Mining waste will include overburden and interburden materials, coal washing coarse rejects and tailings. Initially, all overburden and interburden will be dumped on the out-of-pit dump areas over EPC1080 and eastern side of subcrop on EPC1690. The tertiary overburden will be dumped in the upper sections of the dump profile as a cap over the underlying fresh Permian materials.

All mineralised inter-burden associated with the coal seams will be dumped in the lower layers of the out-of-pit dumps, or within the pit void, to prevent contamination of the surface waters. Based on the assessment undertaken to date (see Volume 4 Appendix V) the majority of the overburden and interburden materials (not immediately adjacent to the coal seams) and roof and floor wastes are not likely to be a source of acid immediately after mining. Nor would most of these materials be expected to an immediate source of salinity. However, some portion could be a source of salinity. The clay materials of the overburden and interburden could have a markedly higher potential to release salts and metals to contact water even though the pH may remain alkaline. Typically however the concentrations of metals in water contacting the waste would be expected to be low while waters remain circum-neutral.

A portion of the carbonaceous mudstone and claystone roof and floor and coal materials could be expected to be potentially acid forming in the longer term. The majority of the overburden and interburden waste from all lithological groups, except possibly mudstone, is likely to be non-acid forming in the longer term. Some mudstone, carbonaceous mudstone, and claystone may be acid forming in the long term and there may be a requirement to manage these materials to prevent or limit the longer-term development of acid mine drainage (AMD). All siltstone overburden and interburden samples were classed as non-acid forming (NAF).

Given the physiochemical characteristics of the waste material it is expected that all mine waste can be effectively managed.

Mitigation Measures

Process wastes will be stored to prevent releases into the environment. Coal CHPP rejects and tailings will be disposed of in below ground voids in Pit J and Pit G, which can subsequently be capped with spoil at the end of the mine life. Temporary above ground pondage facilities for tailings disposal will be capped and decommissioned as soon as permanent below-ground storage is available. Coarse rejects from the CHPP will be blended back into overburden spoil dumps from the CHPP rejects bin. Fine rejects and tailings (materials left over after the process of separating uneconomic fraction of the resource) will be co-disposed in a series of below ground tailings impoundments for the first 10 to 12 years of operations. Thereafter the fine material will be placed in a below-surface open cut void, which will be excavated in the early years of mine operation.

Lots used for storage of process waste will be registered on the EMR.

4.3.6.3 Vehicle Washes

Potential Impacts

Water used to wash vehicles is likely to become contaminated with hydrocarbons from the vehicles. The hydrocarbons may be present in the water as a chemical emulsion, or attached to sediment. If this water is allowed to run overland, it may result in deposition of hydrocarbons on soils. Generally, the concentrations of hydrocarbons in vehicle wash water is unlikely to be high enough to cause any significant soil contamination through this deposition process and natural biodegradation processes may be adequate to remove any deposited hydrocarbons. However, over a long period of time, hydrocarbon build-up may occur. This possibility, together with the potential impacts of hydrocarbon contaminated water entering watercourses will mean that water from vehicle washes must be managed.

Mitigation Measures

Water from washdown facilities will be contained and passed through treatment systems to remove hydrocarbons and sediment. The water will either be recirculated for vehicle washing or returned to the general mine water management system and the oil and oily sediment collected in the treatment system removed and disposed of either to an on-site landfill or by an external waste contractor.

4.3.6.4 Bulk Fuel and Oil Storage and Handling

Section 12.2.3 of the Hazard and Risk Chapter (Volume 2, Section 12), specifically Table 12-5, details the indicative list of hazardous substances from the mine operation.

Potential Impacts

Storage, transportation and disposal of bulk fuel and oil during the construction and operation phases creates a risk of spillage and consequent contamination of soil and groundwater.

An assessment of risk of fuel and oil spills during transport, storage and use has been undertaken as part of the hazard and risk assessment presented in EIS Volume 2 Section 12.

Mitigation Measures

Diesel will be kept in self-bunded double skinned tanks which are designed in accordance with Australian Standard AS 1940:2004. The following mitigation measures will be implemented to minimise the risk associated with fuel or oil leaking from storage tanks:

- Tank level indicators will be installed for monitoring fuel and oil levels and a fuel/oil inventory will be kept so that leaks can be detected
- Maintenance of tanks will be undertaken to ensure safe and effective operation
- Bulk storage tanks will be designed in accordance with AS 1692:2006

Dangerous goods and potential contaminants will be transported in accordance with Australian Code for Transport of Dangerous Goods by Road and Rail. Potential for spillage of hydrocarbons will be minimised through the observation of standard operating procedures for transport, handling and storage of hydrocarbons. Regular inspections of all fuel and oil storage areas will be undertaken to check for leaks, spills and to check that bunds are empty, tanks and containers not showing any apparent damage and that spill containment and clean up equipment is in place.

Additional measure in relation to minimise the risk of spills of fuels and oils are contained in EIS Volume 2 Section 12 Hazard and Risk.

4.3.6.5 Fuel and Oil Spills

Potential Impacts

Refuelling by mobile fuel trucks during the construction phase presents a risk of spillage and consequent contamination of soils. As the capacity of mobile refuelling tankers is typically 20,000 L, the quantity of diesel that might be released is relatively small. Soils in the Project (Mine) area generally have high sand or fine content and spills are likely to infiltrate quickly rather than flow across the land. Some topsoils are underlain by harder material that may retard vertical infiltration of contaminants.

Smaller leaks of 10-20 L of hydraulic oil may also occur from equipment where hydraulic hose breakages occur anywhere that equipment and plant is operated. These breakages will result in localised contamination and, if in a regularly trafficked area, such contamination may build up over time.

Oil spills may also occur in workshops while undertaking equipment maintenance. Quantities will generally be small, in the order of up to 100 L and if the spill occurs within the contained workshop areas, soil contamination is unlikely to arise, unless the spill is left untreated.

If not managed, soils contaminated with hydrocarbons may cause flow on environmental impacts as identified in Section 4.3.4.1.

Mitigation Measures

Mitigation measures in relation to fuel and oil spills must focus on:

- Preventing spills from occurring
- Containing and cleaning up spills that do occur

The following mitigation measures will be minimise the risk of fuel or spills:

- Transportation of fuels and oils within the mine site will be in accordance with relevant requirements of the Australian Code for Transport of Dangerous Goods by Road and Rail
- Wherever practical, refuelling of vehicles and mobile equipment will be undertaken at designated locations with sealed and bunded pads draining to a sump
- Both mobile and fixed refuelling activities will be carried out in accordance with a set procedure and will be supervised at all times
- Operators involved in refuelling activities will be trained in spill response
- Spill containment and clean up equipment will be available at all fixed refuelling locations and in all mobile tankers
- Workshop areas will be designed with a sealed floor, rollover bunds and drainage to a sump
- Workshops and refuelling areas will not be cleaned by hosing with water

In the event that spills and leaks occur to soils, the contaminated material will be removed as soon as practicable after the spill, unless the quantity is very small and the spill occurred in a location where the is a low risk of any further environmental impacts occurring. Contaminated soil material will either be stockpiled and bio-remediated or disposed of as a regulated waste. Off-site disposal may require a permit under the EP Act to move soil from a property listed on the EMR.

4.3.6.6 Sewage

Potential Impacts

Wastewater may contain a range of contaminants that, if released to soil, may cause contamination. Wastewater generated at the workers accommodation village and amenities within the mine site will be of human origin and will not contain metals, hydrocarbons and other contaminants of particular concern in relation to soil contamination. Nevertheless, spills of untreated wastewater to land may result in release of pathogens which may create a human health risk and nutrients in wastewater, while not generally of concern for soil contamination could have adverse effects if mobilised to surface waters and groundwater.

