Appendix 14

Land Technical Report

Byerwen Coal Project – Land Technical Report

NRA Environmental Consultants
NATURAL RESOURCE ASSESSMENT AND MANAGEMENT

Document Control Summary

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1. Introduction and Scope

Natural Resource Assessments (NRA) was engaged by Environment and Licensing Professionals Pty Ltd (ELP) to prepare a technical report addressing selected land items from the Terms of Reference (ToR) for the Byerwen Coal Project environmental impact statement (EIS). Byerwen Coal Pty Ltd is the project proponent. The project scope was as follows.

- Describe land and soil related environmental values that may be impacted by the project.
- Assess potential impacts on land and soil related environmental values and the provision of mitigation measures to minimise those impacts.
- Assess cumulative impacts of the project with respect to soils and land only.

2. Land use and tenure

2.1 Description of environmental values

2.1.1 Landscape character

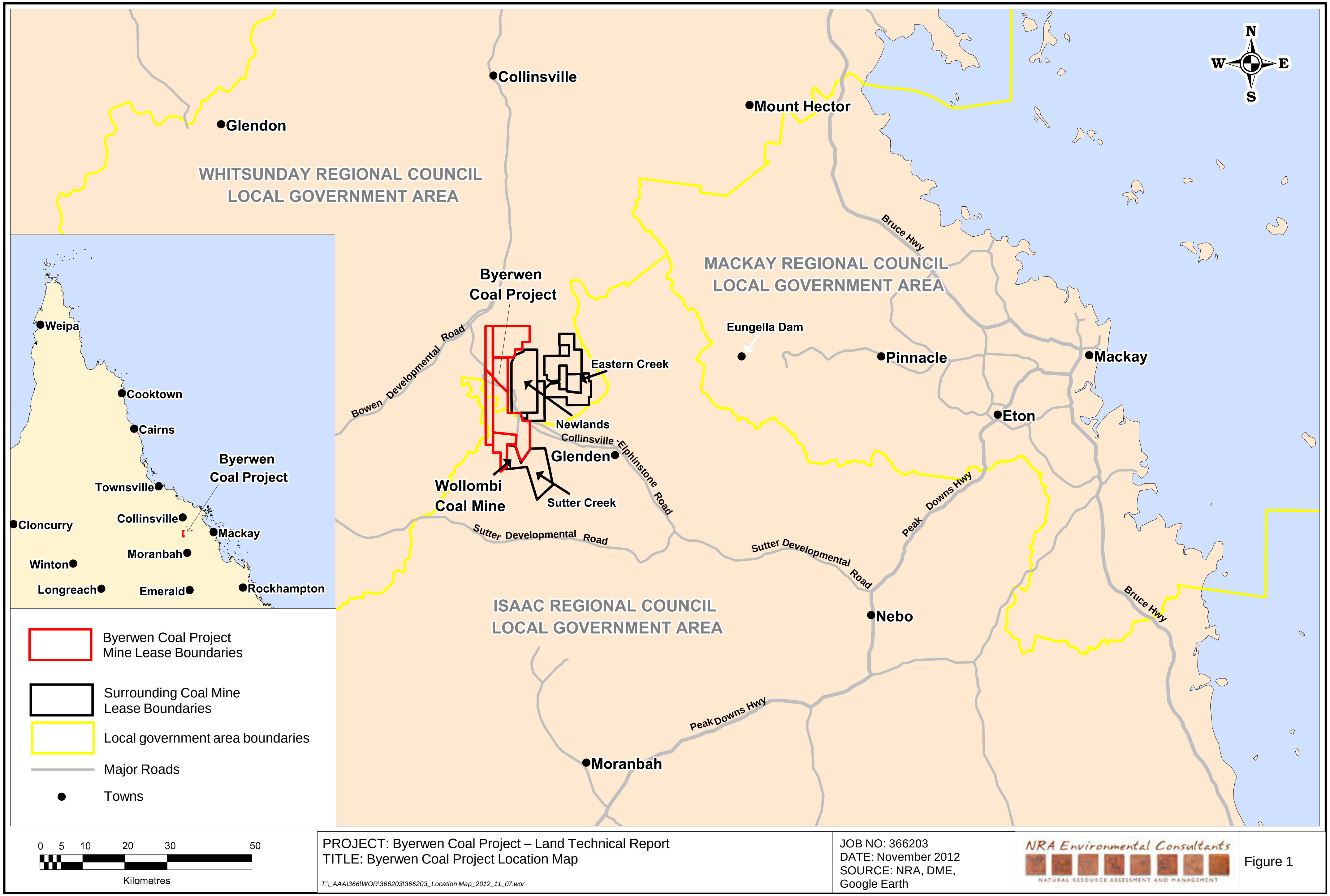
The Byerwen Coal Project (hereafter referred to as the project) is in the Burdekin Natural Resource Management (NRM) Region[1] and in the Northern Bowen Basin province of the Brigalow Belt (North) bioregion (Sattler & Williams 1999). The Burdekin NRM is located in the drier part of the tropics on Queensland's east coast, covering an area approximately 133,400 km^2. This area encompasses a diversity of landscapes including the drier sub-catchment areas of the Belyando and Burdekin Rivers and the very wet coastal plains of the lower Burdekin River. The project site is in the catchment of the Burdekin River, one of the major water systems in the NRM. The region has a humid tropical climate with relatively high temperatures and pronounced wet and dry seasons (Australian Government 2012).

The Northern Bowen Basin contains major areas of outcrops of the Triassic and Permian sediments of the Bowen Basin. There are also areas of basalt and Tertiary sediments. The landscape is predominantly undulating, with vegetation communities dominated by species such as Brigalow (*Acacia harpophylla)*, Dawson Gum (*Eucalyptus cambageana)*, Narrow-leaved Ironbark (*E. crebra)* and Poplar Box (*E. populnea)*. There are also areas of Bluegrass (*Dichanthium sericeum)* (Sattler & Williams 1999).

2.1.2 Project Tenements and Land Ownership

The Byerwen Coal Project (mine) is within both the Isaac Regional Council and Whitsunday Regional Council Local Government Areas (**Figure 1**). In this report ‘project site’ refers to the combined area of mining lease application (MLA) 10355, MLA 10356, MLA 10357, MLA 70434, MLA 70435 and MLA 70436. Project area' includes all land encompassed by the MLAs. In some instances the 'project area' may also refer to a larger area as defined in relation to the subject matter.

[1] The Department of Sustainability, Environment, Water, Population and Communities and the Department of Agriculture, Fisheries and Forestry share responsibility for delivery of the Australian Government's environment and sustainable agriculture programs, which are broadly referred to as natural resource management (NRM).



PROJECT: Byerwen Coal Project – Land Technical Report
TITLE: Byerwen Coal Project Location Map

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JOB NO: 366203
DATE: November 2012
SOURCE: NRA, DME, Google Earth

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Figure 1

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In addition to six MLAs, the project site includes part of seven 'Lot on Plans' and road reserves (**Figure 2**). **Tables 1** and **2** give the lot and plans details.

Table 1: Lot on Plan for properties wholly or partly within the project MLAs

Lot on Plan	Lot area (ha)	Lot area within MLAs* (ha)	Lessee
Lot 1 CP905226	9,879	2,947	Raju Appala Narasimha Gottumukkala
Lot 14 SP225054	17,002	2,872	Colinta Holdings Pty Ltd
Lot 3 SP171922	17,635	7,846	Colinta Holdings Pty Ltd
Lot 4 SP171921 (previously known as Lot 2 on SP193586)	44,098	1,526	Jonathan Charles Philp Margaret Elvey Philp
Lot 667 PH1321	35,580	127	Edward Peter Mason Mora Ellen Mason Valda Ann Mason
Lot 682 CP906890	19,517	2,535	Henry Raymond Gillham William Raymond Gillham
Lot 689 SP251696 (previously known as Lot 689 on PH2015)	6,809	4,587	Leichhardt Pastoral Pty Ltd
Roads and watercourses	-	304	

* The sum of these areas is comparable to the project area reported by QCoal Pty Ltd (22,697 ha) with the discrepancy an artefact artefact of GIS mapping.

Table 2: Mining lease for properties wholly or partly within the project MLAs

MLA	Area (ha)	Lots intersected
10355	5,411	Lot 3 SP171922, Lot 4 SP171921
10356	2,203	Lot 3 SP171922, Lot 14 SP225054
10357	1,893	Lot 3 SP171922, Lot 4 SP171921
70434	7,731	Lot 14 SP225054, Lot 689 PH2015, Lot 682 CP906890
70435	2,560	Lot 1 CP905226
70436	2,894	Lot 3 SP171922, Lot 14 SP225054, Lot 689 PH2015, Lot 667 PH1321, Lot 1 CP905226

2.1.3 Native Title

The Birriah People have a currently registered Native Title Claim (rights and interests set out in the Commonwealth *Native Title Act* 1992) that underlies part of the project area. The Federal Court has made a Native Title Consent Determination recognising the Jangga People's exclusive native title rights over their determination area. This area underlies part of the project area. Therefore, the Birriah People and the Jangga People are the relevant Aboriginal parties for their respective claim areas under Section 35(1) of the ACH Act[2] (**Figure 3**).

2.1.4 Existing land uses and facilities

The existing land use within the project site is cattle grazing and residential. One residence, Suttor North homestead, is located in the south of the project site in MLA 70434 and

2 Searches were conducted by ELP.

MLA 70436. Suttor North Station is owned by Leichhardt Pastoral Pty Ltd which is a wholly owned subsidiary of Byerwen Coal Pty Ltd (Byerwen Coal). Eight other residences (of which one is unoccupied) are located within 20 km of the project site's boundary (**Table 3**, **Figure 2**).

Table 3: Residences within 20 km of the project site boundary

Residence	Approximate distance to project site boundary
Suttor North homestead (will not be occupied during the project life)	Within project site
Wollombi homestead (unoccupied and will remain unoccupied for the project life)	0.6 km
Byerwen homestead	1.3 km
Weetalaba homestead	5 km
Cerita homestead	5.8 km
Suttor Creek homestead	7 km
Lancewood homestead	10 km
Fig Tree homestead	13.2 km
Glenden homestead	18.2 km

The closest population centres include:

- Glenden, approximately 20 km to the east (population 1,308[3])
- Collinsville, approximately 57 km to the north (population 4,044[3])
- Moranbah, approximately 70 km to the south (population 8,965[3]).

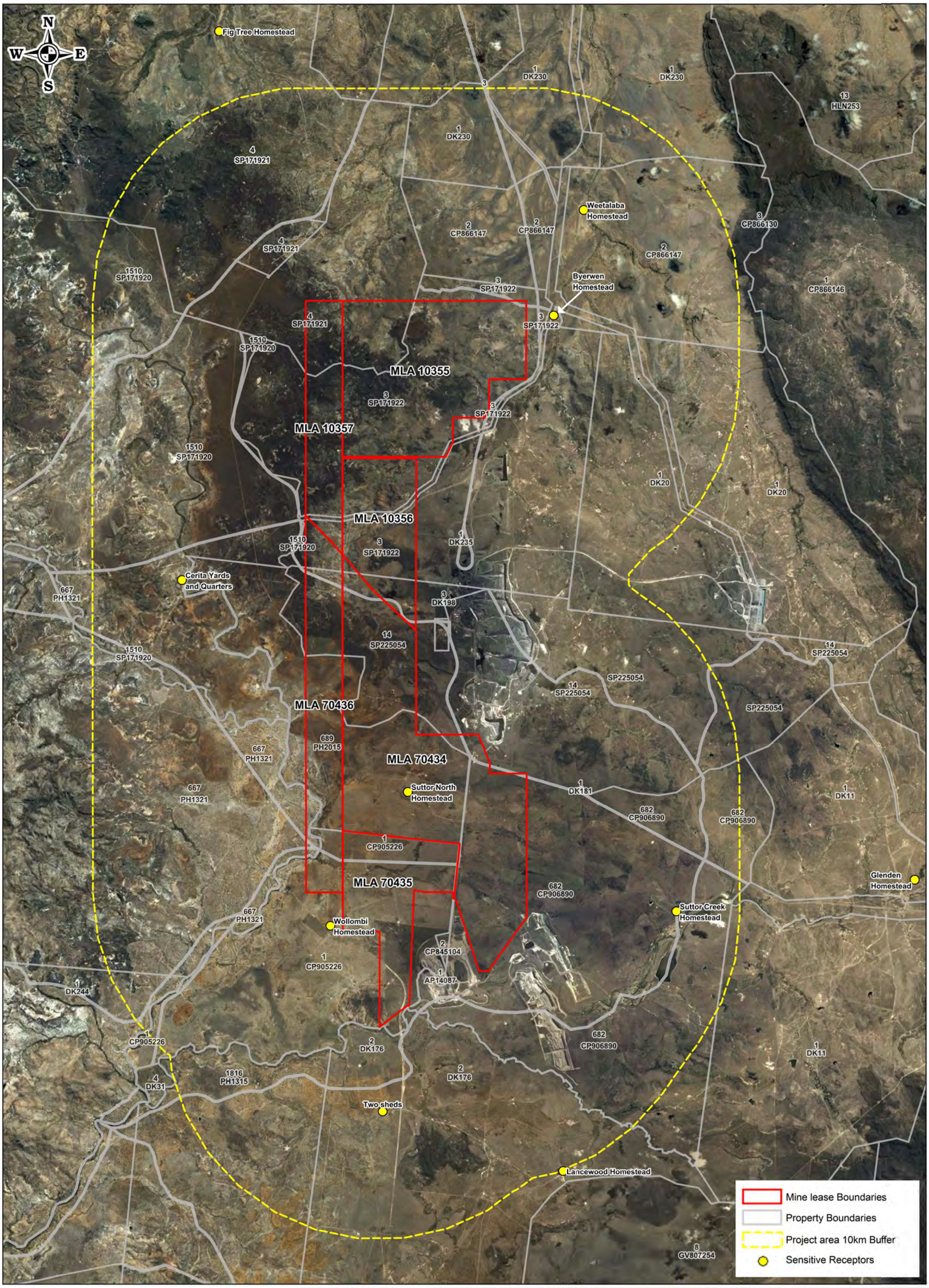
The regional centre of Mackay is located approximately 135 km to the east of the project site.

The existing land environment values are based on agriculture, as the dominant land use at the project site is beef cattle grazing. An area in the south-east of the project site (on Suttor Creek Station) was cultivated for cotton but this is understood to have ceased a number of years ago.

To the east of the project site is Xstrata's Newlands Mine, which has expanded to include Suttor Creek Mine and Wollombi Mine, adjacent to the south of the project site. Therefore both adjacent to the south and the east of the site, land use is currently coal mining. Newlands Mine has existing mining infrastructure, including the Newlands - Abbot Point railway line.

Currently, the project proposes to house site workers in the nearby town of Glenden.

[3] Australian Bureau of Statistics (2012)



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PROJECT: Byerwen Coal Project EIS
TITLE: Byerwen Coal Project Tenements and Sensitive Receptors

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JOB NO: 366203
DATE: October 2012
SOURCE: NRA, QCoal, Google Earth

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Figure 2

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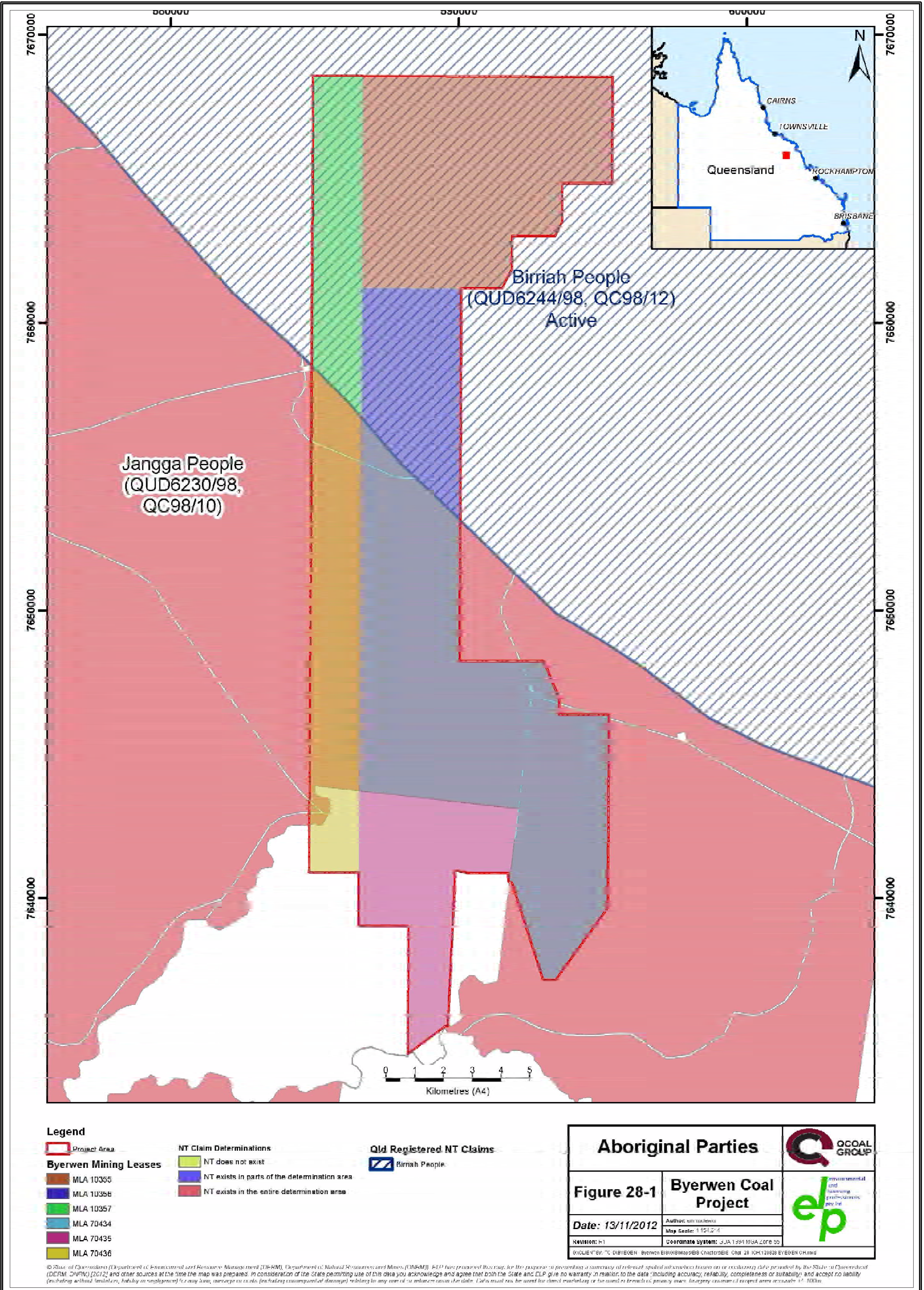

PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Native Title

JOB NO: 366203
DATE: December 2012
SOURCE: ELP

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Figure 3

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Declared water storage catchments

The project site is not within a declared catchment area. The nearest declared catchment area is Eungella Dam, approximately 48 km east (**Figure 1**).