Operation of the sewage treatment facility at the workers accommodation village and MIA may risk spillage and consequent nutrient contamination of soil, groundwater or surface water. Land contaminated with sewage poses a risk to human health due to potential infection from harmful bacteria and viruses.

Mitigation Measures

Sewage will be treated on-site with package sewage treatment plants to Class A or Class A+ in relation to pathogens. Reuse and disposal options will be assessed during the design phase of the Project.

4.3.6.7 Regulated and Domestic Waste

Potential Impacts

Wastes likely to be generated during construction and operation are identified in Volume 2, Section 10. Of wastes potentially generated, waste oils and oily wastes and waste solvents and paints may give rise to soil contamination if not properly managed. Improper disposal in particular may give rise to significant soil contamination over time.

Soils contamination may also occur if there is an accidental spill of leak occurs from a waste container, however in this instance quantities will be relatively small, in the order of up to 100 L.

Mitigation Measures

Management measures for potentially hazardous wastes are proposed in Volume 2, Section 14 and will address the potential for contamination to arise due to improper disposal. If on-site disposal of waste oils and solvent and paint wastes is proposed, this will be to a properly engineered landfill facility capable of containing these types of wastes.

Waste oils and oily wastes will be stored in designated areas with containment in place to capture any spills and leaks.

4.3.7 Summary of Contaminated Land Assessment

A review of the presence and potential for land contamination within the Study Area did not identify any lots registered on the CLR and EMR.

The construction and operation of the Project may increase human exposure to pre-existing contaminated land, or mobilise those contaminants into the water column and sediments, or may release contaminants into soil, groundwater or surface water. It is intended that neither phase of the Project will lead to land contamination requiring registration in the CLR. Notifiable activities listed under Section 3 of the EP Act, carried out as part of the Project (Mine), will be reported to DEHP for registration on the EMR. Any potential impacts can be managed effectively by implementing the appropriate mitigation measures.

4.4 Land Use and Tenure

4.4.1 Introduction

A land use and tenure assessment has been undertaken for the Project (Mine) (refer to Volume 4 Appendix M Mine Land Use Report) which identified the potential impacts of the construction and operation of the Project (Mine) on land uses in and around the Project Area. The current land use of the Project Area is low intensity cattle grazing.

Tenure typically refers to a lease or freehold which conveys possession of land to a person (DERM 2010) while land use refers to the primary use of the land, which may require authorisation by State and local government authorities.

A land use and tenure assessment was undertaken as part of the EIS for the purposes of identifying the potential impacts of the Project (Mine) upon the existing environment throughout the construction and operation of the Project (Mine). Where required, appropriate mitigation measures have been identified to mitigate or alleviate such impacts. The assessment has been undertaken on the basis of a desktop study and community consultation and focused on analysis of factors including but not limited to land use and tenure, Strategic Cropping Land (SCL), Good Quality Agricultural Land (GQAL), existing and proposed infrastructure, cultural heritage and native title.

This section of the EIS responds to Section 3.2.4 of the Project ToR in relation to the Project (Mine). A detailed cross-reference of compliance with the Section 3.2.4 of the Project ToR is provided in Volume 4 Appendix M. A full assessment of the Project (Mine) against the relevant land use planning provisions such as State Planning Policies (SPPs), local government planning schemes and the applicable regional plans has been undertaken in Volume 4 Appendix D.

4.4.2 Methodology

The land use and tenure assessment has been undertaken on the basis of a desktop assessment and community consultation. The desktop assessment involved a review and analysis of the following:

- Legislative requirements and guidelines relevant to the scope and location of the Project (Mine) including but not limited to the *Land Act 1994, Mineral Resources Act 1989* (MR Act), *Land Protection (Pest and Stock Route Management) Act 2002* (LP (PSRM) Act) *and* DERM *Guide to Tenure under the Land Act 1994, 2010*
- GIS analysis to accurately determine how the Project (Mine) relates with key features and tenure information of directly affected properties, such as ownership, rural and mining leases and licences, native title claims and determinations, and location of existing infrastructure (roads, rail lines, gas and water pipelines, stock routes, sensitive receptors and areas of ecological significance)
- Relevant regional plans, specifically the *Mackay, Isaac and Whitsunday Regional Plan 2012*
- Relevant infrastructure plans and mining data retrieved from the *Coal Plan 2030* (DIP, 2010), *Queensland Infrastructure Plan 2011* (DLGP, 2011)
- Feedback from landholder consultation on the potential impacts and issues associated with the Project (Mine), contained within Volume 1 Section 5 of the EIS

A detailed methodology for the land use and tenure impact assessment is contained within Volume 4 Appendix M.

4.4.3 Project Area

For the purposes of the land use and tenure assessment, the Project Area is defined as:

- Project (Mine) onsite infrastructure area, which comprises all Mine infrastructure that is proposed to be developed within the mining lease area
- Project (Mine) offsite infrastructure area, which comprises all Mine infrastructure that is proposed to be developed outside the mining lease area

Table 4-23 describes the Project Area, in terms of land use and tenure.

4.4.4 Description of Environmental Values

4.4.4.1 Regional Overview

From a regional perspective, the Project Area is located across two regional planning areas, with approximately 46,383 ha of the Project Area being part of the Mackay, Isaac and Whitsunday (MIW) Region and approximately 167 ha being part of the Northern Region of Queensland (for which there is no Regional Plan). Accordingly, the *Mackay, Isaac and Whitsunday Regional Plan 20*12 (MIWRP) is applicable to the Project Area.

For the purposes of this assessment, it is appropriate to consider that the regional context constitutes the area subject to the Regional Plan affecting the Project Area, in this case the MIWRP. Section 1.10 of the Project ToR states that the Project (Mine) should be assessed against the Central West Regional Plan (CWRP). The Central West covers the regional council areas of Barcaldine, Barcoo, Boulia, Blackall-Tambo, Diamantina, Longreach and Winton. The Barcaldine council area is the closest regional council area to the Project (Mine), located 30 km from the boundary. Therefore it is assessed that there is no impacts from the Project (Mine) in this Regional Plan area, and it is not further discussed in this assessment.

No regional plan has yet been prepared for the Northern Region (DSDIP, 2012) as such an assessment of impacts arising (noting 167 ha of the Project Area is located within the Northern Region) cannot be undertaken against a regional plan. However, as this is a very small proportion of the overall project, and there are no distinct community or land use changes associated with the regional boundary, it is considered that assessment against the MIWRP provides an adequate level of assessment.

The Project (Mine) is located within the *regional landscape and rural production area* (RLRPA) within the MIW region. RLRPA covers 99.7 per cent of the MIW region and is associated with rural production and values such as cultural and landscape heritage values, extractive resources of economic significance, including mining and forestry plantations, good quality agricultural land (GQAL) and strategic cropping land.

A review of the overarching desired regional outcomes (DROs) prescribed by the MIWRP has been undertaken for the Project (Mine) for the purposes of identifying how the Project (Mine) complies with the MIWRP's planning outcomes. On the basis of assessment undertaken in Volume 4 Appendix D, it has been identified that the construction and operation of the Project (Mine) is generally compatible with the DROs (refer to Volume 4 Appendix D for further information).

4.4.4.2 Local Context

The Project is located across two regional LGA,councils, with the majority of the proposed mining lease in the IRC LGA and a small area in the north-west within the Charters Towers Regional Council (CTRC)

LGA. Development within the IRC LGA is regulated through the *Planning Scheme for Belyando Shire 2009* while development within the CTRC LGA is regulated through the *Planning Scheme for Dalrymple Shire 2006.*

Approximately 167 ha of the Project Area is located within the CTRC LGA and 46,383 ha within the IRC LGA. The Project Area is located within the rural zone under both the *Planning Scheme for Belyando Shire 2009* and the *Planning Scheme for Dalrymple Shire 2006.* Establishment of the 167 ha area of the Mine within the CTRC LGA is not subject to the provisions of the *Planning Scheme for Dalrymple Shire 2006* as it is located within a mining lease and is exempt from SP Act requirements.

An assessment of the Project (Mine) against the desired environmental outcomes (DEOs) of the *Planning Scheme for Belyando Shire 2009* has been undertaken in Volume 4 Appendix D. Given that the construction and operation of the Project (Mine) will be developed within the rural zone of the Belyando Shire which encourages mineral resource development and the Project (Mine) will contribute to the economic growth on the local, regional and national levels, the development of the Project (Mine) complies with the DEOs of the Scheme. Refer to Volume 4 Appendix D for a full assessment of the Project (Mine) against the DEOs of the *Planning Scheme for Belyando Shire 2009.*

4.4.4.3 Project Area Land Use and Tenure

The Project (Mine) lies across six leasehold properties, namely the Moray Downs, Carmichael, Albinia, Lignum, Doongmabulla and Mellaluka properties, all of which are operated as cattle stations (refer to Table 4-23 and Figure 4-19). Adani has purchased the leasehold for Moray Downs and is in discussions with landholders to secure mining rights over other affected properties using processes set out in the MR Act. Lot details and encumbrances and interests currently held within properties covered by the Project (Mine) are listed in Table 4-23 and Table 4-24 respectively.

Adani currently holds EPC1690 and has lodged a mining lease application (MLA) over this land (MLA70441). EPC1690 runs north-west to south-east, covering approximately 45 km in length and approximately 7 km in width. The tenure of the subject parcels of land is leasehold (refer to Figure Figure 4-20). As identified in Table 4-23, the majority of the subject parcels are on a Grazing Homestead and Perpetual Lease (GHPL) and Pastoral Holding (PL). A GHPL is an ongoing tenure issued for the purposes of grazing and/or agricultural purposes in accordance with the *Land Act 1994*, while a PL is a term lease issued for pastoral purposes. The surrounding land use is typically farmland, predominantly livestock with some cropping. There are some improvements existing within the Project (Mine) as part of these cattle properties, including paddocks, watering bores and access tracks.

A total of ten homesteads are located immediately within/surrounding the Project Area (within approximately a 20 km radius). Eight of these homesteads are more than 1.4 km away from the Project Area, while two, namely the Labona and Mellaluka homesteads, are located immediately within the Project Area (refer to Table 4-25 and Figure 4-19). The Labona Homestead, located within the central eastern portion of the mine, will be demolished as part of the Project (Mine) construction activities. The Mellaluka homestead will remain as this portion of the Project Areas will not be utilised for mining activities. Should Adani wish to utilise this portion of EPC1080, the impact upon the Mellaluka homestead will be reassessed as part of the mining activity.

Table 4-23 describes the tenure of the Project (Mine) and surrounding area.

Table 4-23 Project Area Land Use and Tenure

Project Component	Property Details	Area within the Property (ha)	Current Land Use	Current Tenure/Category of Tenure
Mine Area	Lot 1 on AY35 (Carmichael)	167	Cattle grazing	Leasehold (Grazing Homestead Perpetual Lease)
	Lot 1 on SP164918 (Lignum)	4,242	Cattle grazing	Leasehold (Grazing Homestead Perpetual Lease)
	Lot 662 on PH1491 (Moray Downs)	20,857	Cattle grazing	Leasehold (Pastoral Holding)
	Lot 633 on SP228220 (Doongmabulla)	64	Cattle grazing	Leasehold (Pastoral Holding)
Road Easements	Several properties	686	Road	Road easement
	Total area of EPC1690 including road easements: 26,016 ha			
	Total area of EPC1690 excluding road easements: 25,330 ha			
Out-of-pit Spoil Disposal	Lot 662 on PH1491 (Moray Downs)	12,065	Cattle grazing	Leasehold (Pastoral Holding)
	Lot 1 on SP164918 (Lignum)	4,059	Cattle grazing	Leasehold (Grazing Homestead Perpetual Lease)
	Lot 3 on DR17 (Albinia)	119	Cattle grazing	Leasehold (TL)
	Lot 5091 on PH1882 (Mellaluka)	2,339	Cattle grazing	Leasehold (PPH)
	Lot 2093 on PH1883 (Madison)	47	Cattle grazing	Leasehold (TL)
Road Easements traversing	Several properties	85	Road	Road easement
	Total area for part of EPC1080 including road easements: 18,714 ha			
	Total area for part of EPC1080 excluding road easements: 18,629 ha			

Project Component	Property Details	Area within the Property (ha)	Current Land Use	Current Tenure/Category of Tenure
Mine offsite infrastructure: Workers accommodation village	Lot 662 on PH1491 (Moray Downs)	74	Cattle grazing	Leasehold (Pastoral Holding)
Mine offsite infrastructure: Permanent airport	Lot 662 on PH1491 (Moray Downs)	298	Cattle grazing	Leasehold (Pastoral Holding)
Mine offsite infrastructure: Rail siding area	Lot 662 on PH1491 (Moray Downs)	96	Cattle grazing	Leasehold (Pastoral Holding)
Mine offsite infrastructure: Heavy industrial area	Lot 662 on PH1491 (Moray Downs)	948	Cattle grazing	Leasehold (Pastoral Holding)
Mine offsite infrastructure: Water supply infrastructure	Lot 662 on PH1491 (Moray Downs)	413	Cattle grazing	Leasehold (Pastoral Holding)
	Total area for PH1491: 1,820 ha (Not 1,829 ha due to overlap of offsite infrastructure footprints)			
Total land area of Project Area (including easements and offsite infrastructure): 46,550 ha				