Key resource areas

Major extractive resources identified in the State Planning Policy are referred to as key resource areas (KRAs). A KRA encompasses:

- the extractive resource and on-site processing area
- the associated transport route, usually a road haulage route
- a separation area around the resource and processing area and the transport route.

There is no KRA identified under State Planning Policy (SPP) 2/07 *Protection of Extractive Resources and Guideline* located in or near the project site (Department of Natural Resources and Mines, SPP 2/07).

2.1.5 Infrastructure

Current infrastructure services in the proximity of the project site include (**Figure 4**):

- Collinsville- Elphinstone Road
- Bowen Developmental Road
- Suttor Developmental Road
- Wollombi Road
- Goonyella to Abbot Point railway line
- water pipelines operated by SunWater
- North Queensland Gas Pipeline
- powerlines providing electricity to homesteads and Newlands mine.

2.1.6 Existing stock routes

Queensland's stock route network (SRN) provides pastoralists with a means of moving stock 'on the hoof' around the State's main pastoral districts, as an alternative to trucking and other contemporary transport methods. These routes, together with reserves for travelling stock, make up the Queensland SRN. The *Land Protection (Pest and Stock Route Management) Act* 2002 (Land Protection Act) regulates the use of the SRN.

An existing stock route traverses the project site east-west. There is an additional stock route within 1 km of the southern extent of the project site. These stock routes are shown on **Figure 5**.

2.1.7 Agricultural land use evaluation

Several assessment systems are used to determine the potential for land to support different agricultural land uses. Two land use evaluation approaches are discussed below: the land capability assessment based on Rosser *et al.* (1974) and the land suitability assessment given in QDME (1995).

Land *capability* assessment is generally used for developing land resource inventories, with areas of land of good capability later being targeted for more detailed assessment. Land capability assessment has historically been used in the mining industry to describe the capacity of land resources to sustain a broad range of land uses (both agricultural and non-agricultural). Land *suitability* assessment defines a land resource’s fitness to sustain a particular form of land use, for example crops or pasture. It takes into account that although land may be suitable for cultivation and cropping, the requirements for specific uses vary. Land suitability is now the preferred approach for evaluating land for mining activities (QDME 1995).

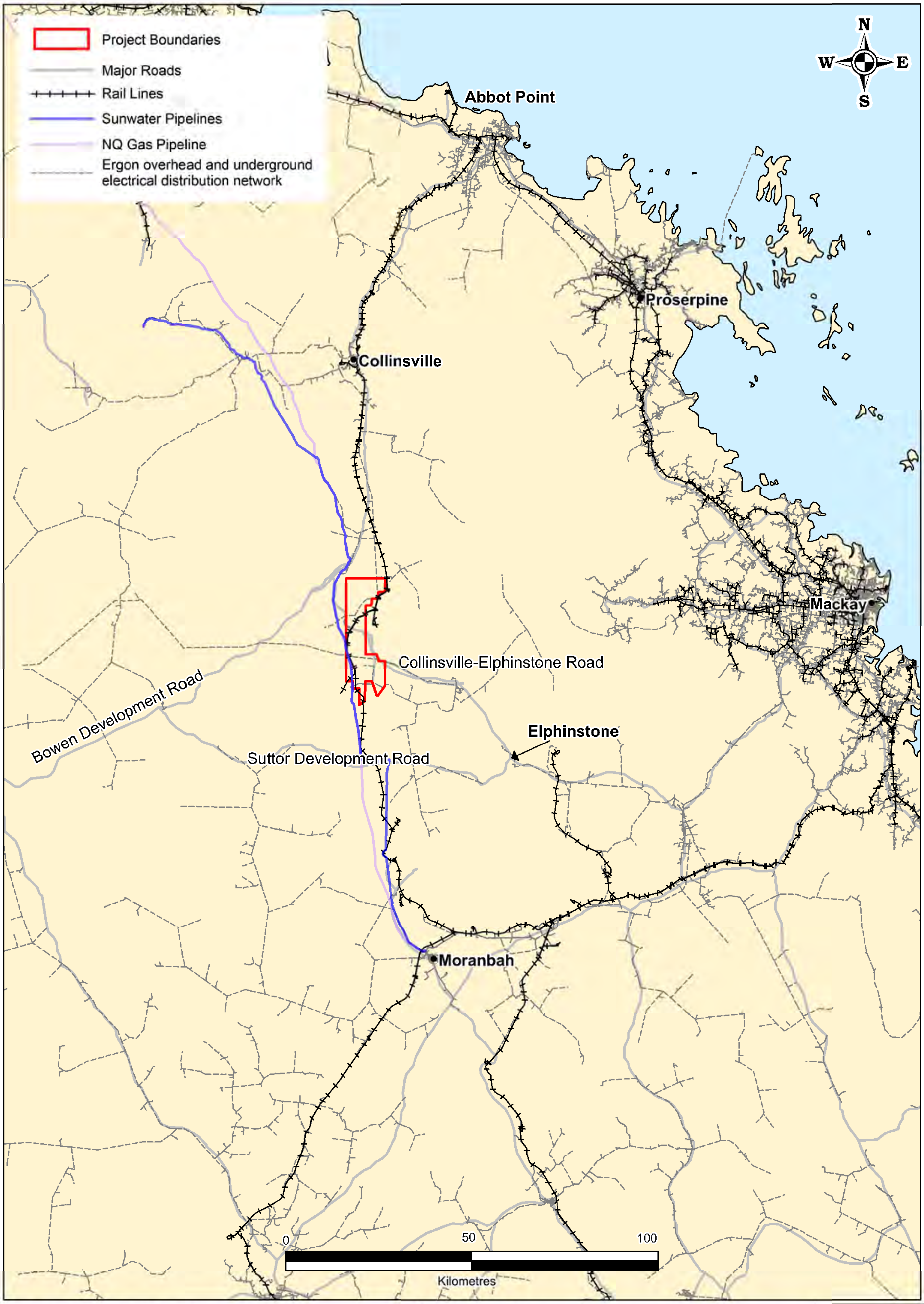
Land suitability

Land suitability assessment works by assigning a suitability class for a land use based on soil, topographic, climatic and economic attributes/potential limitations factors (such as effective soil depth, erosion hazard, slope, flooding, rainfall, and complexity of mapping unit). The assigned land suitability class (LSC) reflects the score of the most limiting attribute.

Five LSCs have been defined for use in Queensland, with suitability decreasing progressively from Class 1 to 5. Classes 1 – 3 are regarded as suitable for a given land use (agricultural) and are generally capable of similar levels of productivity, but Class 3 land requires more inputs (for example resources and management) than Class 1 land. Land of Classes 4 and 5 are generally unsuitable for the given land use. QDME (1995) presents a summary of the suitability classes and also includes descriptors for conservation use (summarised in **Table 4**).

Table 4: Land Suitability Classes (LSCs) for Agriculture and Conservation (QDME 1995)

LSC	Type	Description
1	Agricultural	Suitable land with negligible limitations - land that is well suited to a proposed use.
	Conservation	These areas possess significant conservation benefits (pre-mining) capable of being returned (post-mining).
2	Agricultural	Suitable land with minor limitations - land that is suited to a proposed use but which may require minor changes in management to sustain the use.
	Conservation	These areas are suited to conservation use in that a significant component of the pre-mining benefit can be restored post-mining however, there will be some loss of value.
3	Agricultural	Suitable land with moderate limitations - land that is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use.
	Conservation	These areas possess significant conservation benefits (pre-mining) but restoration of values may not be feasible. These areas could however be restored to a form of conservation use which provides an alternative conservation benefit.
4	Agricultural	Marginally suitable land - land that is marginally suited to a proposed use and would require major inputs to ensure sustainability. These inputs may not be justified by the benefits to be obtained in using the land for the particular purpose and is hence considered presently unsuited.
	Conservation	These areas possess limited conservation value (pre-mining) and/or are incapable of being returned (post-mining), however, may be restored to provide a stable form of use which does not impact on surrounding conservation values.
5	Agricultural	Unsuitable land with extreme limitations - land that is unsuited and cannot be sustainably used for a proposed use.
	Conservation	These areas contain no significant conservation values.



PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Current Infrastructure in the Byerwen Project Area

T:_AAA\366\WOR\366203\366203_Future Disturbance_2012_10_26.wor

JOB NO: 366203
DATE: October 2012
SOURCE: NRA, DEHP

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Figure 4

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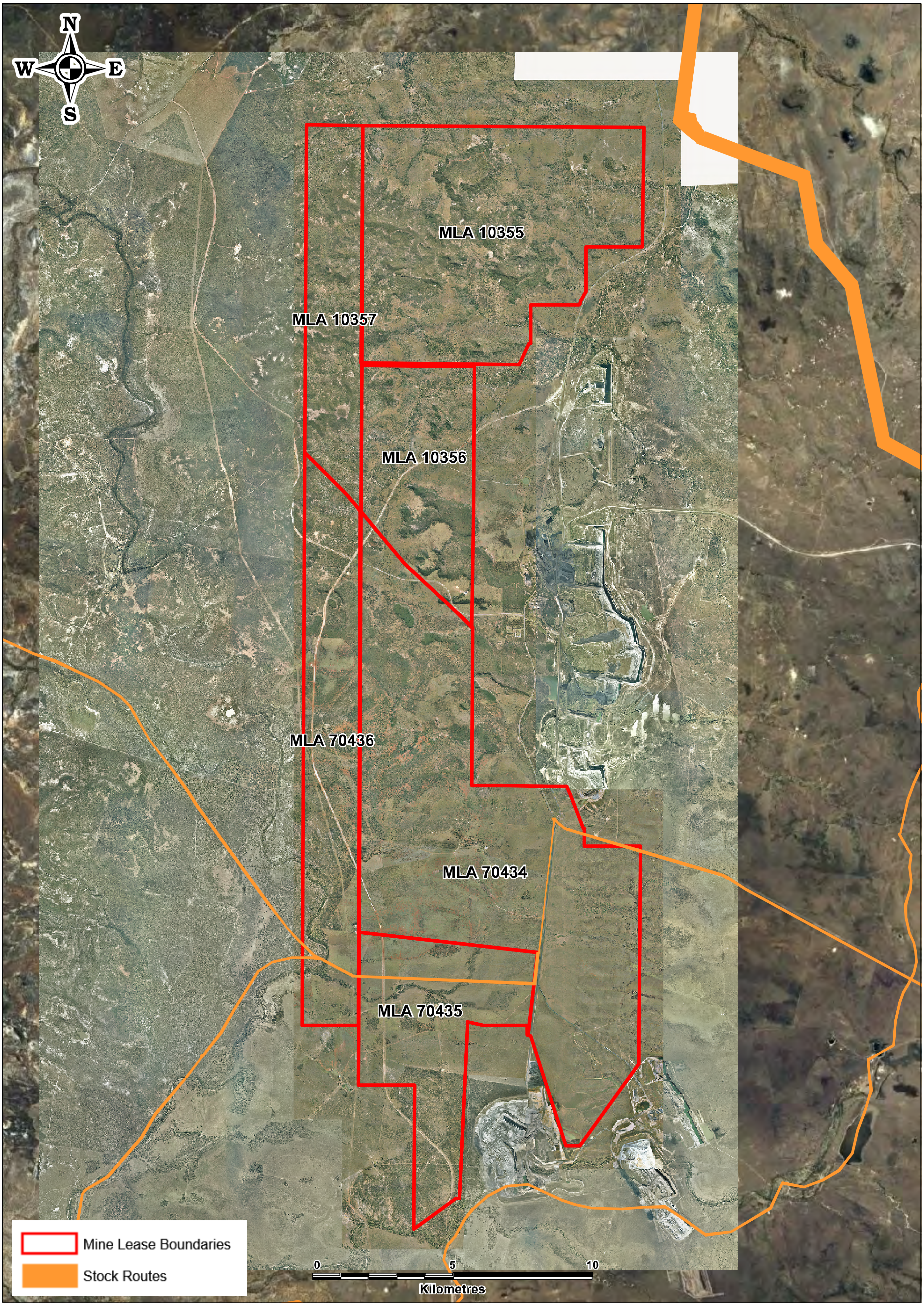

PROJECT: Byerwen Coal Project EIS TITLE: MLA Boundaries and Stock Routes T:_AAA\366\WOR\366203\366203_DCDB and Stock Routes_2012_11_07.wor	JOB NO: 366203 DATE: November 2012 SOURCE: NRA, ELP Google Earth, DCDB	NRA Environmental Consultants NATURAL RESOURCE ASSESSMENT AND MANAGEMENT	Figure 5

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The land suitability of the Byerwen Coal Project for beef cattle grazing (the existing land use) and rain-fed broadacre cropping was assessed in NRA (2011) using criteria provided in the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (QDME 1995); specifically Attachment 2 *Land suitability classification for cropping and grazing in the semi-arid sub tropics of Queensland*. The suitability assessment identifies LSCs based on soil and site characteristics such as plant available water capacity, nutrient properties, physical properties, salinity, rockiness, microrelief, soil pH, ESP, wetness, topography, erosion status and frequency of flooding. Information for the assessment was provided by field observations, soil descriptions and the results of laboratory analyses. Some soil and site characteristics required subjective interpretation (*eg* flooding frequency).

Land suitability assessment for rain-fed crops

The areas and proportions of the LSCs for rain-fed broadacre cropping identified by NRA (2011) are provided in **Table 5** and their distribution is shown on **Figure 6**.

Table 5: Areas of land suitability classes (LSCs) for rain-fed broadacre cropping

LS Class	Area (ha)	Area (%)
1	0	0
2	2,663	12
3	0	0
4	10,738	47
5	9,286	41
Total	22,687*	100

* This is comparable to the area reported by QCoal Pty Ltd (22,697 ha) with the discrepancy an artefact of GIS mapping.

Land suitability for beef cattle grazing

The distribution of the LSCs for Beef Cattle Grazing identified by NRA (2011) is shown in **Figure 7**. **Table 6** provides areas of each LSC on the project site.

Table 6: Areas of land suitability classes (LSCs) for beef cattle grazing

LS Class	Area (ha)	Area (%)
1	0	0
2	6,129	27
3	3,411	15
4	12,666	56
5	482	2
Total	22,687*	100

* This is comparable to the area reported by QCoal Pty Ltd (22,697 ha) with the discrepancy an artefact of GIS mapping.

2.1.8 Assessment for Good Quality Agricultural Land (GQAL)

The project site was assessed for Good Quality Agricultural Land (GQAL) as required by State Planning Policy 1/92 – *Development and the Conservation of Agricultural Land* (DHLGP 1992) and following the State Planning Policy 1/92 Guideline: *The Identification of Good Quality Agricultural Land* (DPI and DHLGP 1993). Two approaches were taken, the first presented the existing GQAL mapping identified in DPI and DHLGP (1993), and the second reinterpreted the land suitability assessment of NRA (2011) to provide a site specific assessment of GQAL.

The GQAL mapping references for the Byerwen project area provided in DPI and DHLGP (1993) are a land suitability study by Shields (1984) and the land system mapping of Gunn *et al.* (1967). The mapping of these two studies have been combined in **Figure 8**, with each of the studies' land units interpreted using the GQAL class given in DPI and DHLGP (1993). These studies are broad-scale (1:250,000 for Shields (1984) and 1:500,000 for Gunn *et al*. (1967)).

A site specific assessment of GQAL on the Byerwen project site based on NRA (2011) is presented as an alternative (**Figure 9**). It has the advantages of being derived from a site-specific land study that included finer scale mapping (*ie* 1:50,000) than that of the earlier studies, the data used were collected from the project site and immediate vicinity and are therefore more likely to be representative of local conditions. In addition the assessment of the data uses current relevant guidelines - specifically that in QDME (1995), based on the Queensland Land Assessment Guidelines (Land Resources Branch 1990), which is recommended in DPI and DHLG&P (1993).

The GQAL assessment based on NRA (2011) (**Figure 9**) reinterprets the land suitability assessment results using the GQAL classes. The scheme used to convert the LSC for rain-fed broadacre cropping and beef cattle grazing to GQAL classes is as follows:

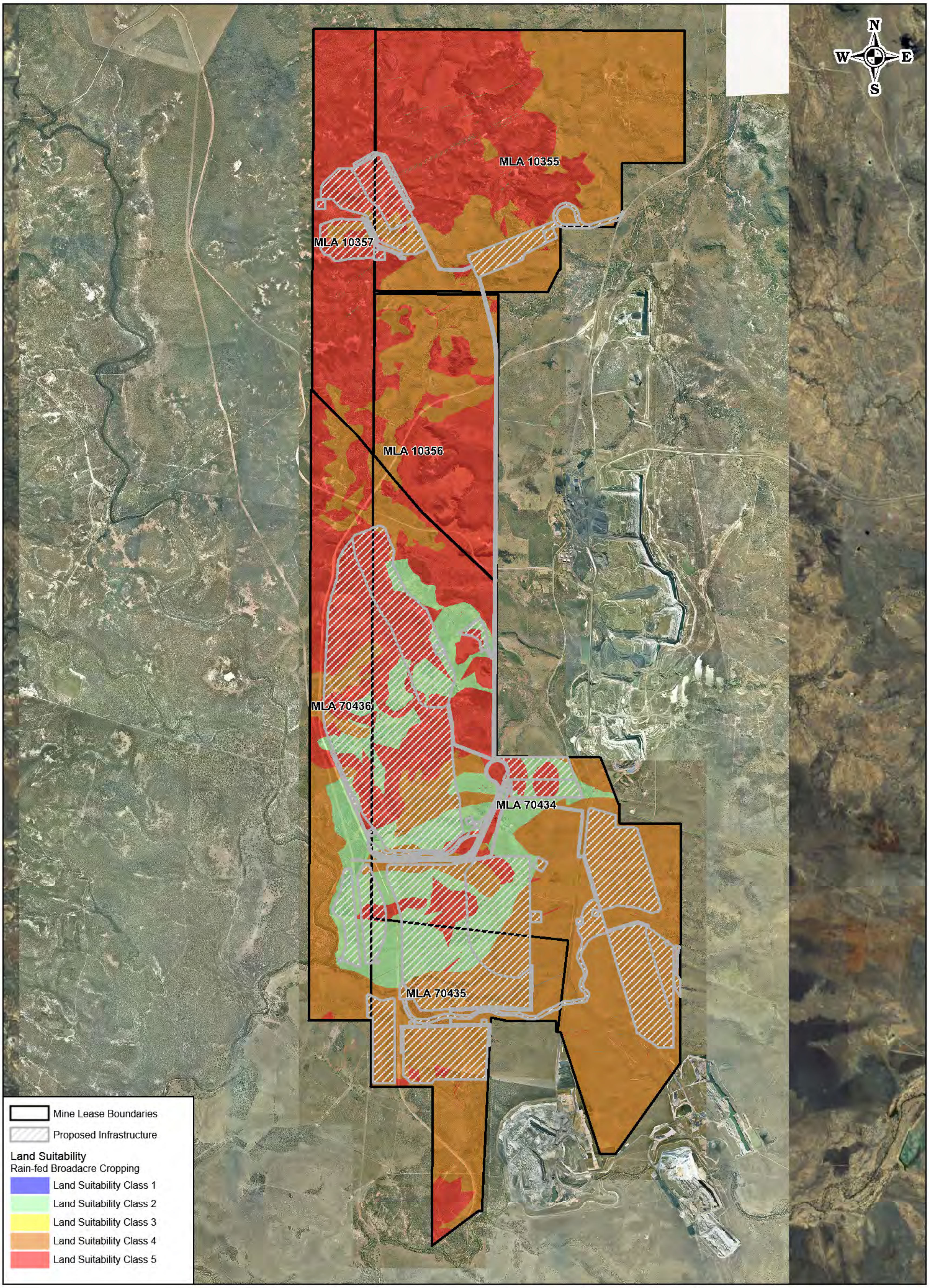
- Land identified as suitable for rain-fed broadacre cropping with negligible or minor limitations (*ie* LSCs 1 and 2) is considered to be GQAL Class A (crop land)
- Land identified as suitable for rain-fed broadacre cropping with moderate limitations (*ie* LSC 3) is considered to be GQAL Class B (limited crop land)
- Land identified as suitable for beef cattle grazing (*ie* LSCs 1 to 3) is considered to be GQAL Class C (pasture)
- Land that belongs to more than one GQAL class is allocated to the highest of the classes.
- All other land is considered to be GQAL Class D (non-agricultural land).

Table 7 provides the areas of each class of GQAL identified by Shields (1984) and Gunn *et al*. (1967) and NRA (2011).

Table 7: Good quality agricultural land areas identified by Shields (1984) and Gunn *et al.* (1967) and NRA (2011)

GQAL Class	A	B	C	D
Based on Shields (1984) and Gunn *et al.* (1967)	4,158 ha	0 ha	12,097 ha	6,414 ha
Based on NRA (2011)	2,666 ha	0 ha	6,887 ha	13,144 ha

The sum of the GQAL classes for each dataset is comparable to the project area reported by QCoal Pty Ltd (22,697 ha) with the discrepancy an artefact of GIS mapping.



PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Land Suitability Assessment for Rain-fed Broadacre Cropping
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DATE: November 2012
SOURCE: NRA, DERM, Google Earth, ELP

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Figure 6

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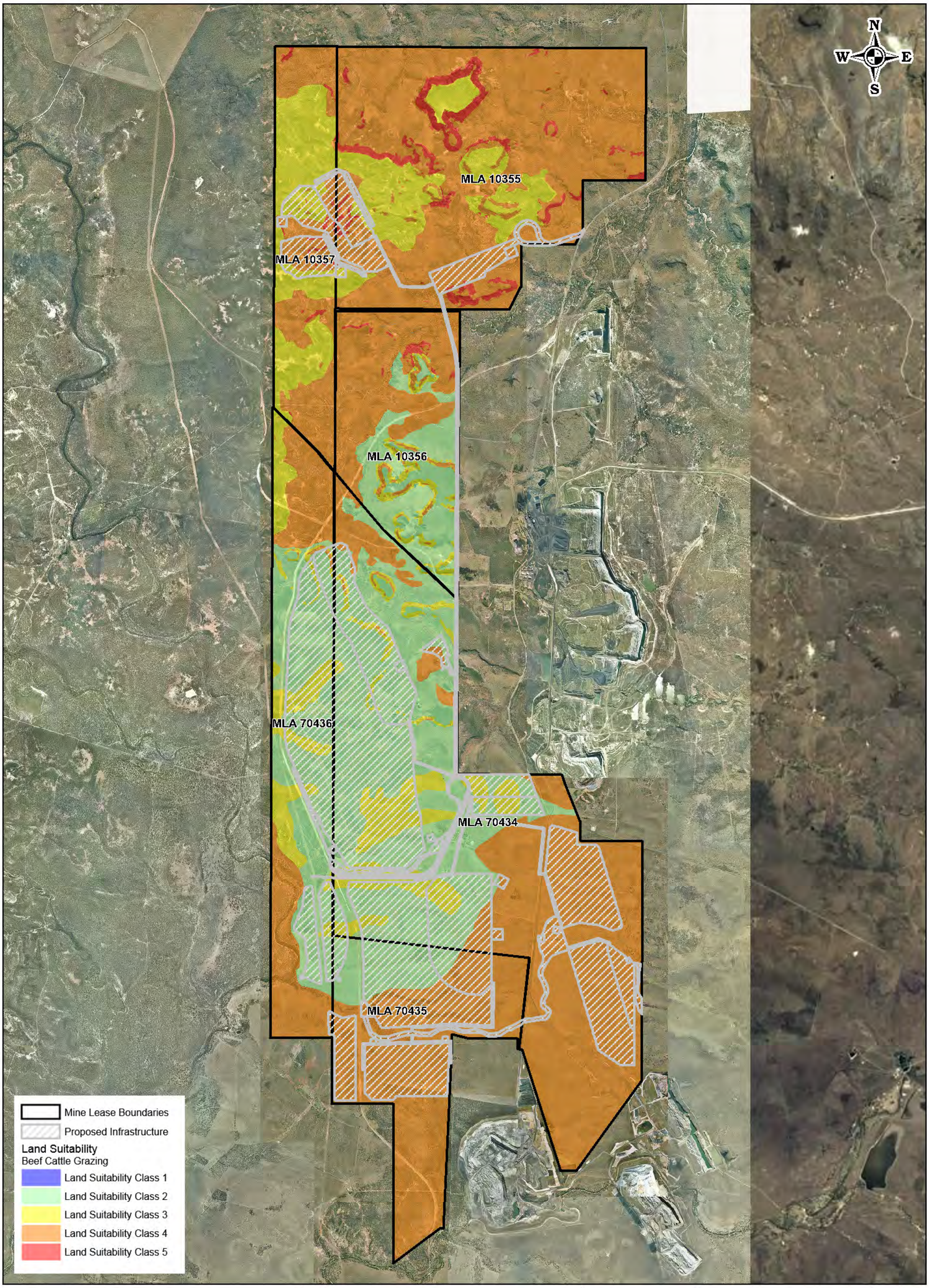

PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Land Suitability Assessment for Beef Cattle Grazing

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JOB NO: 366203
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Figure 7

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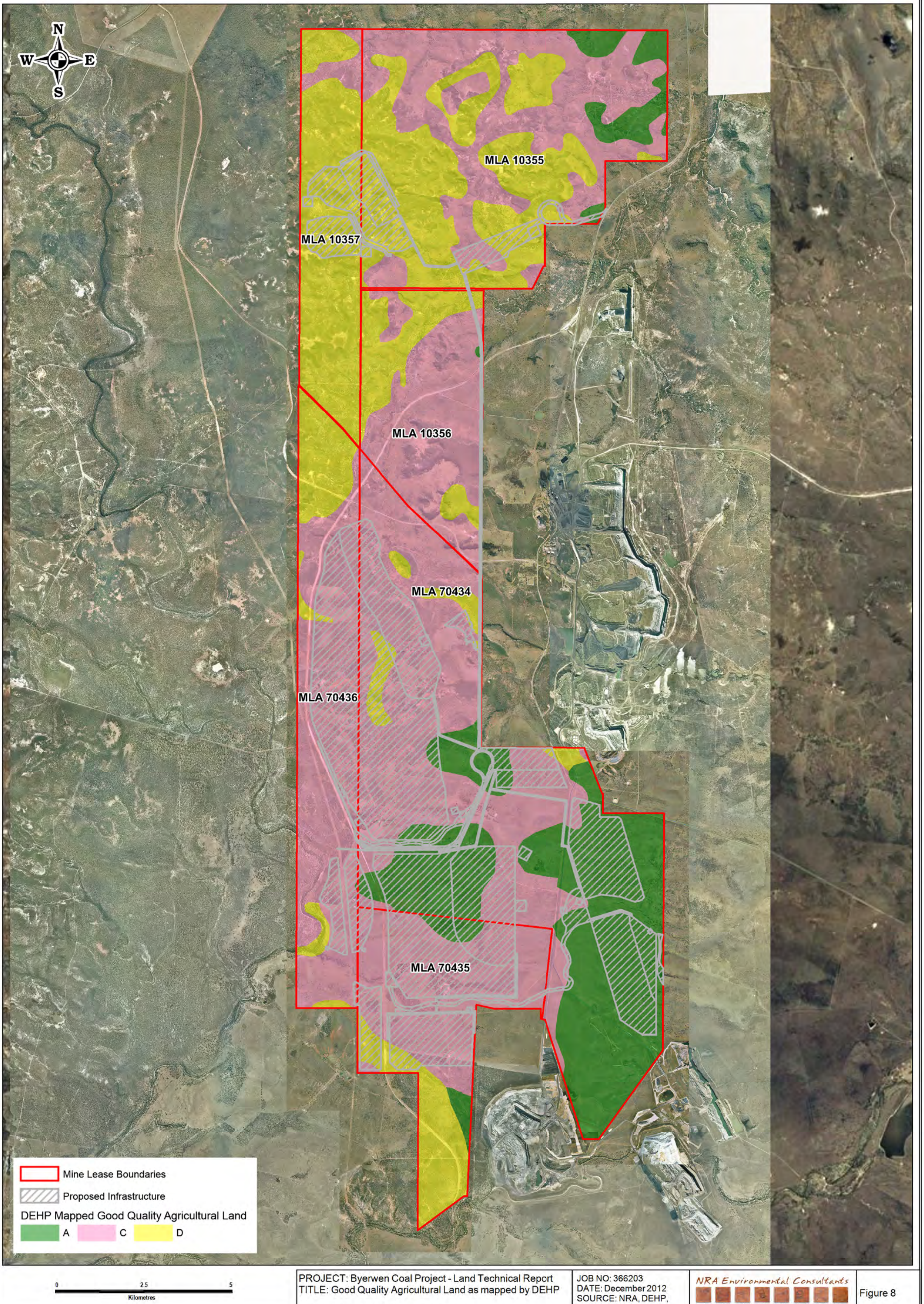

PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Good Quality Agricultural Land as mapped by DEHP

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Figure 8

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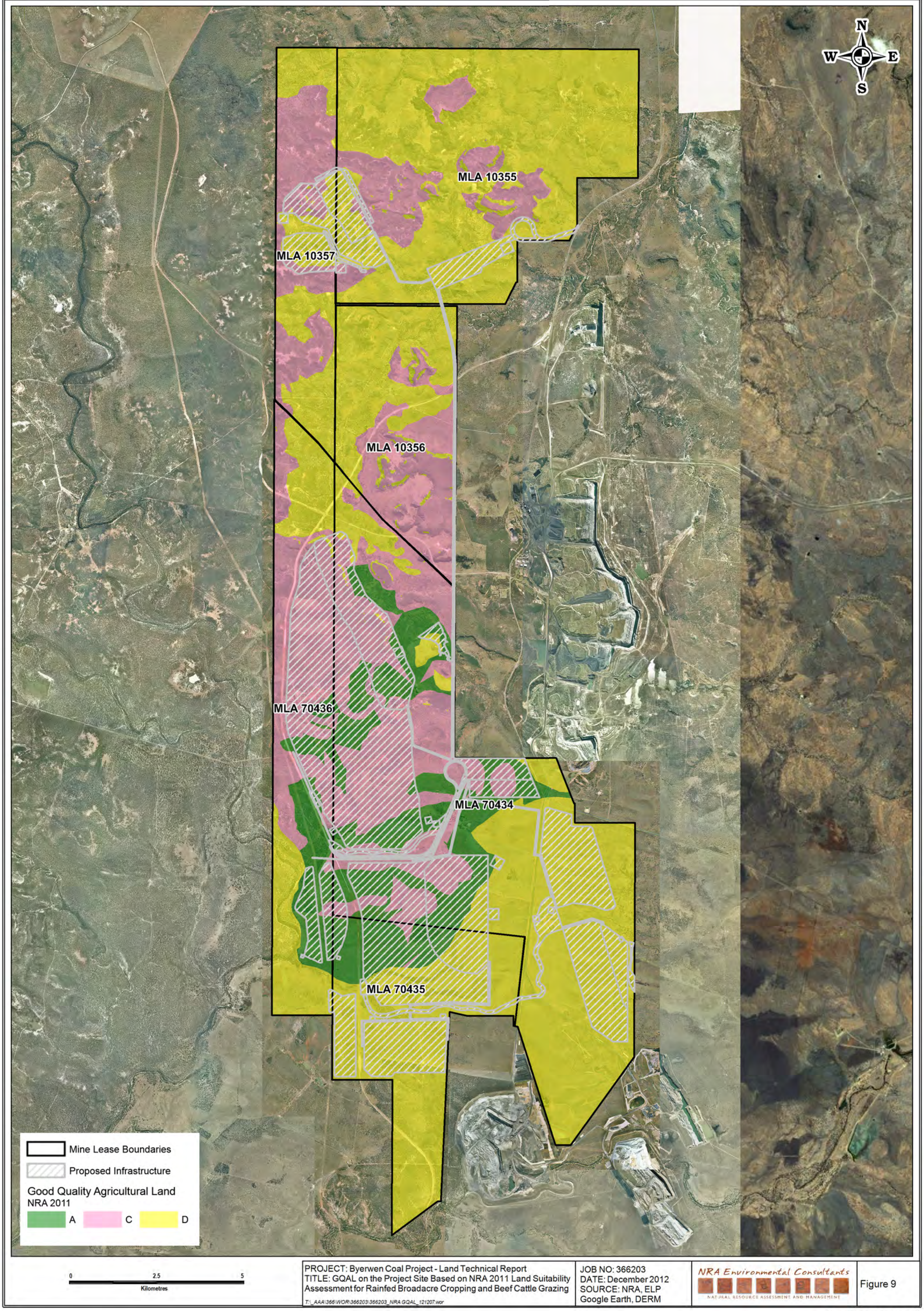


PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: GQAL on the Project Site Based on NRA 2011 Land Suitability Assessment for Rainfed Broadacre Cropping and Beef Cattle Grazing
T:_AAA\366\WOR\366203\366203_NRA GQAL_121207.wor

JOB NO: 366203
DATE: December 2012
SOURCE: NRA, ELP
Google Earth, DERM

NRA Environmental Consultants
NATURAL RESOURCE ASSESSMENT AND MANAGEMENT

Figure 9

Recommended print size: A3

2.1.9 Strategic cropping land

As part of the Queensland Government's commitment to protecting the State's best quality cropping land, it has introduced measures for identifying and protecting strategic cropping land (SCL). Details of how this is to be achieved are provided in *Protecting Queensland's Strategic Cropping Land – A Policy Framework* (DERM 2010) and State Planning Policy 1/12 – *Protection of Queensland's strategic cropping land* (DERM 2012c).

The project site is in a strategic cropping land (SCL) management area (the western cropping zone) and SCL 'trigger' maps show potential SCL within the project site (**Figure 10**). As the Byerwen project is in a SCL management zone, it must meet all 'on-ground' criteria as well as have the 'required cropping history'.

2011 On-ground assessment

An 'on-ground' SCL assessment was conducted in June 2011 as part of the Byerwen Coal Project Soil and Land Assessment (NRA 2011). Areas of land that met all of the SCL assessment criteria were identified within the Byerwen project site. However, the on-ground SCL assessment was conducted before the release of the finalised SCL Guidelines (*ie* DERM 2011, released in September) and therefore the findings should be considered indicative.

The main difference between the 2011 assessment and SCL guidelines is the type of field observations made. The DERM 2011 guidelines identify four types of SCL assessment sites (exclusion, detailed, analysed and check) each with specific information requirements, and prescribe the required number and types of observation required to identify/disprove SCL. As the 2011 guidelines were not available at the time of the June 2011 survey, it was not designed to meet this observational structure. Although the data collected is valid and the conclusions drawn are accurate to the intensity of survey effort, additional survey work would be needed to fully meet the current SCL assessment guidelines. Observations and laboratory data from the 2011 survey will form the basis of any future on-ground assessment. The results of the 2011 on ground assessment are presented in **Appendix A**.

Required cropping history

The required cropping history is the production of at least three crops between 1 January 1999 and 31 December 2010 (more details of exactly what is required are provided in DERM 2012b).

An assessment of cropping history using field evidence from the 2011 soil and land assessment and remote sensing images (Landsat and recent aerial images) indicates that most of the lots within or intersected by project mining leases are unlikely to have the required cropping history (**Figure 10**), and therefore are unlikely to contain SCL (even for land that meets all 'on ground' criteria). However, Lot 682 CP906890, in the south-east of the project site, may have been cropped (as demonstrated by Landsat images and field evidence). It appears that approximately 480 ha of the land within, and adjacent to, the Byerwen project site may have been cultivated for cotton. Of this, about half occurs within the Byerwen project MLAs. The cultivation appears to have ceased in 2004–2005 with the development of the Suttor Creek coal mine, which is understood to have made the scale of cotton production uneconomical. The number of crops produced between 1 January 1999 and the cessation of cropping cannot be definitively established from the Landsat images, and correspondingly, the cropping history of Lot 682 CP906890 is unclear. It should be noted that both the SCL trigger mapping and the 2011 on-ground SCL assessment identify potential SCL in Lot 682 CP906890, albeit inconsistently.