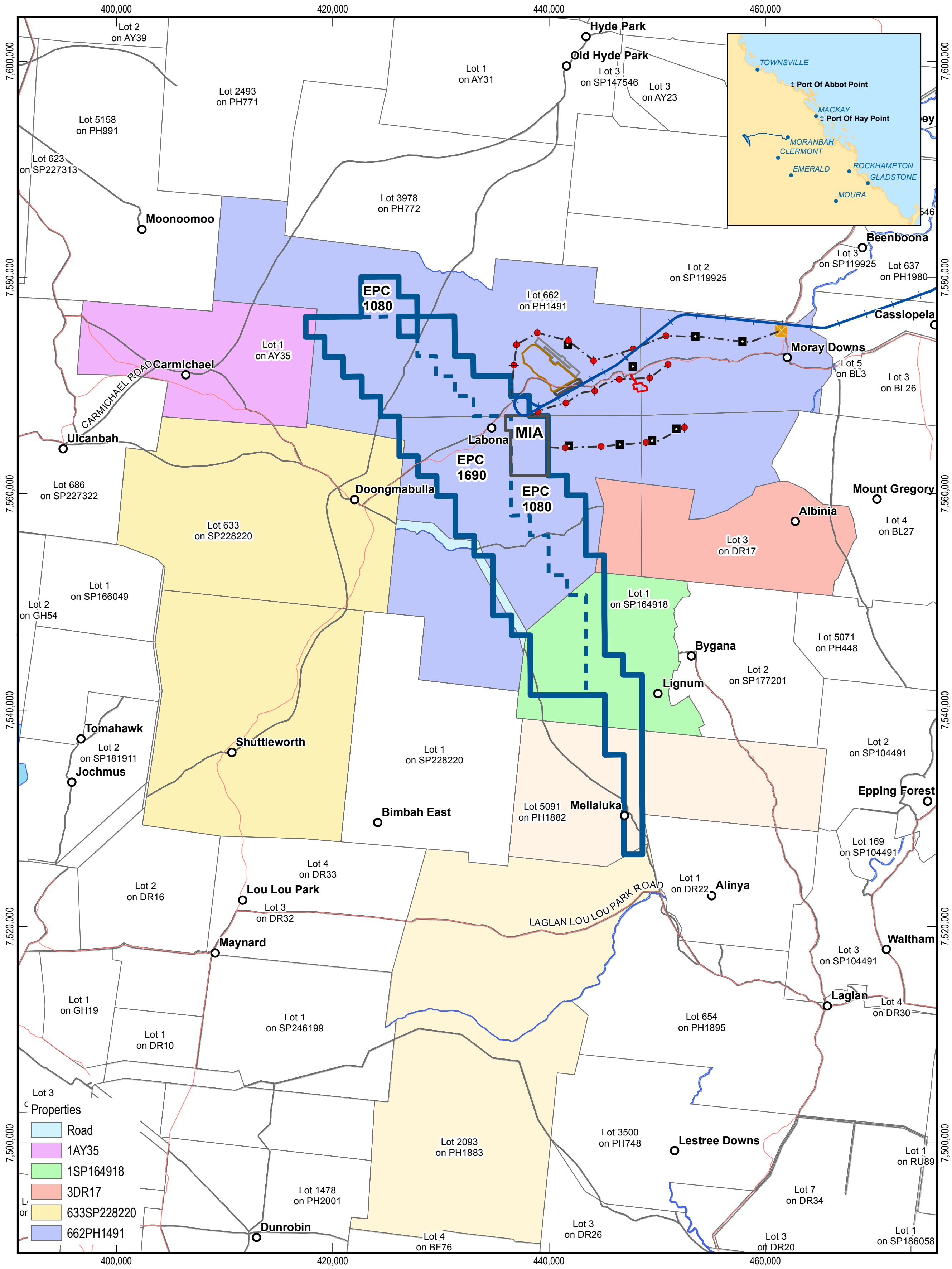
Table 4-24 Encumbrances and Interests

Project Component	Subject Property	Easement
Mine Area	Lot 1 on AY35	Easement Lease No. 17655213 Nature Refuge No. 704134903
	Lot 1 on SP164918	Easement Lease No. 40040496 Nature Refuge No. 708488668
	Lot 662 on PH1491	Easement Lease No. 17665183
	Lot 633 on SP228220	Easement Lease No.17665175
Out-of-pit Spoil Disposal	Lot 662 on PH1491	Easement Lease No. 17665183
	Lot 1 on SP164918	Easement Lease No. 40040496 Nature Refuge No. 708488668
	Lot 3 on DR17	Easement Lease No.40061637
	Lot 5091 on PH1882	Easement Lease No.17669158
	Lot 2093 on PH1883	Easement Lease No. 40058661

Project Component	Subject Property	Easement
Mine offsite infrastructure: workers accommodation village (including onsite services and amenities) and mine airstrip	Lot 662 on PH1491	Easement Lease No. 17665183

Table 4-25 Homesteads Immediately Within or Surrounding Project Area

Homestead Name	Land Use	Tenure	Location/Distance to Project (Mine)
Immediately within Project Area			
Lot 662 on PH1491 Labona	Rural	Leasehold	Within central eastern portion of Project (Mine), specifically EPC1690
Lot 5091 on PH1882 Mellaluka	Rural	Leasehold	On the southern boundary of Project (Mine), specifically EPC1080
Surrounding the Project Area			
Lot 662 on PH1491 Moray Downs	Rural	Leasehold	22.6 km east of the Project (Mine), specifically EPC1080
Lot 663 on SP228220 Doongmabulla	Rural	Leasehold	5.77 km west of Project (Mine), specifically EPC1690
Lot 1 on AY 35 Carmichael	Rural	Leasehold	11 km west of Project (Mine), specifically EPC1690
Lot 1 on SP228220 Bimbah East	Rural	Leasehold	18 km to the south west of Project (Mine), specifically EPC1690
Lot 1 on SP164918 Lignum	Rural	Leasehold	1.4 km to the east of Project (Mine), specifically EPC1080
Lot 2 on SP177201 Bygana	Rural	Leasehold	4.9 km to the east of Project (Mine), specifically EPC 1080
Lot 5158 on PH991 Moonoomoo	Rural	Leasehold	17 km north west of Project (Mine), specifically EPC1690
Lot 3 on DR17 Albinia	Rural	Leasehold	17.9 km east of Project (Mine), specifically EPC1080



LEGEND

Homestead	Cadastre	Rail (West)	Mine (Offsite)	Airport Location
State Road	Waterway	Mine (Onsite)	Borehole	Rail Siding
Local Road		Mine Infrastructure Area	Storage Site (Instream)	Industrial Area
			Storage Facility (Offstream)	Workers Accommodation Village
			Pipeline Network	

1:500,000 (at A4)

0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision B
Date 17-10-2012

Homesteads

Figure 4-19

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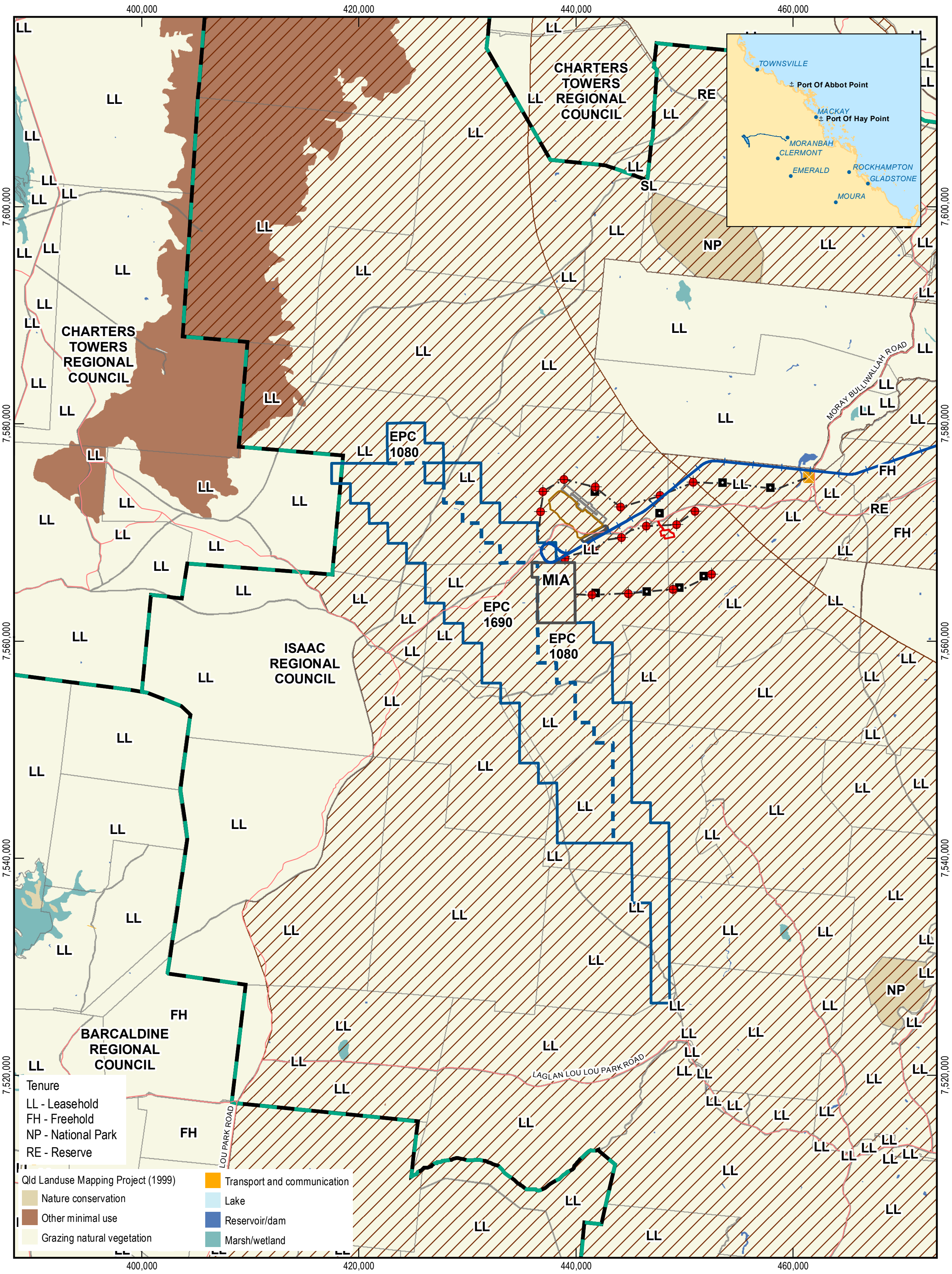
Data Source: GA: Homesteads, Roads (2007); DME: EPC 1690 (2010)/EPC 1080 (2011); DERM: Cadastre (2010), Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW,MS