Mine related disturbance is proposed in Lot 682 CP906890. If the required cropping history is found to exist, a decision will be made by the proponent to identify SCL on the lot by either accepting that the potential SCL indicated on the trigger maps is SCL, or conducting additional work required to make the 2011 'on-ground' assessment consistent with the survey guidelines (DERM 2011).

2.1.10 Environmentally Sensitive Areas

All six mining leases; MLA 10355, MLA 10356, MLA 10357, MLA 70434, MLA 70435 and MLA 70436, contain Category B Endangered Regional Ecosystems (remnant (biodiversity status)). In addition, MLA 70434 abuts a Category C Nature Refuge (Newlands Nature Refuge); located to the east of the project site (**Figure 11**). The Environmentally Sensitive Areas relevant to the project site relate to existing ecological values and as such are addressed in the section of the EIS relating to ecological impacts.

2.2 Potential impacts and mitigation measures

Human activity in the project area is largely confined to farming and mining. The most notable 'land' impact is loss of grazing land with a change of land use to coal mining. That is, an open cut coal mine with associated new infrastructure, including rail loops, power transmission lines, water pipelines and bridges to cross existing and proposed roads and railway lines.

2.2.1 Residential and industrial uses

It is expected that the residence on Suttor North Station will not be occupied at the time construction commences on the project site. There are eight other rural residences (sensitive receptors) within 20 km of the project site boundary (**Figure 2**). The closest urban residential area is Glenden, approximately 20 km to the east of the project site. Access from Glenden is by the Collinsville-Elphinstone Road, a route of approximately 22 km. The closest industrial area is in Moranbah (Queensland Government 2012), approximately 70 km to the south.

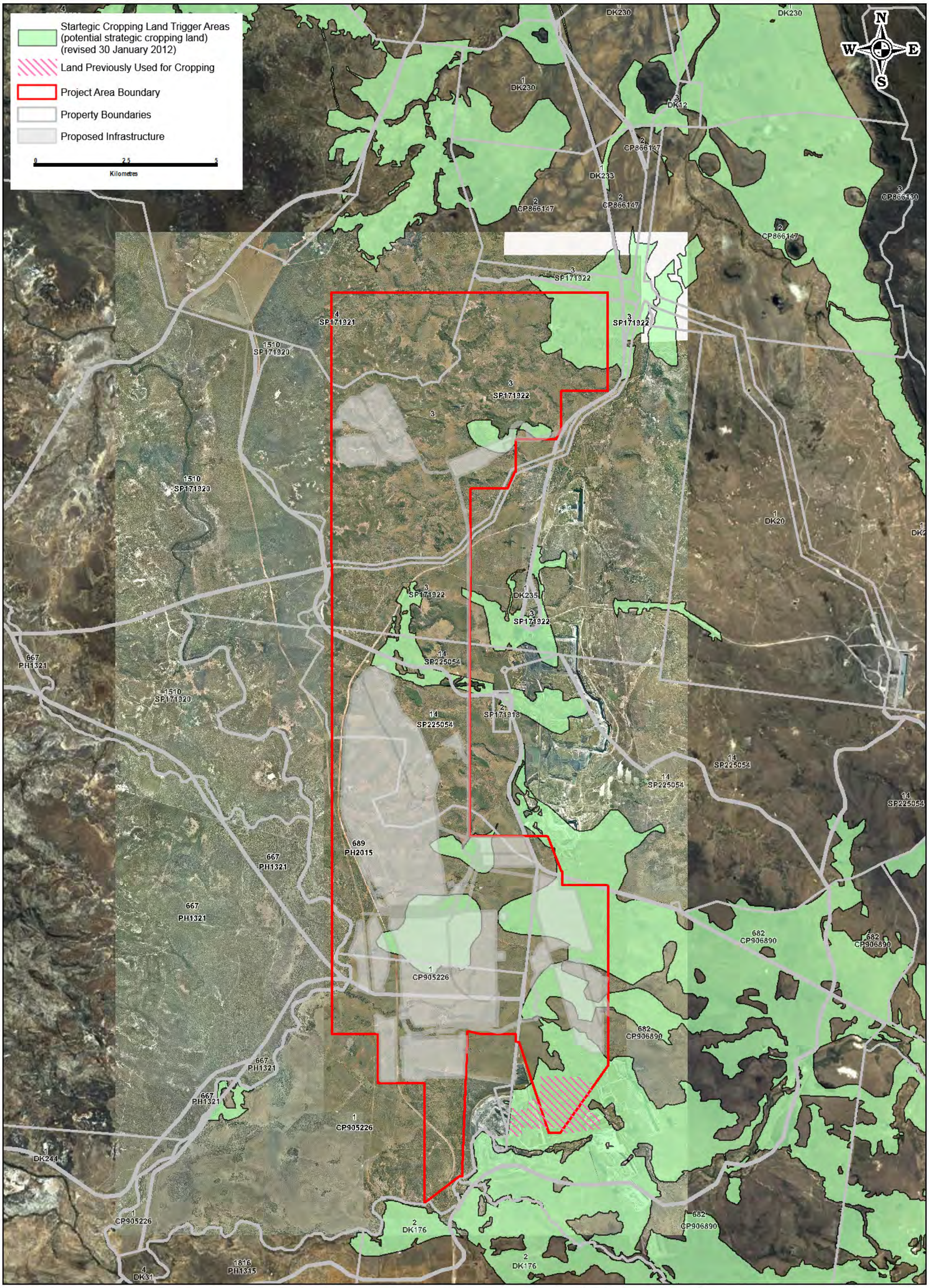
Potential indirect impacts on residences include noise and dust. These impacts are discussed briefly here. More detail is provided in sections of the EIS relating to air quality, noise and transport.

Existing noise sources from the surrounding environment primarily comprise:

- road-based traffic (mainly associated with existing mining operations and the cattle transport industry)
- existing mines
- residential activity noise.

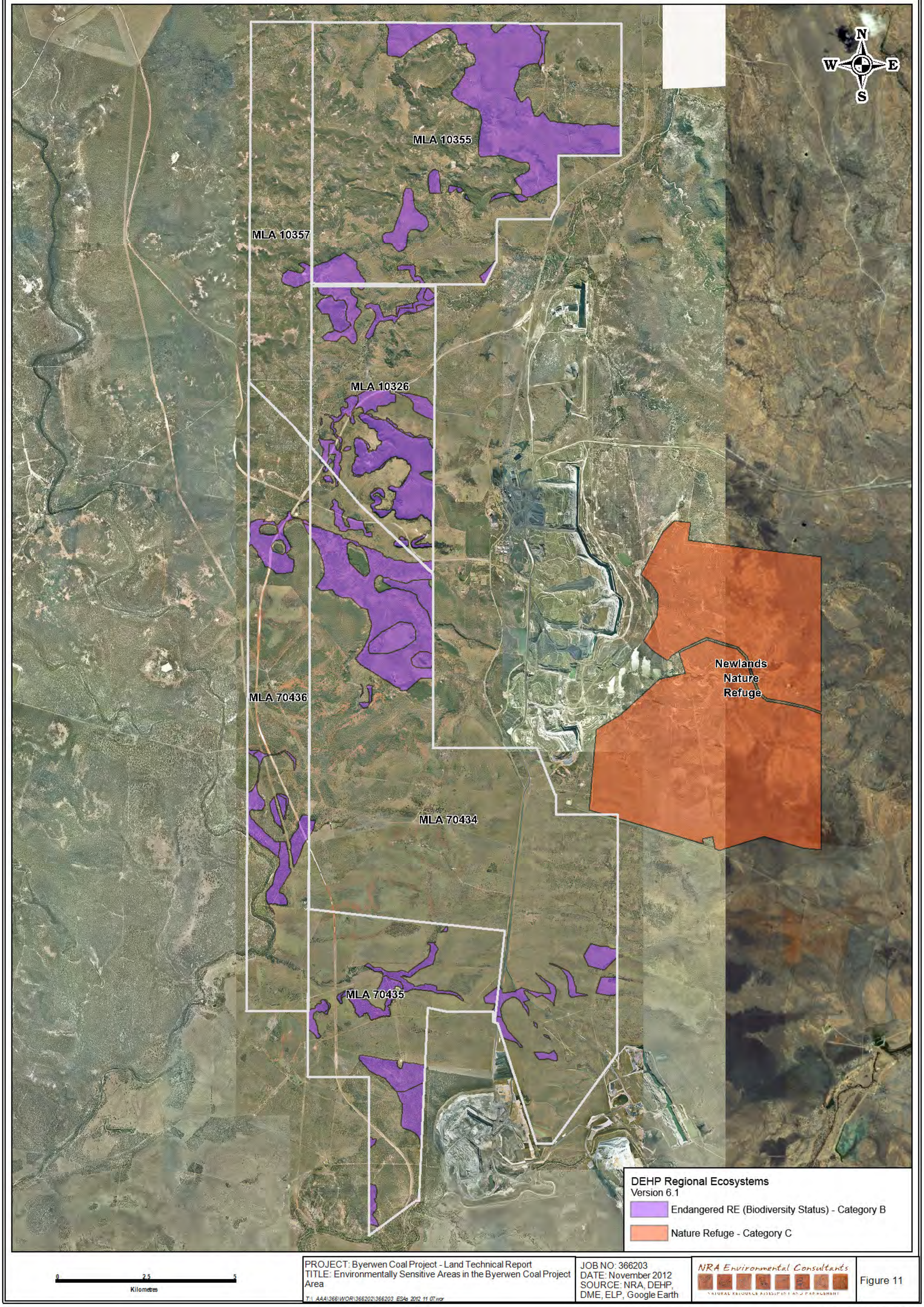
Noise from the project site is unlikely to impact on the community of Glenden, but there is a potential for short-term effects for some people using local roads and/or living close to roads used for materials transport. Mitigation measures are likely to include the adoption of low-noise impact driving techniques (*eg* driving at low-speeds in the vicinity of residences).

Dust generated from the project site is unlikely to impact on the community of Glenden, but there is a potential for short-term effects for some people using local roads and living close to unsealed roads used for material and product transport.



PROJECT: Byerwen Coal Project EIS TITLE: Byerwen Coal Project Potential Strategic Cropping Land T:_AAA\366\WOR\366203\366203_Byerwen SCL trigger areas_2012_11_30.wor	JOB NO: 366203 DATE: November 2012 SOURCE: NRA, ELP Google Earth	NRA Environmental Consultants NATURAL RESOURCE ASSESSMENT AND MANAGEMENT	Figure 10

Recommended print size: A3



PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Environmentally Sensitive Areas in the Byerwen Coal Project Area
T:_AAA\366\WOR\366202\366203_ESAs_2012_11_07.wor

JOB NO: 366203
DATE: November 2012
SOURCE: NRA, DEHP, DME, ELP, Google Earth

NRA Environmental Consultants

Figure 11

Recommended print size: A3

Other impacts

Other impacts may include positive or negative social impacts, which are specifically addressed in social studies for this EIS. This includes aspects of employment, accommodation for employees and impacts in nearby towns, such as Glenden and Collinsville.

Glenden was opened in 1983 to accommodate the employees from the Newlands mine. The *Mackay, Isaac and Whitsunday Regional Plan* (MIW Regional Plan) (Queensland Government 2012) states that increases in housing density are supported in Glenden to support additional growth, though with consideration of constraints on further expansion due to adjacent productive rural land and mining leases. Further industrial development is also supported in these towns to service surrounding mining industries.

2.2.2 Agricultural land uses

Beef production is a significant sector in the Mackay, Isaac and Whitsunday regional economy. Primary industries policy 6.4.5 of the *Mackay, Isaac and Whitsunday Regional Plan* (MIW Regional Plan) (Queensland Government 2012) states the requirement to "*identify and protect suitable primary production areas, rural production activities and aquaculture development areas from incompatible development*." Principle 6.5.1 of the MIW Regional Plan states "*manage mining and extractive resources to maximise economic opportunities and other community benefits, while minimising negative environmental and social impacts for present and future generations*."

The MIW Regional Plan (Queensland Government 2012) identifies the mineral and extractive resource industries, particularly coal and coal seam gas, as significant components of the region's economy but deems it critical to also consider the implications of the expanding extractive resource industry development on areas of good quality agricultural land.

The project would result in changes to land use as the site is currently used primarily for grazing. The area surrounding the project site is within the rural zone and there is unlikely to be conflicts of land use. Current adjacent land uses are likely to continue with the exception of potential development of mine projects and potential expansion of the town of Glenden.

The disturbance area for potential SCL (based on the Queensland Government SCL 'trigger' mapping), GQAL and land suitability (for beef cattle grazing and broadacre rain-fed cropping) is provided in **Table 8** by mine component. From **Table 8**, it can be seen that the following will be disturbed:

- 1,430 ha of potential SCL based on the Queensland Government SCL 'trigger' mapping (subject to validation)
- the following areas of beef cattle grazing land suitability classes:
  - no Class 1 land
  - 3,308 ha of Class 2 land
  - 950 ha of Class 3 land
  - 2,719 ha of Class 4 land
  - 51 ha of Class 5 land
- the following areas of broad-acre rain-fed cropping land suitability classes:
  - no Class 1 land
  - 1,636 ha of Class 2 land

  - no Class 3 land
  - 2,986 ha of Class 4 land
  - 2,402 ha of Class 5 land
- the following areas of GQAL classes based on the NRA (2011) assessment:
  - 1,638 ha of Class A land
  - no Class B land
  - 2,615 ha of Class C land
  - 2,771 ha of Class D land
- the following areas of GQAL classes based on the Based on Shields (1984) and Gunn *et al*. (1967), as mapped by DEHP, assessment:
  - 1,749 ha of Class A land
  - no Class B land
  - 4,316 ha of Class C land
  - 957 ha of Class D land.

Impacts on potential SCL (assuming occurrence of SCL is confirmed) are expected to be limited to Lot 682 CP906890. The final mine plan (Year 46, dated 20 August 2012) shows pits (East Pits 1 and 2), associated spoil heaps, haul roads and a creek diversion in Lot 682 CP906890. The land disturbance of each of these features has potential to impact on SCL.

It is assumed that once mining has ceased, the land not occupied by remnant mine structures (*eg* final voids and spoil heaps) will be available for the pre-existing land use (*ie* beef cattle grazing), though possibly at a reduced level of suitability.

Spoil heaps and co-disposal dams will be rehabilitated and the flat to gently sloping areas of these structures are expected to be available for beef cattle grazing (assuming they are accessible to cattle). The land suitability of the slopes of such structures is often reduced due to stability issues under grazing conditions.

Land occupied by the final voids is unlikely to be available for beef cattle grazing.

See **Section 3.2.7** for recommended rehabilitation measures.

Table 8: Byerwen project disturbance areas for potential strategic cropping land (SCL), good quality agricultural land (GQAL) classes and land suitability classes for beef cattle grazing and broadacre rain-fed cropping

		GQAL (ha)						Land Suitability (ha)						
Mine Component	Potential SCL* (ha)	Based on Shields (1984) and Gunn *et al.* (1967) as mapped by DEHP			Based on NRA (2011) †			For beef cattle grazing#				For broadacre rain-fed cropping$		
		A	C	D	A	C	D	2	3	4	5	2	4	5
Codisposal North	8.77			9.03			9.03			9.03			9.03	
Codisposal South	23.23	23.23	71.57		47.10	47.64		50.76	44.04			47.10		47.69
Creek Diversion Central	14.68	14.68	23.93		16.78	21.96		26.72	11.90			16.66	11.90	10.06
Creek Diversion East	5.14	11.39					11.39			11.46			11.33	0.13
Creek Diversion North			1.00	30.46		14.59	16.87		14.59	12.80	4.07		3.55	27.91
Creek Diversion South	16.63	50.29	78.43				128.71			128.71			128.71	
Final Void East Pit 2	9.30	88.09					88.09			88.09			87.81	0.28
Final Void North Pit				163.66		26.21	137.46		26.21	118.24	19.22		15.25	148.41
Final Void South Pit 1	205.70	246.11	298.70		221.50	124.00	199.00	279.34	66.47	199.00		221.50	265.27	58.04
Final Void West Pit	8.96		548.37		142.70	384.67	22.09	465.75	60.53	22.09		142.70	8.77	396.89
Haul Roads	22.49	29.29	34.21	10.04	9.45	18.36	45.74	24.47	3.34	45.74		9.45	46.03	18.07
MIA^ North	29.87		61.35	79.41	0.00	0.25	140.51	3.28	0.25	137.23			140.48	0.28
MIA South	33.73	34.57	74.31	5.82	49.32	62.11	3.14	52.93	58.63	3.14		49.32	3.12	62.26
Power Central	1.59	2.42	18.38	6.00	1.09	18.43	7.29	17.14	2.38	7.29		1.09	5.50	20.22
Powerline South	5.76	5.76	9.69		5.00	10.48	7.72	9.99	5.49			5.00	6.54	3.94
Powerline South Pit			7.71							7.72			7.71	0.01
Rail North	14.43	3.90	7.13	17.40		2.38	26.05		2.38	26.86			26.05	3.19
Rail South	23.70	25.74	12.46		9.26	28.98		21.60	16.59			9.23	15.74	13.22
Road Central	1.57	2.50	18.34	5.99	1.09	18.65	7.09	17.52	2.21	7.09		1.09	5.32	20.42
Waste Rock East Pit 1	360.41	384.26	25.74				410.01			410.00			409.41	0.60
Waste Rock East Pit 2	201.08	352.95					352.95			352.95			352.26	0.69
Waste Rock North Pit				374.45		113.03	261.43		113.03	234.86	26.56		135.24	239.21
Waste Rock South Pit 1	380.35	388.63	811.46		628.52	232.23	337.02	748.71	114.34	337.02		627.58	396.95	175.54
Waste Rock South Pit 2			397.35	104.45			501.80			501.80			477.58	24.23
Waste Rock West Pit	54.64	67.01	1,728.50	124.86	465.85	1,456.74	0.77	1,526.72	392.86	0.77		464.94	375.48	1,079.95
Water Central	1.57	2.63	17.63	5.89	0.86	17.88	7.43	16.97	1.78	7.73		0.86	5.11	20.50
Water South	6.31	6.31	5.14		2.88	8.60		6.04	5.42			2.88	6.20	2.38
Dams‡		9.60	64.81	19.98	36.70	8.15	49.67	39.96	7.77	48.56	1.11	36.60	30.15	27.64
Total	1,430	1,749	4,316	957	1,638	2,615	2,771	3,308	950	2,718	51	1,636	2,986	2,402

† No Class B GQAL was identified by NRA 2011.