LEGEND

- Town
- State Road
- Local Road
- Local Government Area
- Native Title Register
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision D
Date 17-10-2012

Project Area Land Use and Tenure — Figure 4-20

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GA: Roads (2007); DME: EPC 1690 (2010)/EPC 1080 (2011); DERM: Cadastre, LGA (2010), Landuse (1999), Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012) . Created by: BW,MS

4.4.4.4 Mining and Petroleum Tenure

Review of Queensland Government (2011) data illustrates that the Project Area is surrounded by a number of coal and petroleum exploration tenures. The majority of the identified tenures are located within a 20 km radius of the Project (Mine). These tenures are predominantly EPCs.

The following tenures have been identified within the immediate vicinity of the Project (Mine):

- EPC1080 owned by Waratah Coal Pty Ltd and running to the east and west of EPC1690
- EPC1105 owned by Waratah Coal Pty Ltd and running parallel to the western side of the Project (Mine)
- EPC1104 owned by Vale Coal Exploration Pty Ltd and running immediately to the south boundary of EPC1690
- EPC1078 owned by Vale Coal Exploration Pty Ltd and running immediately to the south of EPC1690
- EPC1957 owned by Mining Investments One Pty Ld and running immediately to the east of the Project (Mine)
- EPP1044 owned by Queensland Energy Resources Limited and running underneath the EPC1690 as well as extending to the east, south and west
- EPP744 owned by Comet Ridge Ltd located to the west of EPC1690
- PPL172 owned by Energy World Corporation traversing the Project Area (not granted and non-current)

Refer to Figure 4-21 and Volume 4 Appendix M for further information regarding the abovementioned mining tenures.

4.4.4.5 Existing and Proposed Infrastructure

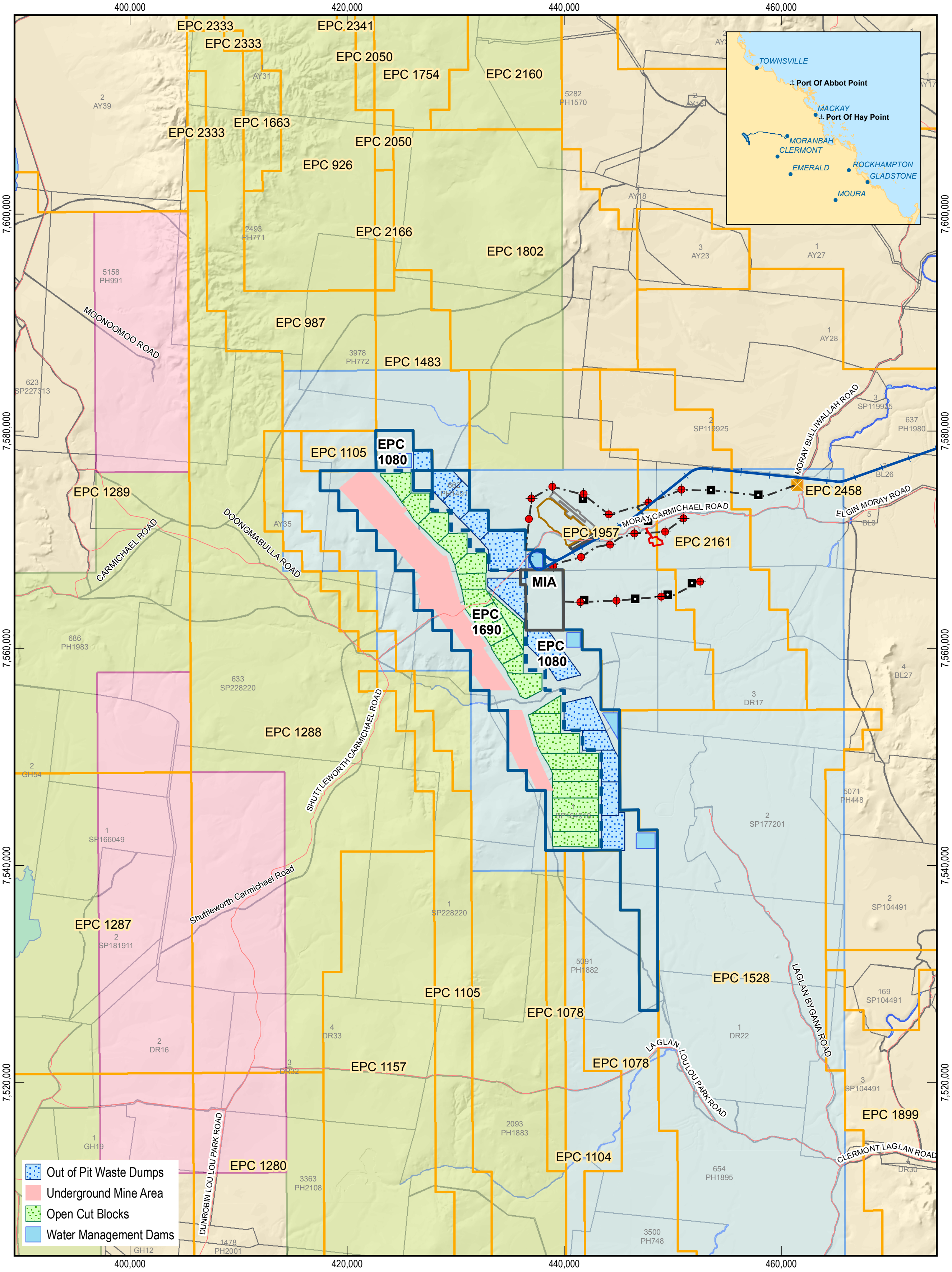
Existing and proposed infrastructure includes roads, railways, airports, landing strips, ports, gas pipelines, water pipelines, electricity easements or telecommunication easements within or near the Project Area, other than infrastructure proposed for the Project (Mine).

A review of the Queensland Infrastructure Plan (DLGP, 2011) and MIWRP identified the following existing infrastructure within the Project Area:

- The Moray Carmichael Road which traverses the Project (Mine) from west to east
- Stock Route U385BELY01, which traverses the open cut portion of the Project (Mine) and EPC1080 from west to north
- Stock Route U303BELY01, which traverses the underground portion of the Project (Mine) on the south-western boundary and the southern portion of EPC1080

Project (Mine) offsite infrastructure will be located on the Moray Downs cattle station, Lot 662 on PH1491. Proposed offsite infrastructure consists of a workers accommodation village, a permanent airport, land for development of a heavy industrial area and rail siding area, and offsite water supply infrastructure. The offsite water supply infrastructure will consist of a series of dams, boreholes, pipelines, storage facilities and pump stations and extend along the waterways North Creek and Belyando River, in the vicinity of other offsite infrastructure.

An upgrade and realignment of Moray Carmichael Road is also proposed, along with the establishment of access roads to the mine site and Project (Mine) offsite infrastructure. Refer to Volume 4 Appendix M Mine Land Use Report for further detail regarding existing and proposed infrastructure in the Project Area.