No beef cattle grazing land suitability Class 1 land was identified.

$ No broad acre rain-fed cropping land suitability Class 1 or Class 3 land was identified.

* Occurrence of SCL as defined by DERM (2012c) is yet to be confirmed.

‡ Where the dams overlap with other infrastructure, the overlap area has not been included in the dam area.

^ Mine infrastructure area (MIA)

Mitigation

Where it is practicable to do so, disturbed areas will be rehabilitated to a condition suitable for the desired post-mine land use. Rehabilitation measures are detailed in **Section 3.2.7**. Post-mine land use options follow the pre-mine land use, *ie* beef cattle grazing and native vegetation. To account for possible differences in pre- and post-mining grazing management and/or intensity, agreements with the landholders will be developed that take into account the project site's final landform and its potential grazing capability. When it is unlikely that disturbed land can be returned to a condition suitable for beef cattle grazing, *eg* waste rock dump slopes, it will be returned to a 'native vegetation' land use.

In general, agricultural land use impacts and rehabilitation of disturbed areas will be addressed through the development and implementation of:

- the Rehabilitation Management Plan
- a Post Closure Monitoring Plan.

Depending on an examination of the most feasible approach to managing SCL, and if occurrence as defined in DERM (2012c) is confirmed, a mitigation strategy (*eg* avoidance, rehabilitation or, where SCL is permanently lost, payment of 'mitigation costs' (as detailed in DERM 2012c) or a combination of these) will be developed before significant disturbance occurs.

Specific impacts to SCL (if confirmed) on Lot 682 CP906890 include East Pit 1 and East Pit 2 Spoil Heap. These will be profiled (to provide stability) and rehabilitated. As these structures are considered permanent impacts, SCL values will not be re-instated in these areas.

2.2.3 Land units requiring specific management

Areas of saline and/or sodic soil have been identified, specifically the areas of sodosols, southern dermosols and brown vertosols. Specific actions for managing areas of these soils and implications for rehabilitation are provided in **Sections 3.2.4** and **3.2.7**.

2.2.4 Stock route network

Closures and relocation of stock routes may occur during the construction and operation of the mine. Alternative access routes and arrangements will be made for any temporary closures or relocations. Where feasible, existing stock routes will be reinstated after mine closure. Where existing stock routes cannot be reinstated, alternative routes will be identified and provided.

2.2.5 Areas of high conservation value

All six MLAs contain Category B Environmentally Significant Areas (Endangered Regional Ecosystems (remnant (biodiversity status)). In addition, MLA 70434 abuts a Category C Nature Refuge (Newlands Nature Refuge). Any additional areas of high conservation value are identified in sections of the EIS relating to ecological impacts. These sections will include potential impacts and mitigation measures.

2.2.6 Native title

Native Title parties have been identified. Negotiation between the proponent and these parties will be required with respect to future land use, and is not addressed further here.

2.2.7 Land use conflicts and mitigation strategies

Site and Public Infrastructure

Current infrastructure services in the immediate proximity of the project site include:

- Collinsville-Elphinstone Road
- Bowen Developmental Road
- Suttor Developmental Road
- Wollombi Road
- Goonyella to Abbot Point railway line
- water pipelines operated by SunWater
- North Queensland Gas Pipeline
- powerlines providing electricity to homesteads and Newlands mine.

Proposed infrastructure services include:

- Central Queensland Integrated Rail Project (inside lease area)
- Alpha Coal Project railway line (inside lease area)
- Arrow Bowen pipeline (outside lease area).

Temporary closures and relocation of public roads may occur during the construction and operation of the mine. Alternative access routes and arrangements will be made for any temporary closures or relocations of public roads. Sealing of road surfaces, laydown areas and hardstands may be required. Some private landholder roads may be temporarily closed or relocated. Alternative arrangements or access routes, built to the same standard as existing private roads will be provided to private landholders. Rail crossings will be provided as required.

Existing powerlines within the project area may be reconfigured and additional powerlines and substations will be installed to provide electricity to the site.

The GAP rail line traverses the project tenements from south to north. Two rail line connections to the GAP railway, one in the northern and one in the southern tenement areas, are planned on-site for the transport of product coal from stockpiles adjacent the northern and southern coal handling and processing plants (CHPPs). It is expected that rail upgrades approved as part of QR National's GAP Expansion Project will provide sufficient capacity for the Byerwen Coal Project.

Road upgrades will be considered for the Collinsville-Elphinstone Road and the site access road and Collinsville-Elphinstone Road intersection. Proposed road upgrades will be described in the transport section of the EIS.

There are two infrastructure corridors within the project site that are part of the Byerwen operations, the:

- central infrastructure corridor and
- southern infrastructure corridor.

The project's central infrastructure corridor will contain:

- a road for light and heavy mine site vehicles
- powerlines
- raw water supply pipeline

- communications.

The central infrastructure corridor will be used for the transfer of mining equipment between the various pits so as to limit impacts on public roads. It will cross the Collinsville-Elphinstone Road (a public road), the GAP rail line and potentially the proposed Alpha Coal Project rail line which will run parallel to the GAP rail line. Crossing points are required to be established where roads cross the Collinsville-Elphinstone Road and the railway lines.

Additional crossing points will also be required to allow waste rock haul truck traffic to cross the GAP rail line and proposed Alpha Coal Project rail line in the southern portion of the project to access out of pit dump locations and to facilitate equipment movement. Waste rock will either be transported by conveyor or by haul truck over a constructed bridge crossing.

The crossing of Kangaroo Creek and of other ephemeral drainage lines, including the diversion channel between West Pit 1 and South Pit 1, will be designed and constructed to provide sufficient flood immunity for a 1 in 100 year flood event. The watercourse crossing will be designed to limit works within the watercourse itself. Further details of creek crossing design are provided in the transport section of the EIS.

Landholder properties will be bisected by the central infrastructure corridor. Crossing points will be designed along the infrastructure corridor to allow movement of vehicles and stock around properties.

Adjacent areas

There are a number of potential impacts of the project on adjacent land.

Infrastructure, *eg* spoil piles and waste dumps, which is inappropriately sited near boundaries may limit land use and/or damage ecosystems on adjacent land. Mine planning includes provision for separation distances between waste dumps and ML boundaries. During mining these separation distances will be achieved through survey controls.

Surface soils, surface water and groundwater may be contaminated from discharges associated with inappropriate site drainage. This would be controlled through implementation of the requirements of a Mine Water Management Strategy (KBR 2012a).

The Water Management Strategy will manage water generated within the project area and reuse or control releases to the environment in a manner that does not cause adverse impacts to surface water quality or stream hydrology.

Stormwater management will:

- Minimise the impact of mining and production activities on the landscape.
- Divert run-off from undisturbed catchments upstream of the mining area around the disturbed area.
- Utilise water that cannot be discharged directly into receiving watercourses for other uses such as dust suppression.
- Segregate water by quality or source.
- Commence rehabilitation early to avoid the accumulation of large volumes of dirty water on-site.

This will involve the following.

- Separation of run-off from undisturbed land (“clean water”) and disturbed land run-off (“dirty water”).

- Discharge off-site of the clean water.
- Blending of clean water with mine-affected water (if required) to facilitate release.
- Discharge to occur only when there is flow in the receiving environment that is derived from a run-off event, or soon after such an event has occurred.
- Establishment of levee bank and barrier mounds that will surround the pit and waste dumps to separate dirty and clean water.
- Establishment of drains and sediment control ponds to contain dirty water.
- Dirty water to be retained on-site in holding dams and used in the mine's operations or evaporated in preference to treatment and release.
- Site roads to be designed such that all drainage from the road will be collected in roadside collection ponds.
- Scour protection works to be installed to prevent erosion at sediment control pond overflow outlets and other high water velocity or steep gradient situations.

Hazardous dams will be assessed, designed and constructed according to the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* (DERM 2012a).

Significant atmospheric dust arises from the disturbance of granular material exposed to the air and is generated by two basic mechanisms.

- Pulverisation and abrasion of surface materials by application of mechanical force (*eg* by wheels, blades).
- Entrainment of dust particles by the action of turbulent air currents, such as wind erosion of an exposed surface.

Potential dust emission sources resulting from the project site are:

- erosion of stockpiles and exposed areas on-site
- handling, transfer and storage of overburden, soil and coal
- vehicle movements along internal access roads
- crushing/screening of material.

Controls and management practices will be implemented to manage environmental impact. These may include, but will not be limited to the following.

- The mining disturbance area will be contained within the ML boundaries.
- Coal loading facilities will comply with QR guidelines.
- Ancillary road development will be limited and their locations will be clearly designated. When use of ancillary roads is high, these roads will be watered by a water truck.
- Redundant roads/access tracks will be ripped and revegetated.
- Watering the road surface and exposed areas of the site to suppress dust emissions.
- Speed limits on-site to control the dust emission on unpaved roads.
- Coal handling areas will be kept in moist conditions through the use of water application by water trucks.
- Coal stockpiles will be maintained in a moist condition particularly during dry and windy periods.
- Large overburden areas that remain unused and are exposed for extended periods of time will be covered by temporary seals, such as cover crops or temporary revegetation measures.

- Rehabilitation to take place as soon as practicable and the established vegetation to be continually maintained. Seeding of all disturbed areas will be conducted in accordance with the rehabilitation management plan for the project site.

A dust monitoring programme post-site commissioning will evaluate the effectiveness of the site-specific ameliorative measures. Consideration may also be given to trials of other methods of dust suppression to reduce the use of water.

Rehabilitation

Post-mining lands, proposed for grazing, must achieve specific completion criteria in order to achieve successful rehabilitation. Relevant criteria would include the following points.

- Sustainable production of sufficient bulk of forage material for livestock.
- Adequate access to the site to enable practical management of livestock.
- Flood-free and relatively dry ground conditions.
- Adequate stock drinking water and shelter.
- Rehabilitation of existing or provision of alternative stock routes throughout the rehabilitated site.

Rehabilitation of land in the project site is covered in detail in **Section 3.2.7**.

Statutory or non-statutory plans

The project site is in two superseded local government areas, Nebo Shire (which was amalgamated with the Belyando and Broadsound Shires to become the Isaac Region Local Government Area) and Bowen Shire (which was amalgamated with Whitsunday Shire to become the Whitsunday Local Government Area). Both planning schemes of both superseded shires (the *Nebo Shire Plan* (Nebo Shire Council 2008) and the *Bowen Shire Planning Scheme 2006* (Bowen Shire Council 2006)) zone the land of the project site as rural.

Northern Economic Triangle

The Northern Economic Triangle (NET) was established by the Queensland Government in 2007 as a plan to foster sustainable development and growth in the Mount Isa, Townsville and Bowen areas, for mining, mineral processing and industrial development. The project is outside the taskforce area but does support the strategies and actions of the *Northern Economic Triangle Infrastructure Plan 2007–2012* (NET Infrastructure Plan) to:

- raise the regional and international profile of North West and North Queensland
- expand mining and mineral processing operations to supply world markets
- exploit global demand for minerals and metals
- maximise opportunities for potential development presented by large international companies
- promote collaborative solutions for the provision of critical infrastructure and opportunities for private sector investment.

Mackay, Isaac and Whitsunday Regional Plan

The *Mackay, Isaac and Whitsunday Regional Plan* (MIW Regional Plan) (Queensland Government 2012) is discussed in **Sections 2.2.1** and **2.2.2** with regard to residential, industrial and agricultural land use.

The project would result in changes to land use as the site is currently used primarily for grazing. The area surrounding the project site is within the Regional Landscape and Rural

Production Area (RLRPA) and there is unlikely to be conflicts of land use. The RLRPA identifies land with regional landscape, rural production or other non-urban values. The RLRPA does not impede existing land-use rights. This ensures that existing commitments and significant activities such as agricultural production, access to natural resources, mineral extraction, water storage, tourism, outdoor recreation and nature conservation can continue. Current adjacent land uses are likely to continue with the exception of potential development of mine projects and potential expansion of the town of Glenden.

The MIW Regional Plan states that once extraction ceases, areas subjected to mining are to be rehabilitated to facilitate multiple end-uses of sites, ensuring their continuing contribution to the economic, social and environmental values of the region (Queensland Government 2012). Rehabilitation is discussed in **Section 3.2.7**.

State Planning Policies

State Planning Policies (SPP) which have been considered under specific sections in this report, relate to:

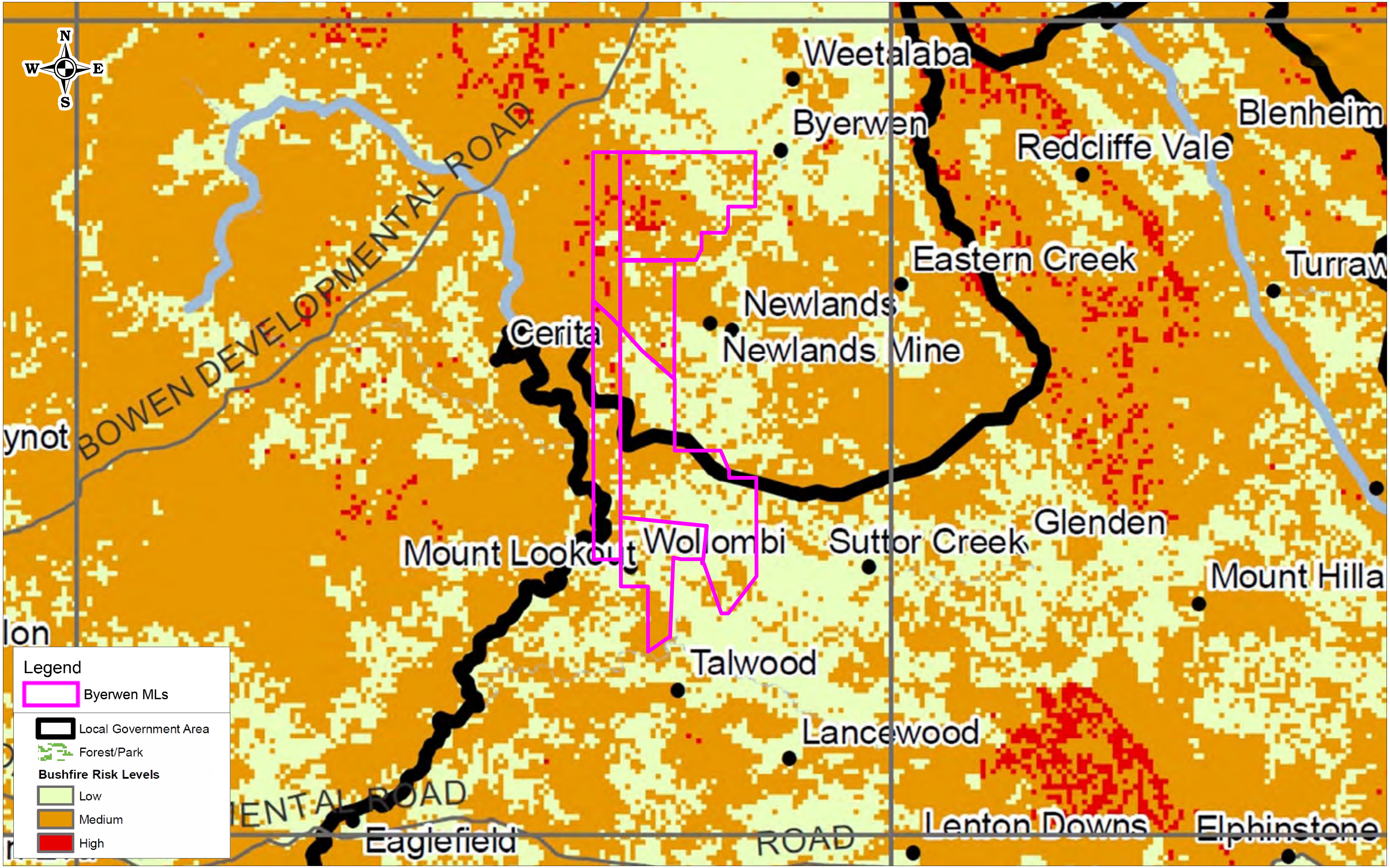
- Development and Conservation of Agricultural Land (SPP1/92)
- Protection of Extractive Resources (SPP 2/07)
- Protection of Strategic Cropping Land (SPP 1/12).

Other SPPs related to land use are:

- Mitigating the Adverse Impacts of Flood, Bushfire and Landslide (SPP 1/03)
- Planning for Prosperity (Temporary SPP 2/12).

The majority of the landscape of the project site is mapped as low or medium risk in the Bushfire Risk Analysis for Whitsunday Regional Council (Queensland Government 2008) (**Figure 12**). Fire management will need to be incorporated into site management plans.

Planning for Prosperity is unlikely to impact upon the project and provides mechanisms for resolving land use conflicts that may arise during planning and development.



PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Byerwen Mine Bushfire Risk Analysis

T:_AAA\366\WOR\366203\366203_Byerwen fire risk_2012_10_09.wor

JOB NO: 366203
DATE: October 2012
SOURCE: QFRS, DME, NRA

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Figure 12

Recommended print size: A4

3. Topography, geology and soils

3.1 Description of environmental values

3.1.1 Topography

Elevation on the project site ranges between approximately 250 m AHD (where Kangaroo Creek leaves the site) to approximately 390 m AHD (on the mesas in the north). Most of the southern third of the site is level-to-very-gently inclined (slope <1 – 3 %). The central and northern sections are more undulating and include level-to-very-gently inclined areas interspersed with moderately-inclined-to-steep areas, with the steeper areas typically bounding small mesas or the sandstone highlands in the north-west (**Figure 13**).

3.1.2 Geology

The project is located within the Northern Bowen Basin in Central Queensland. The Bowen Basin is part of a connected group of Permian-Triassic basins in eastern Australia, which includes the Sydney and Gunnedah Basins. The Bowen Basin contains large reserves of Permian coals, which have been mined on a large scale by open-cut and underground methods since the 1970s.

The project resource includes coal within both the Moranbah and Rangal Coal Measures. The Moranbah Coal Measures represent the main stratigraphic unit of interest in the project area, and contain up to seven persistent coal seams. The Moranbah Coal Measures are approximately 290 m thick in the project area and strike north-south, dipping to the east at between 4 and 12 degrees. Both normal and thrust faults are present in the project area, which lead to seam offsets and displacement.

The principal seams of economic interest are the Goonyella Lower (GL - 6 to 8 m thick), Goonyella Middle (GM – 6 to 10 m thick), and P Rider (2 to 4.5 m thick) seams. The main seam of interest in the Rangal Coal Measures is the Leichhardt seam, a correlative of the Upper Newlands seam which averages 6.5 m thick in the nearby Newlands Mine (east of the project) and 4.5 m thick in the Suttor Creek mining lease area.

In the project area the Bowen Basin is characterised by typical basin-fill fluvial (and some marine) sediments, comprising mudstones, siltstones, sandstones and coal seams. Spoil materials will predominantly comprise mudstone, siltstone and very fine- to fine-grained sandstone. Coal seam roof and floor zones (immediately above and below coal) and coal partings (thin zone of non-coal material between coal seams) are typically comprised of very fine-grained sedimentary lithologies, such as mudstones, siltstones and very fine-grained sandstone, which is typical of the 'low energy' depositional environment of coal. These roof, floor and parting zones are also commonly carbonaceous, containing wispy coal laminations.

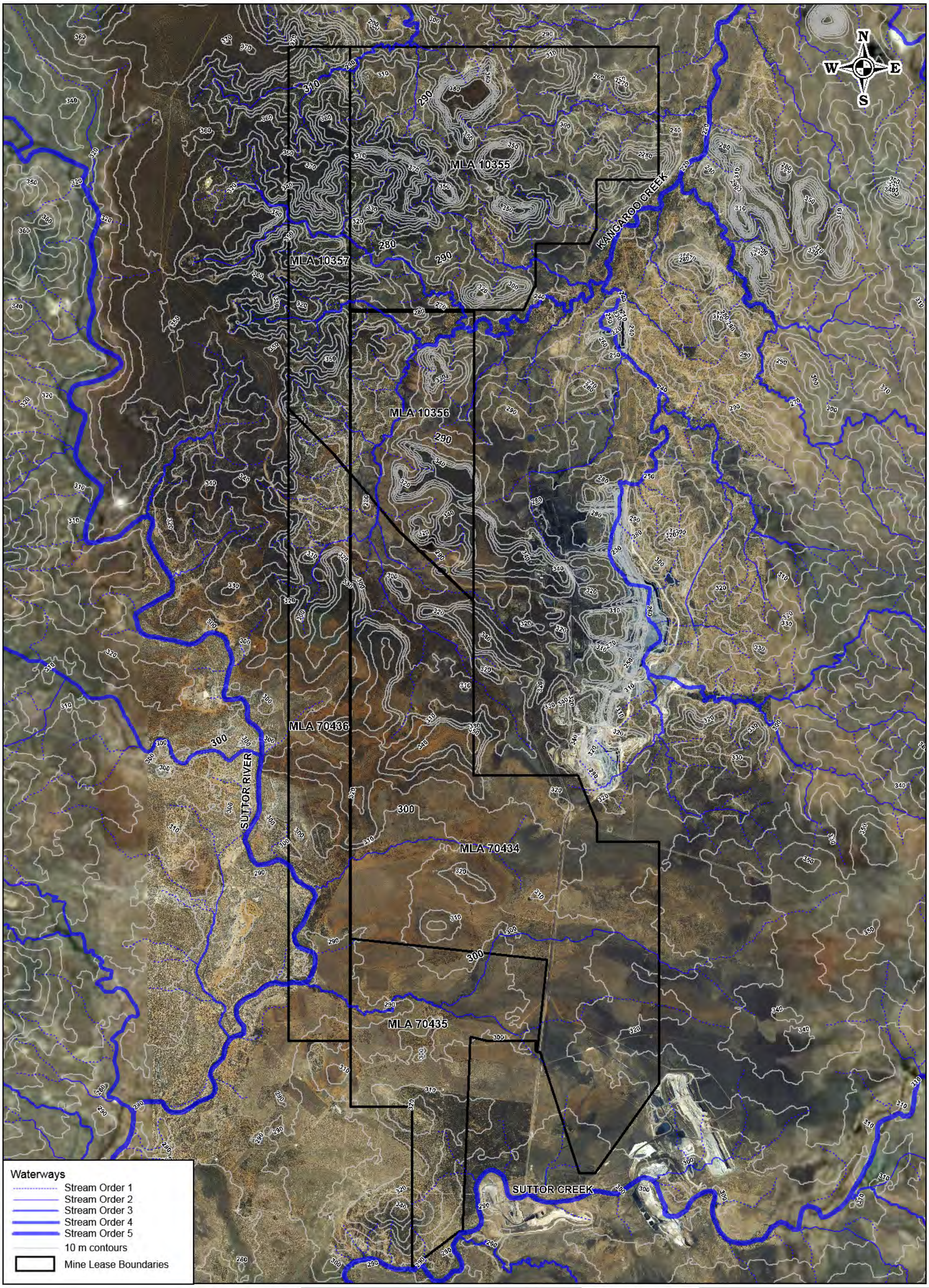
A geology map of the project site taken from the Mount Coolon 1:250,000 geology map (QDME 1997) is given as **Figure 14** and geological units mapped in the project area are described in **Table 9**. The coal seams to be mined are shown on geological cross-sections (**Figure 15**). Outcrop in the project area is largely obscured by deep soils.

ELP advise that the likelihood of uncovering significant fossils is expected to be low based on information from the Newlands Coal Expansion, which identified that significant fossils have not been identified during the ongoing operations at the existing mine (KBR 2012b). No fossil localities are shown in the project area on the Mount Coolon 1:250,000 geology map (QDME 1997). However, pieces of fossilised tree were found during the NRA 2011 land survey in the far north-eastern corner of ML 10355 (the location is outside the project disturbance footprint) in the area of the Fort Cooper Coal Measures (Pwt). The Fort Cooper Coal Measures also outcrop at Homevale Station (approximately 60 km east of the project site), where they reportedly contain an important *Glossopteris* plant fossil site (Australian Heritage Council 2012).

In the situation where a suspected significant fossil find is made, mine operations will be managed to preserve the find and a mine geologist will assess it. The find will be reported to the regulator (or appropriate government agency).

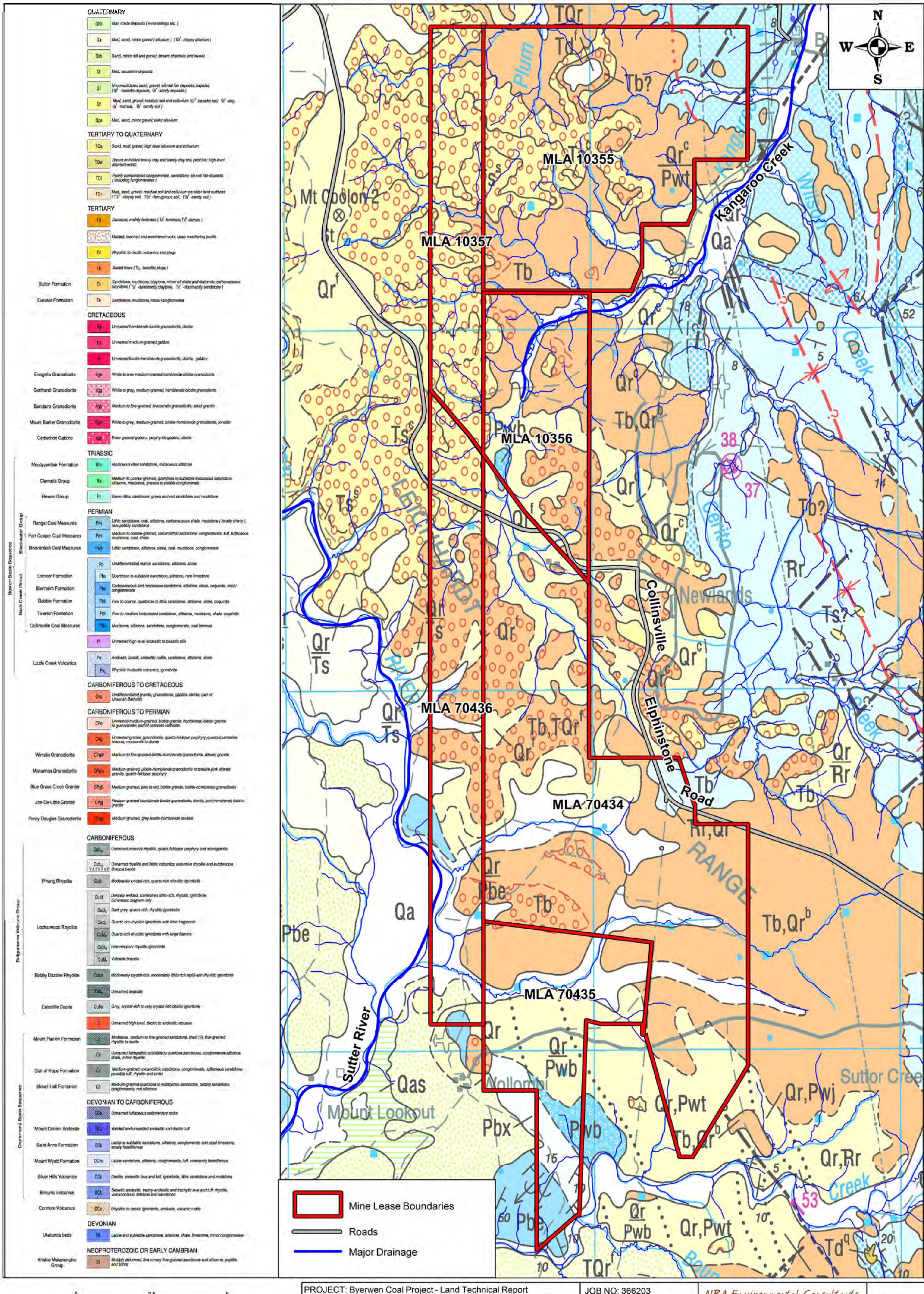
Table 9: Geological units mapped by QDME (1997) in the project area

Unit	Description
Quaternary	
Qa	Mud, sand, minor gravel (alluvium)
Qr	Mud, sand, gravel; residual soil and colluvium
Qr^b	Mud, sand, gravel; residual soil and colluvium; basaltic soil
Qr^c	Mud, sand, gravel; residual soil and colluvium; clay
Qpa	Mud, sand, minor gravel; older alluvium
Tertiary	
Ts^C	Dominantly claystone, but also sandstone, mudstone, minor oil shale and diatomite; carbonaceous claystone
Ts^S	Dominantly sandstone, but also mudstone, claystone, minor oil shale and diatomite; carbonaceous claystone
TQr^f	Mud, sand, gravel' residual soil and colluvium on older land surfaces; ferruginous soil
Tb	Basalt flows
Td^f	Duricrust, mainly ferricrete; ferricrete
Triassic	
Tr	Rewan Group – Green lithic sandstone, green and red sandstone and mudstone
Permian	
Pwt	Fort Cooper Coal Measures – Medium to coarse-grained, volcano-lithic sandstone, conglomerate, tuff, tuffaceous mudstone, coal, shale
Pwb	Moranbah Coal Measures – Lithic sandstone, siltstone, shale, coal, mudstone, conglomerate
Pbx	Exmoor Formation – Quartzose to sub-labile sandstone, siltstone, rare limestone
Pbe	Blenheim Formation – Carbonaceous and micaceous sandstone, siltstone, shale, coquinite, minor conglomerate



PROJECT: Byerwen Coal Project - Land Technical Report TITLE: Byerwen Project area topography T:\ AAA\366\WOR\366202\366202_BCP Topography 2012 09 21.wor	JOB NO: 366203 DATE: September 2012 SOURCE: NRA, DEHP, DME, Google Earth	NRA Environmental Consultants NATURAL RESOURCE ASSESSMENT AND MANAGEMENT	Figure 13

Recommended print size: A3



0 2.5 5
Kilometres

PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Geology Map

T:_AAA\366\WOR\366203\366203_Geology Map_2012_10_26.wor

JOB NO: 366203
DATE: September 2012
SOURCE: NRA, QCoal, DME

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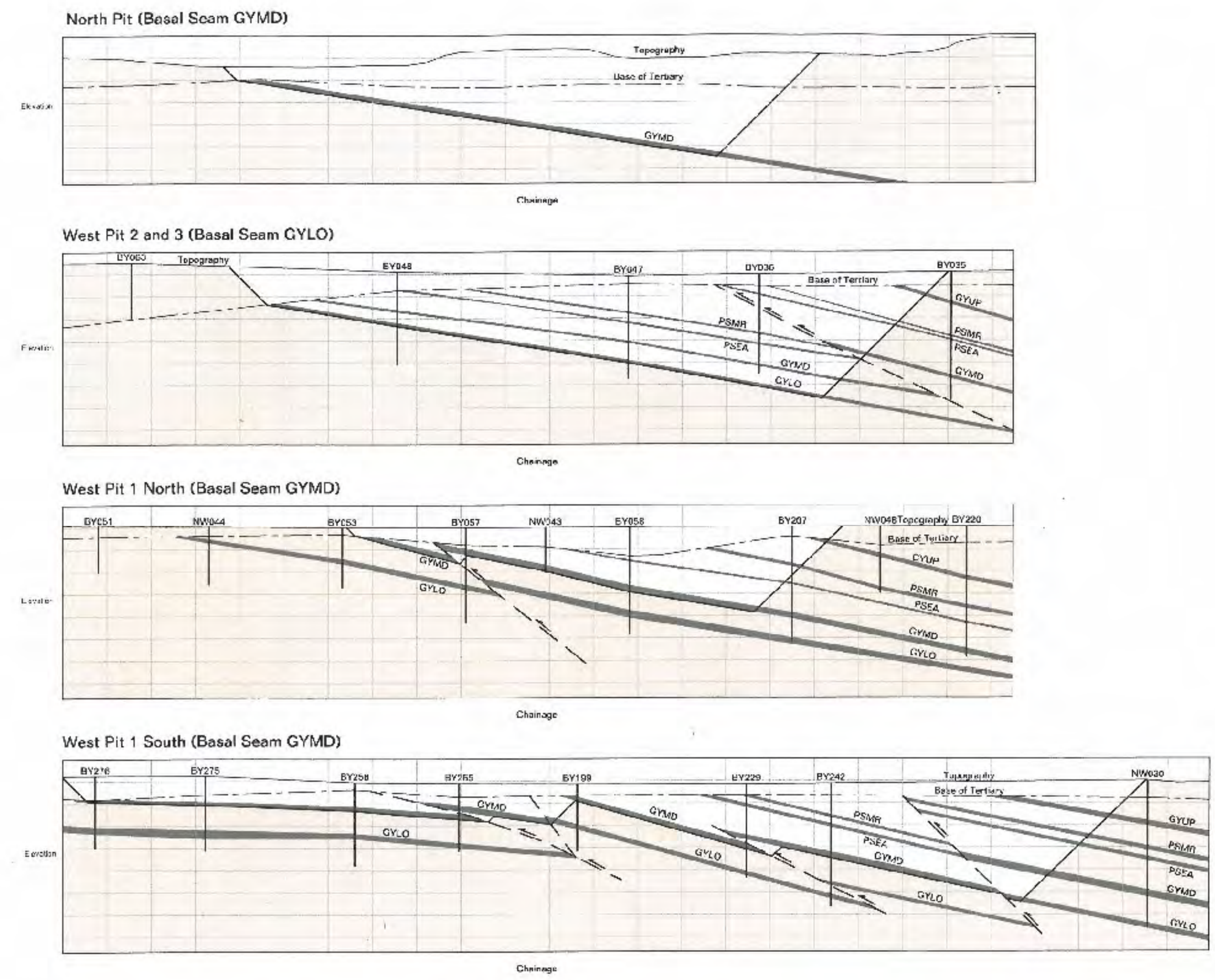
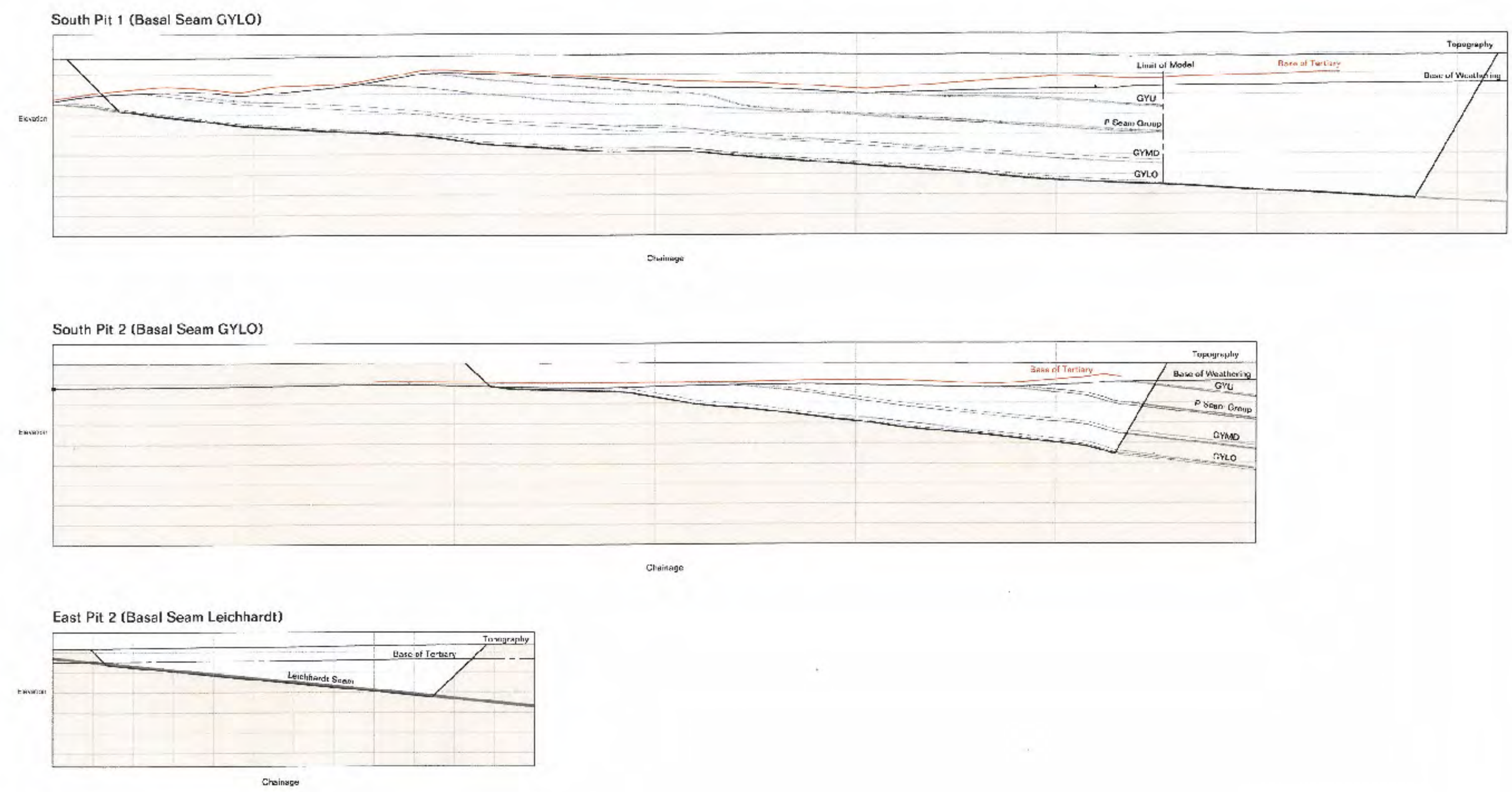
Figure 14

Recommended print size: A3



BYERWEN COAL PROJECT

Cross Sections - West Pit and North Pit



BYERWEN COAL PROJECT

Cross Sections - South pit and East Pit

PROJECT: Byerwen Coal Project - Land Technical Report TITLE: Byerwen Coal Project Pit Geological Cross Sections	JOB NO: 366203 DATE: September 2012 SOURCE: NRA, BC Pty Ltd	Figure 15

NRA Environmental Consultants

T:_AAA\366\WOR\366203\366203_Geology X sections 2012 09 26.wor

Recommended print size: A3

3.1.3 Soils

A soil and land assessment was conducted of the project site in 2011 by NRA, the full details of which are in NRA (2011). The survey consisted of observation of land use, landform, erosion, and detailed description of dominant soils using methods in the *Australian Soil and Land Survey Field Handbook* (NCST 2009). The survey was designed cognisant of the *Guidelines for Surveying Soil and Land Resources* (McKenzie *et al.* 2008), and based on the profile descriptions made in the field, the soils were classified using *The Australian Soil Classification* key of Isbell (1996). Soil data collected by the study is used to inform rehabilitation, land suitability, stormwater run-off and erosion aspects of the Byerwen Project.