LEGEND

- State Road
- Local Road
- Cadastre
- Waterway
- EPC Boundary
- EPP 744
- EPP 1015
- EPP 1044
- Rail (West)
- Mine (Offsite)
- Mine Infrastructure Area
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

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Date 17-10-2012

Mining and Petroleum Tenure

Figure 4-21

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GA: Roads, Homesteads (2007); DME: EPC1690 (2010), EPC1080 (2011), EPC and EPP Boundary (2012); DERM: Cadastre (2010);Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW.

4.4.4.6 Strategic Cropping Land

A review of the mapping for Strategic Cropping Land (SCL) has been undertaken to identify if the Project (Mine) will interfere with any SCL. It has been identified that no SCL is located within or in near proximity to the Project Area.

4.4.4.7 Good Quality Agricultural Land

The Queensland Government recognises the importance of land that is capable of sustaining long-term agricultural practices for present and future agricultural commodities. Therefore, it is required that the location and extent of GQAL be identified and included in strategic plans, where present.

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. There are four classes (A to D) of agricultural land defined for Queensland as detailed in Table 4-26.

Table 4-26 Agricultural Land Classes

Class	Description
Class A	**Crop land** – Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels.
Class B	**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.
Class C	**Pasture 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.
C1	Land suitable for sown pastures with moderate limitations
C2	Land suitable for sown pastures with severe limitations
C3	Land suitable for light grazing of native pastures in inaccessible areas
Class 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 and DHLGP, 1993

Australia has a limited supply of good quality agricultural land, with only 1-2 per cent of land supporting highly productive agriculture. Environmental impacts from farming in these lands are easier to manage than in other areas, as the soil, topographic and climatic conditions are more favourable. Like any limited and non-renewable resource, it is important to conserve this land and SPP 1/92 Development and the Conservation of Agricultural Land sets up the policy basis for protecting land that is suitable for agricultural production.

A desktop review has been undertaken over the Project (Mine) EPC1080 area and the offsite infrastructure areas based on the Planning Scheme for Belyando Shire 2009. The Planning Scheme recognizes classes A, B and C1 GQAL land. In general most of the land within the EPC1080 Project (Mine) area and the offsite infrastructure area is not considered as GQAL based on the planning scheme. However, some pockets of GQAL Class B and C1 were identified in the central and southern extent of the EPC1080 area and pockets of GQAL Class A, B and C1 were identified within the workers accommodation village.

A soil survey has been undertaken over part of EPC1690 (refer to Volume 4 Appendix L). The survey did not identify the presence of Class A and B of Good Quality Agricultural Land (GQAL) which confirms the Department of Natural Resources and Mines (DNRM) mapping for the area (see Figure 4-22).

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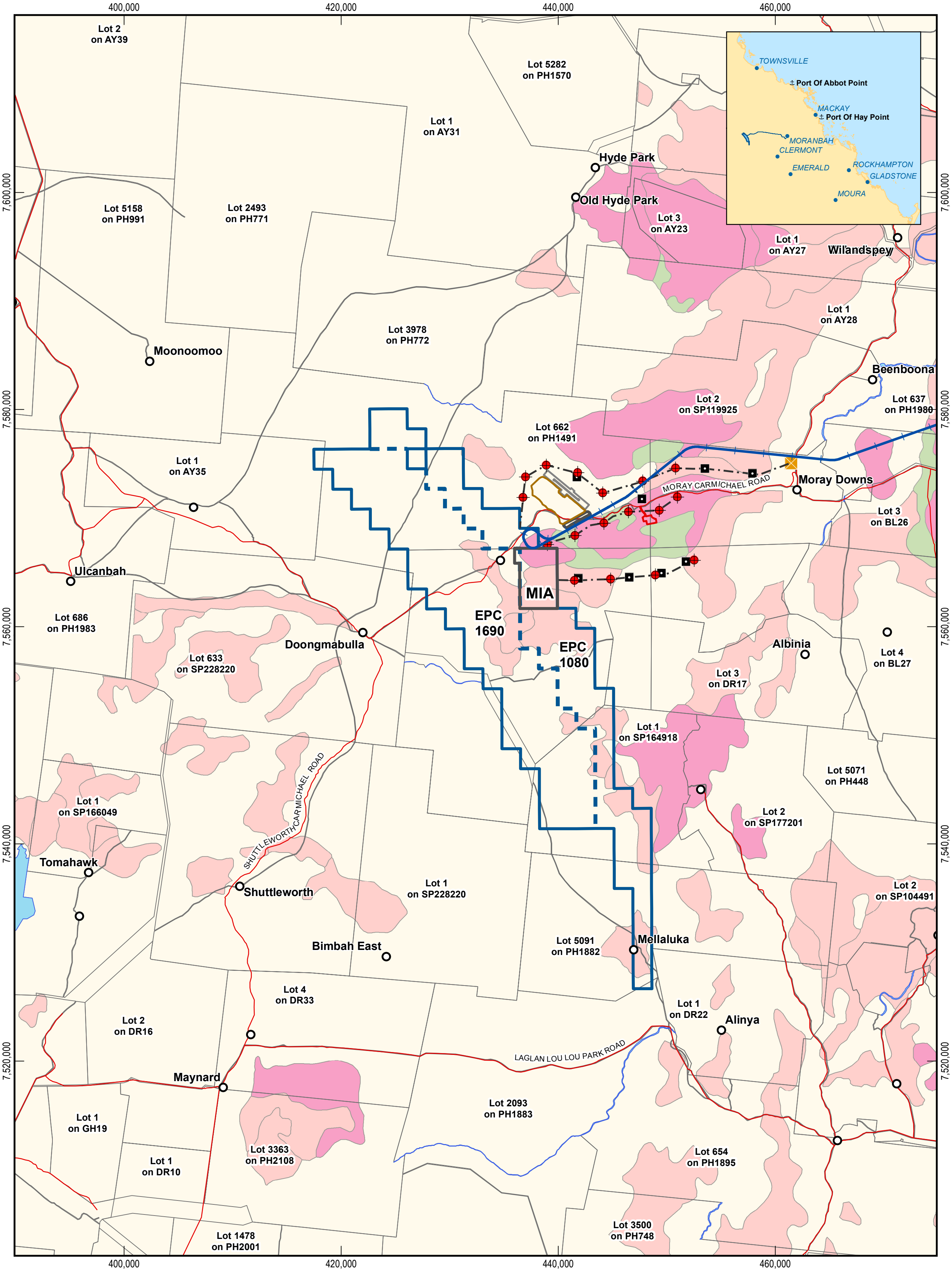

LEGEND

Homestead	Rail (West)	**Mine (Offsite)**	Airport Location	**GQAL**
Local Road	Mine (Offsite)	Borehole	Rail Siding	A
Cadastre	Mine Infrastructure Area	Storage Site (Instream)	Industrial Area	B
Waterway		Storage Facility (Offstream)	Workers Accommodation Village	C1
		Pipeline Network		

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision D
Date 17-10-2012

Good Quality Agricultural Land

Figure 4-22

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GA: Homesteads, Local Road (2007); DME: EPC 1690 (2010)/EPC 1080 (2011); DERM: Cadastre (2011); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); Belyando Shire Council Planning Scheme: GQAL (2008). Created by: BW, MS

4.4.4.8 Cultural Heritage

A cultural heritage assessment has been undertaken by ARCHAEO Cultural Heritage Services (ARCHAEO) as part of the Project EIS (refer to Volume 1 Section 7). The assessment was conducted at bore pads and other early infrastructure across the Project Area (specifically the EPC1690 component). The assessment located 39 culturally significant sites, including several large sites incorporating numerous scattered artefacts at high density, against a continuous background scatter of lower density.