Soils identified during the survey were mapped using field observations informed by existing soil and geology maps and remote sensing imagery. Field observations and existing soil mapping were sufficient to map the soils in most of the project area at a scale of 1:50,000.

Ten soil groups were identified during the field survey (**Table 10**). The soils are described below and their distribution shown in **Figure 16**.

It is considered that the dominant soils on the project site were encountered during the survey and are described below. However, an area on the south-western boundary was not accessible at the time of the survey. Previous soil mapping by Isbell and Murtha (1970) describes a soil in this area that is similar to the sodosols (land mapping unit GH24). This area has been tentatively mapped and assessed as containing sodosols (**Figure 16**).

Table 10: Soil groups on the Byerwen Coal Project mining leases

Soil Group	Brief Description
Rudosols	Poorly developed soils (alluvium)
Sodosols	Texture contrast soils
Northern Kandosols	Deep unstructured soils
Central Kandosols – Red – Brown	Deep unstructured clayey soils Red form Brown form
Central Dermosols	Deep structure brown soils
Southern Dermosols	Deep structured brown soils
Brown Vertosols	Deep cracking soils in areas of gilgai
Northern Dark Vertosols	Deep cracking soils
Central Dark Vertosols	Shallow cracking soils
Southern Dark Vertosols	Deep cracking soils

Soil groups on the Byerwen Coal Project mining leases are described in detail in **Appendix B**. A summary of each soil type and any management issues is presented below.

Rudosols

Rudosols were found in the centre of the project site. They appear to have a small distribution limited to the upper tributaries of Kangaroo Creek. These soils have fertility issues and become sodic below 0.3 m. Examples of moderate gully erosion were observed in these soils.

Sodosols

Sodosols were found either side of Kangaroo Creek and down-slope of the sandstone bluffs throughout the central and northern regions of the project site. These soils have fertility issues below 0.3 m, and are sodic below 0.6 m. Magnesium enhanced sodicity may also be an issue below a depth of 0.3 m. Moderate to severe gully erosion was observed where these soils had been disturbed.

Northern Kandosols

These soils are typical on the elevated areas of sandstone in the north of the project site. The surface material is acidic and the soil has fertility issues below 0.6 m. None of the analysed samples reported significant ESP or Magnesium enhanced sodicity.

Central Kandosols

The central kandosols occur in two forms – brown and red. These soils are similar and inter-related and are treated as one unit. The red kandosols are dominant on the elevated, better-drained areas and the brown kandosols are more common on areas of lower elevation. These soils may have fertility issues below 0.6 m, and magnesium enhanced sodicity may be an issue below 0.9 m.

Central Dermosols

Central dermosols have a limited distribution in the centre of the project site in association with the central kandosols, central vertosols, rudosols, and chromosols. These soils have fertility issues and become sodic below 0.3 m.

Southern Dermosols

The southern dermosols occur in association with the southern dark vertosols and central kandosols in the southern part of the project site. The soils have fertility issues and are sodic (including Magnesium enhanced sodicity) below 0.3 m.

Brown Vertosols

Brown vertosols occur in areas of melonhole gilgai and are typically associated with the central kandosols. These soils are strongly sodic (including Magnesium enhanced sodicity) and saline below 0.3 m.

Northern Dark Vertosols

The northern dark vertosols occur mainly in the north-eastern part of the project site. These soils are sodic (with Magnesium enhanced sodicity) below 0.3 m and have fertility issues throughout the profile.

Central Dark Vertosols

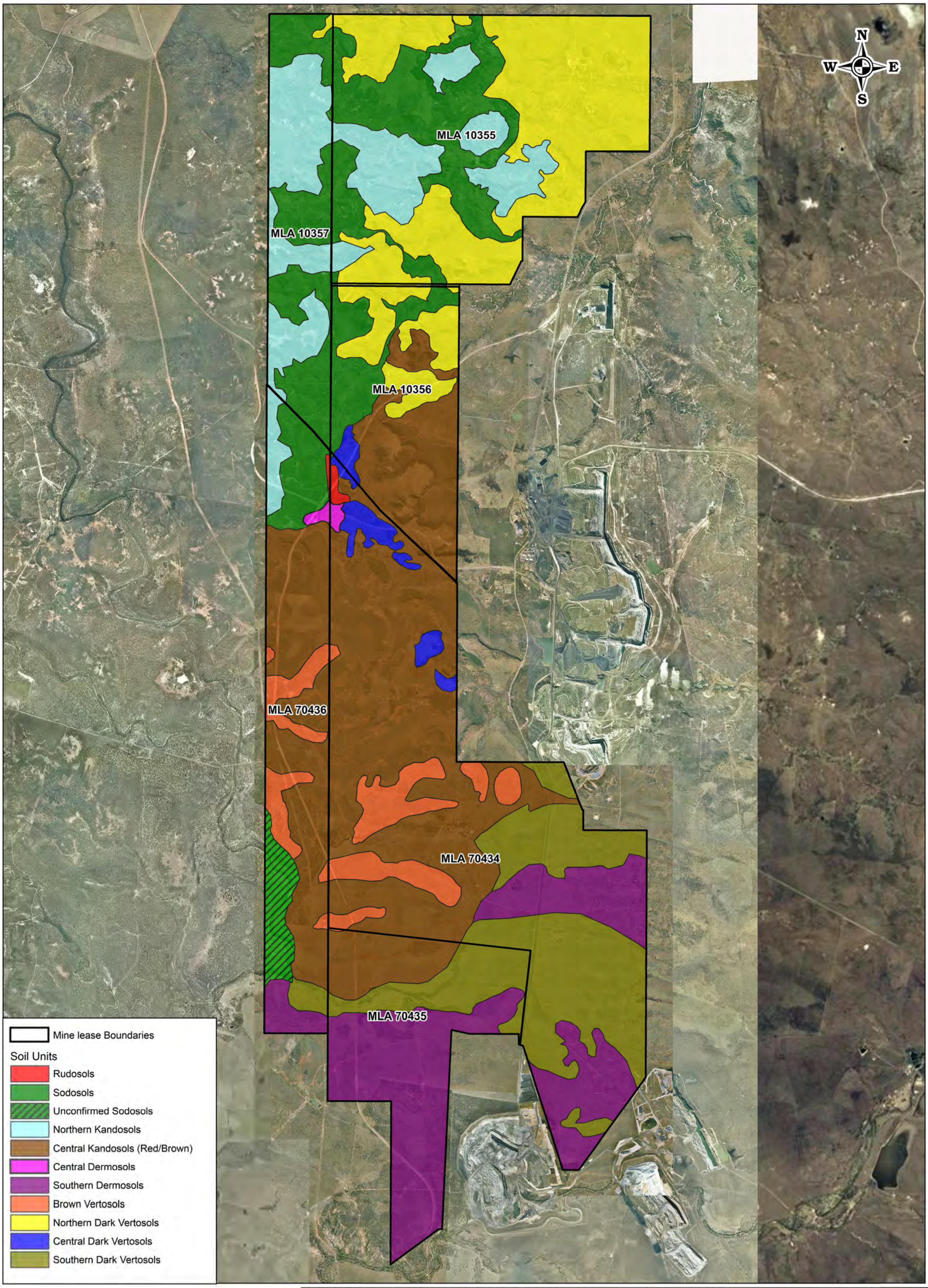
The central dark vertosols are shallow cracking clays that occur in association with the rudosols, sodosols, central dermosols, and central kandosols. These soils appear to be stable and have minor fertility issues below 0.3 m.

Southern Dark Vertosols

The southern dark vertosols occur in association with the southern dermosols and the central kandosols. Typically they are deep clays that form a cracking surface. Magnesium enhanced sodicity may be an issue in these soils.

Geotechnical properties

No geotechnical studies have been conducted on the suitability of the soils for construction purposes. Geotechnical surveys will be conducted to inform the detailed design stage of the project.



PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Soil Map for the Byerwen Coal Project

T:_AAA\366\WOR\366203\366203_Byerwen Soil Boundaries_2012_11_07.wor

JOB NO: 366203
DATE: November 2012
SOURCE: NRA, DME, ELP, Google Earth

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Figure 16

Recommended print size: A3

3.2 Potential impacts and mitigation measures

3.2.1 Topography

Impacts

Final voids, spoil dumps and co-disposal dams are expected to permanently alter the topography of the project site.

Mitigation

Final landform planning will take into account impacts on topography when developing rehabilitation and post-mine land use plans (refer to **Section 3.2.7**).

3.2.2 Local waterways

Impacts

The movement of eroded soil into waterways results in degradation of water quality with respect to suspended solids/turbidity, nutrients associated with soil material and metals and metalloids associated with mineralised soils leading to the following:

- Impacts on aquatic organisms and waterway productivity through light interception, proliferation of nuisance organisms or direct toxicity.
- Changes in species composition as a result of changes in water quality.
- Reduction in potential potability of water for humans and livestock.
- Reduction in quality of water for crop irrigation.
- Decline in aesthetic and recreational values that may be of cultural significance.

The deposition of eroded soil and sediment, sometimes at considerable distance from the site of soil loss can result in the following:

- Smothering and degradation of natural in-stream and near-stream habitats.
- Increase in stream bank erosion and channel width resulting in riparian habitat and property loss.
- Reduced navigability.
- Increase in over bank flooding due to stream bed aggradation and potential impacts on surrounding land uses or environmental values.
- Damage to in-stream infrastructure (dams, culverts).

Mitigation

Erosion mitigation measures are outlined in **Section 3.2.6**. Additional measures specifically relevant to waterways include the following:

- Where earthworks are carried out in proximity to a watercourse disturbance should be repaired and stabilised immediately on completion of works.
- Felled timber should be removed from the area and stockpiled away from the watercourse.
- Temporary earth banks are to be installed along any cleared slope on approaches to watercourses to divert dirty water away from the watercourse and into a vegetated area or sediment control structure.
- Clean rock (with minimum fines) and culverts are to be used for temporary watercourse crossings. These structures are to be removed with care to minimise sedimentation of the watercourse.

- Where buried infrastructure crosses a drainage line, work should be scheduled for the dry season (no flow conditions) with sufficient lead time to allow any backfilling and stabilisation to take place prior to wet season flows.
- The discharge of diverted water (piped or pumped) must not cause stream bed or bank erosion downstream of the works.
- Water discharged to a waterway should meet project water quality criteria, in terms of turbidity and total suspended solids.

3.2.3 Land disturbance

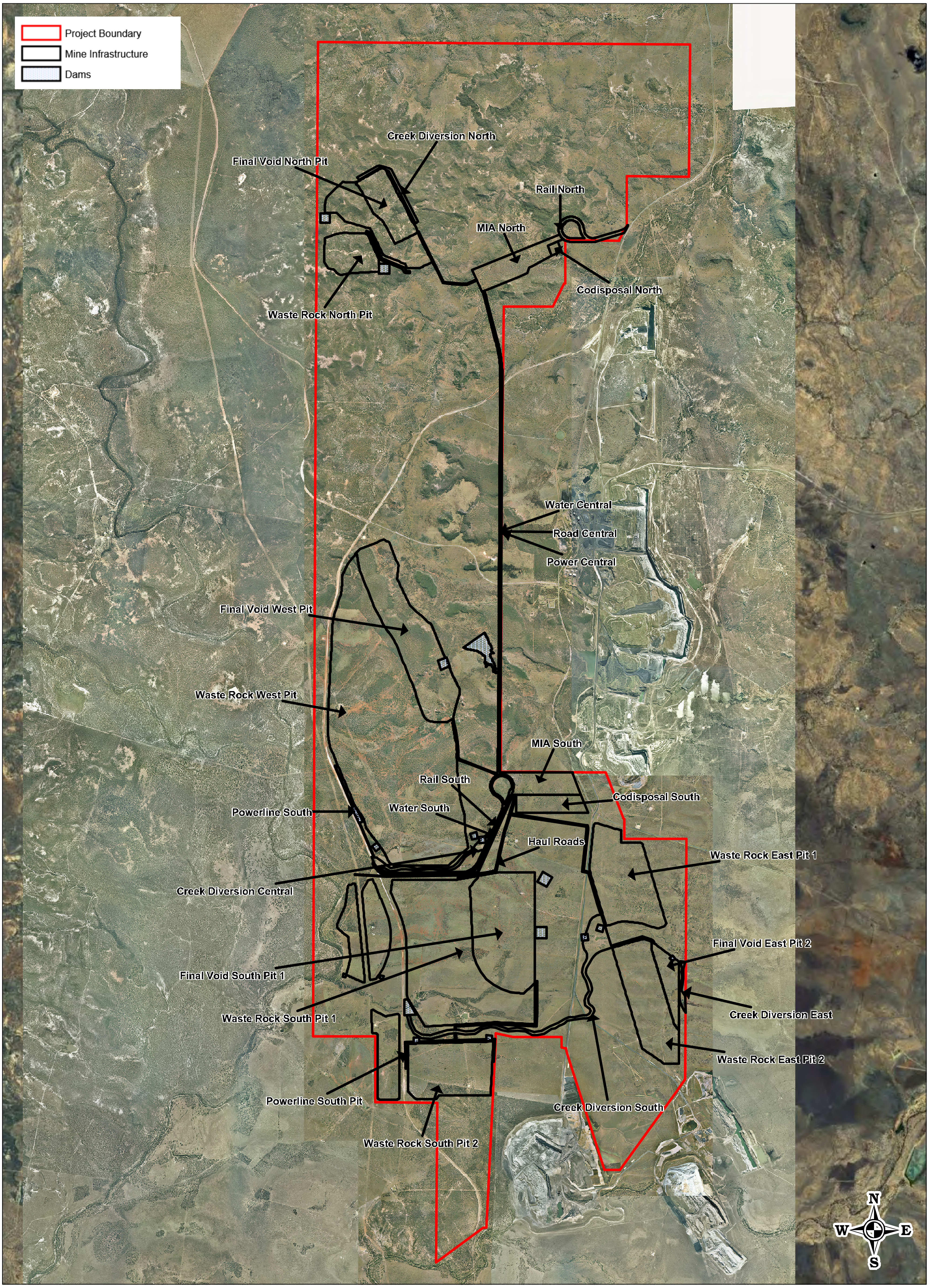
The footprint of the project is shown in **Figure 17** and the disturbance area of each mine component given in **Table 11**.

Table 11: Disturbance area for mine components

Mine Component	Area (ha)	Overlap with dams (ha)
Powerline South Pit	7.72	0.6
Powerline South	15.48	0.95
Haul Roads	73.54	
Rail North	33.57	
Water Central	27.01	
Power Central	26.95	
Road Central	26.96	
MIA South	114.70	
MIA North	140.76	
Codisposal South	94.79	
Codisposal North	9.03	
Water South	11.47	
Rail South	38.23	
Final Void West Pit	549.52	6.23
Final Void South Pit 1	544.81	
Waste Rock North Pit	374.45	
Final Void North Pit	163.66	
Waste Rock West Pit	1,923.93	
Waste Rock South Pit 2	502.02	
Waste Rock South Pit 1	1,201.33	
Waste Rock East Pit 1	410.00	
Waste Rock East Pit 2	352.95	
Final Void East Pit 2	88.09	1.06
Creek Diversion Central	38.74	2.24
Creek Diversion South	128.71	4.24
Creek Diversion North	31.46	
Creek Diversion East	11.51	
Dams†	94.52	
Total	7,035.91*	-

* This is comparable to the area reported by ELP (6,918 ha) with the discrepancy an artefact of GIS mapping.

† Where the dams overlap with other infrastructure, the overlap area has not been included in the dam area.



PROJECT: Byerwen Coal Project - Land Technical Report
TITLE: Byerwen Coal Project Disturbance Areas

T:_AAA\366\WOR\366203\366203_Infrastructure_2012_11_30.wor

JOB NO: 366203
DATE: November 2012
SOURCE: NRA, ELP, Google Earth

NRA Environmental Consultants
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Figure 17

Recommended print size: A3

3.2.4 Soil

Impacts

Soil is one of the most valuable resources on-site in terms of successful rehabilitation.