Large sites of special significance were located in areas with major waterways, such as the Carmichael River, Cabbage Tree Creek and a network of creeks and associated gilgai or soaks running roughly southerly across an area north of the Carmichael River (northern creek system). Scattered artefacts located away from these major waterways tended to be of lower density.

Potential impacts of the Project (Mine) onsite and offsite infrastructure upon the identified cultural heritage matters will be appropriately mitigated or avoided through implementation of the Cultural Heritage Management Plan (CHMP). The CHMP for the Project has been approved by the Wangan and Jagalingou Native Title claimants and the DEHP. Refer to Volume 1 Section 7 for further information regarding cultural heritage.

4.4.4.9 Native Title

A Native Title search has been undertaken on the Project Area, which identified that a Native Title Claim exists over the site, namely the Wangan and Jagalingou Native Title Claim boundary (QC04/5; QUD85/04 accepted for Registration on 5 July 2004). The Native Title Claim boundary is depicted in Figure 4-20).

Adani is currently undertaking negotiations with the Native Title claimants as per the following:

- Negotiations are currently being undertaken with the Wangan and Jagalingou People
- Early works agreements are in place with all Aboriginal parties, with early works managed for the Wangan and Jagalingou People through a CHMP
- A CHMP for the life of the Project has been established and approved by the Chief Executive for the Wangan and Jagalingou People
- Adani are progressing Native Title negotiations with relevant parties. Indigenous Land Use Agreements (ILUAs) and extinguishment assessments are being progressed.

4.4.4.10 Environmentally Sensitive Areas and Declared Water Storage Catchments

For identification of and assessment of potential impacts upon the Environmentally Sensitive Areas (ESA) refer to Volume 2 Section 5. For the declared water storage catchment relevant to the Project (Mine) refer to Volume 2 Section 6.

4.4.5 Potential Impacts and Mitigation Measures

4.4.5.1 Overview

The construction and operation of the Project (Mine) will have a direct impact upon the land use and tenure of the Project Area. The impacts will be consistent across both stages of the Project, with majority of the change occurring immediately at the commencement of the Project (Mine) construction.

4.4.5.2 Change in Land Use

Potential Impacts

The Project (Mine) will affect the current land use of the Project Area progressively, with the first ten (10) years of the Project (Mine) focusing on construction, overburden removal and open cut mining.

The potential impacts of the Project (Mine) upon land use include:

- Over the life of the Project (Mine), there will be a progressive change of 44,730 ha low intensity cattle grazing land use to a mining land use. This area of land will be developed for the purposes of establishing the Project (Mine) onsite infrastructure
- Change of 74 ha of low intensity cattle grazing land use to a residential land use for the purposes of the workers accommodation village. This change is likely to occur within the first construction year of the Project (Mine)
- Change of 298 ha of existing low intensity cattle grazing land use to special use (aviation) for the purposes of the permanent airport. This change is likely to occur within the first construction year of the Project (Mine)
- Change of 948 ha of existing low intensity cattle grazing land use for the purposes of establishing the heavy industrial area to be utilised for mine machinery maintenance and repairs, bulk fuel storage and other operations associated with the Project (Mine). This change is likely to occur within the first construction year of the Project (Mine)
- Change of 95 ha of existing low intensity cattle grazing land use for the purposes of establishing the rail siding area. This change is likely to occur within the first construction year of the Project (Mine)
- Change of 413 ha of existing low intensity cattle grazing land use for the purposes of establishing water supply infrastructure. This change is likely to occur within the first construction year of the Project (Mine)

Adani have lodged a mining lease application over EPC1690. Once a mining lease is granted Adani will have rights to establish mining activities over this area. Whilst Adani will have a lease to mine the property, the underlying leasehold tenure remains. A mining lease gives the holder the right to carry out the mining activity. The mining lease over EPC1690 impacts on the respective landholder as they lose the use of the land in its current form as it undergoes a permanent change from a rural use to a mining use. It is intended that another mining lease will be obtained over the eastern portion of EPC 1080, with the same effect.

Mitigation Measure

The impacts of the Project (Mine) upon current land use and tenure are unavoidable due to the location of the coal deposit.

Post mining land use is likely to be restricted to cattle breeding country, given the poor physical properties of the soil. Amelioration measures have been identified to improve the physical properties of the soil. Progressive rehabilitation of the Project Area will be undertaken over the life of the Project

(Mine). Rehabilitation is scheduled to commence in 2020, at completion of mining in I Pit. Volume 2 Section 2 Description of the Project identifies potential rehabilitation landforms.

4.4.5.3 Sterilisation of Potential Coal Deposit

Potential Impacts

Establishment of the Project (Mine) offsite infrastructure will require approximately 1,820 ha of land. This infrastructure is proposed to be established over EPC1957 and as such has potential to result in resource sterilisation. A geological investigation has been conducted and a report issued from Xenith Consulting stating that the likelihood of viable coal being present under EPC 1957 is low (refer Volume 4, Appendix Z1 Xenith Rail Easement Study).

The eastern side of EPC1080 will be utilised for the out-of-pit dump spoil making it unlikely that this area could be utilised economically for mining in the future. Xenith consulting conducted a geological investigation over this area. The eastern side of EPC1080 is likely to be the eastern extent of the Permian coal seam. It is unlikely Permian age coal exists to the east of the EPC1080 (refer Volume 4, Appendix Z1 Xenith Rail Easement Study).

Mitigation Measure

Adani will undertake ongoing consultation with the holder of the EPC1957 in regards to project timing and progress in order to minimise where possible any sterilisation of coal resource which may be present.

4.4.5.4 Change in Amenity of Adjacent Land Uses

Potential Impacts

A total of ten homesteads are located within or surrounding the Project Area (within approximately a 20 km radius) (see Figure 4-19). Labona homestead located within the Project Area has been acquired and will be demolished as part of the Project (Mine) construction activities. On this basis it is no longer identified as a sensitive receptor. The Mellaluka homestead is located within the southern portion of EPC1080 which is not currently planned to be utilised for stockpiling or mining activities. On this basis, the Project (Mine) is unlikely to affect this homestead. However, should Adani wish to utilise this portion of EPC1080, the impact upon the Mellaluka homestead will be reassessed.

The Project (Mine) will not generate land use related impacts upon the eight other homesteads surrounding the Project Area. The construction and operation of the Project (Mine) is unlikely to generate noise and vibration and dust related impacts upon the identified homesteads, however some changes to amenity may occur closer to the boundary of the mine activities (see Volume 4 Appendix U Mine Noise and Vibration and Volume 4 Appendix S Mine Air Quality Assessment). Further to this, no significant landscape and visual impacts upon these homesteads is predicted (see Volume 4 Appendix K Mine Landscape and Visual Assessment).

Road access to properties will be maintained at all time during operations. The Moray Carmichael Road will be re-aligned as required during operations but will remain open providing public access west of the Mine. Re-alignment of the road is not expected to impact road users.

No other residential or industrial uses are located within or in near proximity to Project Area, as such the Project (Mine) will not affect any industrial land uses or residential (with the exception of Labona homestead).

Mitigation Measure

Refer to Volume 2 Section 7 Air Quality and Volume 2 Section 9 Noise and Vibration regarding mitigation measures for potential dust, noise and vibration impacts upon sensitive receptors.

4.4.5.5 Alteration of Stock Route Network

Potential Impacts

The Project (Mine) impacts on two stock routes:

- Stock Route U385BELY01 runs across the northern end of both the Project (Mine) and EPC1080 (running from west to north). This stock route will run over the portion of the Project (Mine) to be developed for open cut mining.
- Stock Route U303BELY02, which runs on the south-western boundary of the Project (Mine). This stock route runs over the portion of the Project (Mine) to be developed for underground mining. It will also run through the southern portion of EPC1080, which at this stage is unlikely to be utilised for stockpiling or mining activities. Should this portion of the Project Area be utilised for either mining or stockpiling, impact upon this stock route will be reassessed.

Stock Route U383BELY01 is likely to be closed as it will interfere with the proposed open cut mining operations. Adani is currently undertaking further investigations and discussions with DNRM regarding re-alignment of this stock route.

Stock Route U303BELY02 is likely to be affected by the Project (Mine) as the stock route traverses the south-western boundary of the Project Area, which is to be used for underground mining operations. An investigation report into likely mine subsidence provided by Mine Subsidence Engineering Consultants (MSEC), predicts a maximum of 7.5 m of subsidence at the surface over the shallow longwalls with the total subsidence decreasing with depth. This stock route will be realigned during underground mining operations to avoid areas impacted by subsidence. The stock route will be reintroduced once mining is complete, subsidence has occurred and the land surface is stable.

Mitigation Measure

The following mitigation measures are proposed for the existing stock routes within the Project Area:

- Request DNRM to designate a stock route deviation outside of the Project Area prior to closing the current alignment of the stock route. This will avoid delays and disruption to stock route use.

Adani has undertaken relevant consultations with the IRC in March 2011 regarding the affected stock routes. Adani will continue to consult with the IRC and DNRM in order to avoid causing undue disruption to the use of the subject stock routes.

4.4.5.6 Alteration of Existing Road Network

Potential Impacts

Road access to the Mine site (specifically to the boundary of EPC1080) will be via approximately 80 km of currently unsealed local roads off the Gregory Developmental Road. Adani has entered into an agreement with IRC regarding the long term maintenance and development of the entire lengths of the Elgin Moray and the Moray Carmichael Roads which run from the intersection of the Gregory Developmental Road westerly through the Mine to intersect with the Shuttleworth Carmichael Road.

The roads will be upgraded in stages and maintained to a similar engineering standard as the Gregory Developmental Road.

Access east to west will be maintained during the operation of the Project (Mine) yet the alignment of the Moray Carmichael Road may vary during this time depending on the mining activities. Realignment of the Moray Carmichael road near the site of the workers accommodation village is also planned.

Mitigation Measure

The alignment of the Moray Carmichael Road running through the Mine may move from time to time to accommodate mining activity, however it will continue to be open to the public and meet a required engineering standard. Adani will also work with IRC and landholders along the route to realign the road in places to provide a better alignment to accommodate mining traffic.

Adani is also working with the Department of Transport and Main Roads (DTMR) in the design of grade separated road/rail crossing points and intersection improvements. Additional and improved signage around intersections and road/rail crossings will also be developed and installed to comply with DTMR requirements.

Ultimate road closure of the Moray Carmichael Road will not be considered and the utility of Moray Carmichael Road as a public road link will be maintained at all times.

4.4.5.7 Good Quality Agricultural Land

Potential Impact

A soil survey has been undertaken over part of the Project Area, being EPC1690 (refer to Volume 4 Appendix L). The survey did not identify the presence of Class A and B of Good Quality Agricultural Land (GQAL) which confirms the DNRM mapping for the area (see Figure 4-22). The DNRM mapping identifies the presence of C1 GQAL and the soil survey confirmed and delineated the extent of C1 GQAL. Approximately 964 ha of C1 GQAL (identified as Class 3 within Volume 4, Appendix I, Table 7) is present within EPC1690, specifically to the north of the Carmichael River and south of the Cabbage Tree Creek.

As a result of this analysis, it is concluded that the EPC1690 contains limited GQAL and as such has been assessed as "breeding country" with limited agricultural potential. Accordingly, an assessment of only the grazing suitability has been undertaken for the EPC1690 (refer to Volume 4, Appendix I).

The Project (Mine) EPC1080 and the offsite infrastructure area has the potential to fragment land parcels leading to a reduction and loss of access to agricultural land. GQAL mapping indicates that in the order of 7,477 ha (EPC1080) and 1,749 ha (offsite infrastructure area) of GQAL classed as A, B and C1 will potentially be affected by the Project, as detailed in Table 4-27. Further soil studies are proposed to be undertaken to assess the occurrence of GQAL in EPC1080 and the offsite infrastructure area (see Volume 4, Appendix M for further detail)

The potential loss of Class A and Class B GQAL is small and will not have an impact on agricultural development within the area.

Table 4-27 Good Quality Agricultural Land within the Project (Mine)

GQAL Class	Area within the Project (Mine) EPC1690 (ha)	Area within the Project (Mine) EPC1080 (ha)	Area within the Offsite Infrastructure Area (ha)
A	-	-	392.2
B	-	693.79	1,227.2
C1	964	6,783.3	129.7
Total	964	7,477.09	1,749.2

Management Measures

There is limited impact to GQAL and this is unavoidable.

Post mining land use is likely to be restricted to cattle breeding country, given the poor physical properties of the soil. Amelioration measures have been identified to improve the physical properties of the soil. Progressive rehabilitation of the Project Area will be undertaken over the life of the Project (Mine). Rehabilitation is scheduled to commence in 2020, at completion of mining in I Pit. Volume 2 Section 2 Description of the Project identifies potential rehabilitation landforms.

4.4.5.8 Impact upon Other Infrastructure

Potential Impacts

No other known existing infrastructure (rail, airports, landing strips, ports, gas and water pipelines or electricity and telecommunication easements) are present within or in near vicinity to the Project Area, as such no other impacts are likely to be generated.

The Project (Mine) is not in close proximity to any known proposed infrastructure as such no impact will be generated by the Project (Mine).

Mitigation Measure

No mitigation measures are applicable.

4.4.6 Summary

The Project (Mine) will have a direct impact upon the current land use and tenure of the Project Area. A progressive shift from the current cattle grazing land use to a mining related land use will occur throughout the life time of the Project (Mine). These Project (Mine) impacts are unavoidable due to the location of the coal deposit. The mining lease over EPC1690 impacts on the respective landholder as they lose the use of the land in its current form as it undergoes a permanent change from a rural use to a mining use. However, the Project (Mine) will be decommissioned upon completion of the Project (Mine) life and the Project Area will be rehabilitated progressively to a state consistent with the surrounding habitat.

The Project (Mine) will not have an impact upon strategic cropping land, as there is no presence of strategic cropping land within the Project Area. No Project (Mine) impacts will be generated upon KRAs as the Project (Mine) is not in proximity to any KRAs identified within the MIW. The Project (Mine) will have an impact upon extents of Project Area consisting of Class A, B and C1 GQAL. There is limited impact to GQAL and this is unavoidable.

As detailed in Volume 4 Appendix U and Volume 4 Appendix S, the construction and operation of the Project (Mine) is unlikely to generate noise and vibration and dust related impacts upon the identified homesteads, however some changes to amenity may occur closer to the boundary of the mine activities. Road access to properties will be maintained at all time during operations. The Moray Carmichael Road will be re-aligned as required during operations but will remain open providing public access west of the Mine. Re-alignment of the road is not expected to impact road users.

The construction of the Project (Mine) will require closure of the stock route traversing the northern portion of the Project Area. However, no significant impacts are likely to be generated upon the use of the route if a stock route deviation is created outside of the Project Area. The stock route traversing the south-western boundary of the Project Area is likely to be affected by subsidence as this area to be used for underground mining operations. This stock route will be realigned during underground mining operations and reintroduced once mining is complete, subsidence has occurred and the land surface is stable.

Existing public roads will be enhanced to cater for current traffic, and traffic generated by the Project (Mine). Public roads leading to, and running through, the Project (Mine) will be upgraded and maintained by Adani in accordance with agreements with IRC. No other existing infrastructure is located within or near the Project Area and as such no other impacts are likely to be generated.

The Project (Mine) will not generate an impact upon proposed infrastructure as it is not in close proximity to any known planned infrastructure.