Soils can be physically degraded (compaction, deformation and loss of structure) *in-situ* without alterations to landform, particularly where heavy machinery is used and through the development of temporary roads. This degradation can severely limit revegetation potential and can also decrease water infiltration, increase run-off and cause accelerated erosion even on low slopes.

Soil quality can also be affected by mixing, poor topsoil stripping and handling and by contamination from mining activities. All of these have the potential to affect productivity and rehabilitation success. Contamination has the potential to affect the suitability of land for growing food. Some natural mineralisation may already occur at the site, but contamination from other sources (such as acid mine drainage) and ore concentrate can cause additional impacts.

The movement of soil also has the potential to move weeds and pathogens into areas previously unaffected.

Mitigation

A Topsoil Management Plan should be developed and implemented at commencement of the development to ensure that soil with suitable physical and chemical properties for rehabilitation is protected through mine life. Suitable soils will be nominally stripped to 0.3 m (more where required) from disturbance areas and stockpiled or directly placed for rehabilitation.

Table 12 presents the approximate coverage of each soil, considerations for rehabilitation, relative erosion risk, and potential stripping depths for areas to be disturbed by mining activities.

Ideally, areas where soils have saline and/or sodic properties should be avoided altogether (*ie* areas of sodosols, southern dermosols and brown vertosols). Where it is impracticable to avoid these areas then the management approach will need to consider the following.

1. Surface material is invariably of greater agronomic value than overburden and therefore as a general rule should be salvaged (to a nominal depth of 0.3 m) for use in rehabilitation activities.
    - Where the disturbance activity is permanent such as in the case of overburden placement, tailings/reject disposal or open pit development the surface material should be salvaged.
    - Where the disturbance activity is temporary such as roads, tracks, infrastructure areas, the decision to salvage must be made in the context of the inherent limitation of subsurface soils, *ie* exposure of problematic subsurface soils may present a greater environmental risk than not collecting surface material ahead of disturbance.
2. For all other soils, in the circumstance where suitable soil material extends to depth and the mining activity represents a permanent loss of the land (*ie* overburden placement, tailings/reject disposal and/or open pit development) soil material recovery to the maximum depth possible should occur (**Table 12**). Surface soil material (nominally 0–0.3 m) should be salvaged and stored separately.

Table 12: Potential soil stripping depth and approximate salvage volumes

Soil	Disturbance (ha)†	Potential stripping depth	Considerations/Erosion Risk*	Volume of soil potentially available for salvage (m^3)
Rudosols	0	Collect surface material only (surface to 0.3 m)	• Sodic below this depth • Moderate gully erosion observed • Erosion risk: high	0 (no expected disturbance)
Sodosols	408	Collect surface material only (surface to 0.3 m)	• Fertility issues and Mg enhanced sodicity below 0.3 m, sodic below 0.6 m • Moderate to severe gully erosion observed • Erosion risk: low for surface material (to 0.3 m), high below 0.3 m	1,224,000 of surface material
Northern Kandosols	163	Collect and stockpile surface material (surface to 0.3 m) and sub-surface material (0.3 to 1.0+ m) separately	• Surface material is acidic (fertility) • Material below 0.6 m has fertility issues • Erosion risk: low	489,000 of surface material 1,141,000 of subsurface material (available)
Central Kandosols	3,373	Collect and stockpile surface material (surface to 0.3 m) and sub-surface material (0.3 to 0.9 m) separately	• Fertility issues below 0.6 m • Magnesium enhanced sodicity may be an issue below 0.9 m • Erosion risk: low to 0.9 m, medium below 0.9 m	10,119,000 of surface material 20,238,000 of subsurface material (available)
Central Dermosols	4	Collect surface material only (surface to 0.3 m)	• Fertility issues and sodic below 0.3 m • Erosion risk: low for surface material (to 0.3 m), high below 0.3 m	12,000 of surface material
Southern Dermosols	910	Collect surface material only (surface to 0.3 m)	• The soils have fertility issues and are sodic (including Mg enhanced sodicity) below 0.3 m • Erosion risk: low for surface material, high below 0.3 m	2,730,000 of surface material

Soil	Disturbance (ha)†	Potential stripping depth	Considerations/Erosion Risk*	Volume of soil potentially available for salvage (m^3)
Brown Vertosols	700	Not suitable for rehabilitation	• Strongly sodic and Mg enhanced sodicity • Erosion risk: high	Do not salvage. Dispose of within spoil piles at depth or in co-disposal dams
Northern Dark Vertosols	204	Collect surface material only (surface to 0.3 m)	• These soils are sodic (with Mg enhanced sodicity) below 0.3 m and have fertility issues throughout the profile • Gully erosion observed • Erosion risk: low for surface material (to 0.3 m), high below 0.3 m	612,000 of surface material
Central Dark Vertosols	8	Collect and stockpile surface material (surface to 0.3 m) and sub-surface material (0.3 to 0.7 m) separately	• Material below 0.3 m has fertility issues. • Erosion risk: low	24,000 of surface material 32,000 of subsurface material (available)
Southern Dark Vertosols	1,166	Collect and stockpile surface material (surface to 0.3 m) and sub-surface material (0.3 to 0.9 m) separately	• Magnesium enhanced sodicity may be an issue in this soil (though dispersion was not observed during testing) • These have fertility issues below 0.9 m • Erosion risk: medium	3,498,000 of surface material 6,996,000 of subsurface material (available)
Total	6,934#	-	-	18,708,000 of surface material 28,407,000 of subsurface material (available)

* The erosion risk assigned is relative to the other soils on the Byerwen side. It is based on field observations of erosion and results for sodicity and dispersiveness.

This is comparable to the area mapped by ELP (6,916 ha) with the discrepancy an artefact of GIS mapping.

† Disturbance area for soils does not include dams.

3. Wherever practicable, salvaged soil material should be directly placed on areas to be rehabilitated. Typically, it is not possible to operate a salvage and direct placement approach from the outset; however, it is advisable that as soon as such an approach is practical that it be adopted rather than continue to stockpile soils. It is also preferable that minimal quantities of soil be stockpiled, to the extent that salvageable soils available for direct placement are used preferentially to previously stockpiled soils.

The selection of locations for soil stockpiles should be incorporated into mine planning and drainage design. The locations, creation date, source of soil and volumes of all soil stockpiles should be recorded in a Topsoil Management Plan and this plan updated if stockpiles are relocated or if resources are used in rehabilitation.

In order to maximise the value of topsoil resources on-site, be they from areas of GQAL or otherwise, the Topsoil Management Plan should include consideration of the following precautions.

- Plan mining activities to minimise soil disturbance.
- In particular, the sodosols, northern dark vertosols and southern dark vertosols are prone to gully formation. Where these soils will be disturbed and left exposed (such as after stripping, but before excavation or re-covering), or stockpiled, ensure appropriate drainage is constructed to avoid high water velocities/concentration of drainage.
- Prepare a sediment and erosion control plan for the site.
- Where possible, time soil disturbance to occur during the dry season.
- Surface and sub-soils should be stripped, handled and stockpiled separately.
- Soil quality declines in storage particularly after the first year. Where stripped soils cannot be directly placed, they should be stockpiled. Stockpiles should not exceed a maximum height of 2 m and should be located in a suitable area *eg* free of future disturbance, away from drainage lines.
- Where possible, soils should not be stripped, handled or respread when they are wet and prone to damage through smearing and compaction or when they are dry and powdery. Ideally soils should be friable and moist and not smear when worked in the hand. Soil that is stripped when it is wet will be damaged and may become anaerobic in storage thereby killing beneficial microorganisms and viable seed. This diminishes its value and potentially compromises rehabilitation outcomes.
- Soil should not be pushed to the edges of the disturbance area. It should be transported to specific locations where it can be effectively protected and managed.
- Earth scrapers (or box scrapers) towed by a tracked vehicle are likely to be used for stripping. Equipment movements on the unstripped topsoil should be minimised. If excavators are used, equipment should work on the exposed subsoil or overburden so as to minimise the compaction of the topsoil being stripped. All haulage routes must be located on the subsoil or overburden, not the unstripped topsoil.
- Soil stockpiles should be located away from watercourses and areas that may be subject to flooding or water logging or where they could be impacted by vehicular traffic and contamination from mine wastes.
- Soil stockpiles should be located on areas of planned disturbance to minimise the total disturbance area.
- Allow soil stockpiles to self-seed with existing species and/or seed stockpiles with plant species selected for rehabilitation.
- Diversion banks or drains should be installed upslope of the stockpile to minimise run-on and stockpile erosion. Sediment fencing should be installed downslope of the stockpile to minimise sediment export.

3.2.5 Spoil and reject geochemistry

The geochemistry of the spoil and coal reject material has been investigated by RGS-Terrenus (2012). The investigation includes details on spoil and coal rejects, as well as geochemical suitability of soil for rehabilitation and revegetation. See **Chapter Waste Rock and Tailings** for details.

3.2.6 Soil erosion

Impacts

The removal of vegetation and/or topsoil and the creation of new landforms can impact on soils resistance to erosion. The impacts of soil erosion and sediment transport are located at the site of erosion, in the transporting waters and at the site of sediment deposition. At the site of erosion the most serious impact is generally the loss of valuable soil, particularly topsoil. This soil loss, and associated poor surface stability, reduces the potential for agriculture, site rehabilitation and natural regeneration. Additional impacts include damage to infrastructure such as roads and building foundations, exposure of bedrock, which hinders construction activities, and creation of deep rills or gullies that can cause access problems. Soil erosion may also occur off-site due to increased water run-off. The transport of soil into waterways can affect hydrology and geomorphology as well as water quality.

Soil erosion may result in the following.

- Potential loss of agricultural productivity.
- Decrease in rehabilitation potential or increase in management effort required for successful rehabilitation particularly where infertile subsoils are exposed.
- Decreased capacity for soils to intercept and store rainfall resulting in decreased soil water storage and increased run-off potentially affecting downstream hydrology.
- Decrease in ecosystem services.
- Decrease in visual amenity.

Erosion rates

An indication of erosion rates from permanent and temporary landforms is provided by experimental work conducted by NRA (2000) at the Burton coal mine (approximately 50 km to the south-east of the Byerwen project). This work examined erosion rates of plots on re-profiled landforms (spoil heaps) with varying vegetation coverage. Plot slopes were between 8° and 10°. The greatest erosion rates were observed on plots with the least vegetation cover and *vice versa*. The relationship between ground cover and soil loss is represented graphically in **Figure 18**. Similar erosion rates could be expected on Byerwen landforms. From this it can be seen that one of the most important aspects of erosion control is the reinstatement of ground cover. Erosion loss decreases exponentially with percentage ground cover (NRA 2000; Morgan 2005) and is greatly reduced when cover exceeds 50% (Loch, 2000; NRA, 2000). For long-term stabilisation in tropical climates, IECA (2008) recommends a minimum ground cover of 80% and this should be the target for this project.

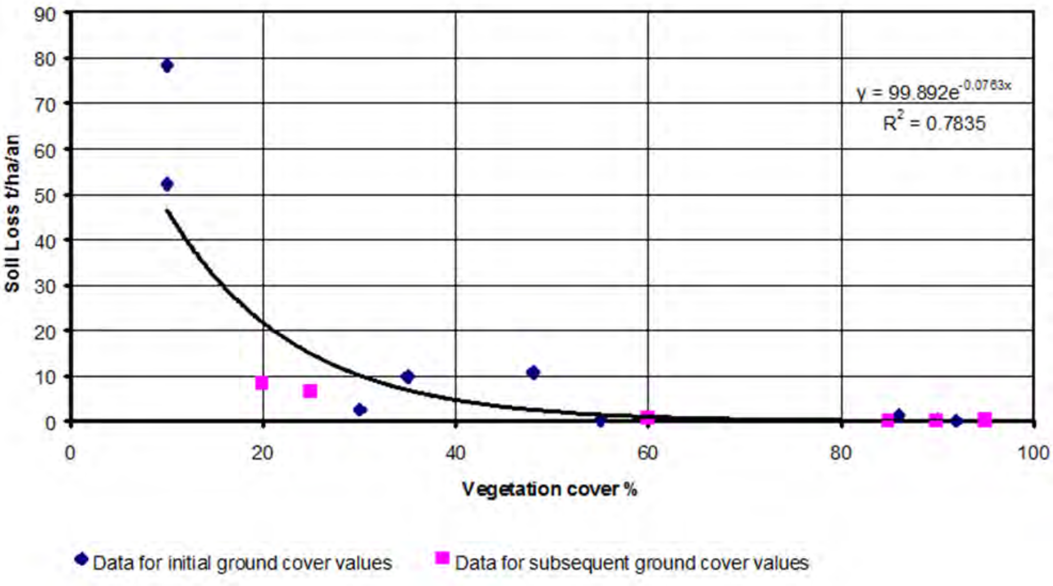


Figure 18: Relationship of erosion rate to percentage vegetation cover on re-profiled spoil heaps at the Burton Coal mine (from NRA 2000)

Mitigation

General site-wide measures

An Erosion and Sediment Control Plan (ESCP) should be developed for the project. The Terms of Reference for the Byerwen EIS require the erosion and sediment control be in accordance with the *Soil Erosion and Sediment Control-Engineering Guidelines for Queensland Construction Sites* and the *EPA Best Practice Urban Stormwater Management-Erosion and Sediment Control* guideline. Additional guidance can be obtained from IECA (2008) *Best Practice Erosion and Sediment Control*. The ESCP must be approved by a suitably qualified person (such as a Certified Professional in Erosion and Sediment Control). The most critical aspects of the ESCP are set out below.

- Development of the ESCP should be integrated into the mine planning process.
- Sensitive areas (soils with high or very high erosion potential) that may require specific measures should be identified. Such soils will include the sodosols, rudosols, brown vertosols, northern dark vertosols and the southern dark vertosols. Other sensitive areas may be delineated from flora and fauna or cultural studies.
- The period of maximum disturbance should be planned to occur in the dry season (nominally May to October) where possible.
- Extent and duration of disturbance (topsoil and subsoil exposure) should be minimised.
- Boundaries of areas to be cleared shall be delineated on project drawings and/or in the field to define the extent of authorised clearing. Clearing should be authorised by use of a ‘permit to clear’ system. Boundary constraints may also be imposed based on the outcomes associated with flora and fauna or cultural studies.
- If vegetation clearing must be carried out well ahead of earthworks, clearing should be limited to woody vegetation. Grubbing out and removal of ground cover should be carried out as close to the time of earthworks as possible.
- Erosion potential and volume of run-on water should be controlled to minimise the amount of dirty water released or requiring treatment by diverting upslope clean water around the disturbed areas in a controlled manner (or passing it through the site in a manner that separates it from dirty site water).

- All drainage structures and sediment control must have design specifications appropriate to the rainfall regime and design life.
- Erosion controls (such as surface protection or vegetation) should be used to prevent on-site damage and minimise sediment generation and mobilisation.
- Sediment controls (such as silt fencing, check dams and sediment dams) should be used to treat all run-off from disturbed areas prior to leaving the site.
- Sediment controls should be located as close to the source as possible.
- As far as practicable all necessary erosion and sediment control structures should be installed prior to site disturbance.
- Grading of soil shall be away from watercourses and any stockpiled material should be located at least 10 m from any watercourse (Karssies & Prosser 2001).
- Disturbed areas are to be stabilised as soon as possible (progressively).
- Control structures should be inspected regularly, particularly after rain, to identify and rectify failures or maintenance requirement (*eg* repair, removal of sediment).

Soil and spoil with a risk of erosion have been identified on-site. These materials require specific erosion and sedimentation control measures, such as:

- drainage controls on roads/disturbance areas on slopes (whoa boys and turnout drains spaced to reflect slope)
- minimising slope lengths on disturbed areas/engineered landforms
- drains to channel water over high erosion risk materials (*eg* over spoil piles that contain high erosion risk materials).

Remnant mine landforms should be designed to minimise slope angle and length. Low erosion risk soil should be preferentially used on areas with longer and/or steeper slopes. **Table 12** provides a relative erosion risk for soils expected to be disturbed by the project.

One of the most important aspects of erosion control is the reinstatement of ground cover. Temporary surface protection may be provided by trash blanketing or other measures such as hydromulching, bonded fibre matrix (BFM) or erosion control matting, but vegetation establishment will be required for long-term soil stabilisation. Fast establishing grasses and ground covers can provide good early surface protection against sheet and rill erosion. Ideally they should be non-invasive (preferably native) and have a horizontal growth habit. Deeper rooted plants (generally trees and shrubs) provide the best protection from mass movement. On cut and fill batters both forms of protection are required in the long-term.

Monitoring of the performance of erosion and sediment control structures should be carried out both pre- and post-wet season and following any significant events. Monitoring may be done using visual methods (such as those for recording erosion features in NCST (2009)) and/or more quantitative methods such as those using erosion monitoring pins, or measuring sediment loads from monitored ’catchments’. Landscape function analysis methods may also be applicable (*eg* Tongway & Hindley 2005).

3.2.7 Rehabilitation and landscaping

A Rehabilitation Management Plan that defines the final landform design and rehabilitation requirements of the project will be prepared. This is a potentially complex process and the land uses that may, for example, be considered will vary according to:

- regulatory requirements
- location of the disturbance
- nature of the disturbance

- pre-disturbance land use
- geotechnical and geochemical stability and health and safety considerations
- environmental impacts and the protection of environmental values
- known site constraints limiting land use options
- rehabilitation techniques and economics.

The development of land use objectives requires early engagement with stakeholders (such as regulators, landholders, community groups). It will require open communication and discussion about site constraints to allow the expectations of all parties to be managed at an early stage.

The EHP Guideline *Rehabilitation requirements for mining projects* (EM1122 22/08/12) describes the policy framework and assessment process for determining the acceptability of rehabilitation outcomes and strategies.

The Guideline defines the following four general rehabilitation goals for rehabilitation of areas disturbed by mining.

- Safe to humans and wildlife.
- Non-polluting.
- Stable.
- Able to sustain an agreed post-mining land use.

Based on project baseline information and Guideline 18, the following site rehabilitation goals have been developed for the project.

- The site does not present a safety hazard to people, fauna or stock.
- Constructed landforms such as spoil dumps are geotechnically stable and do not impact on surface water or groundwater quality.
- Potentially contaminated areas are remediated or a site management plan is developed for future management.
- In areas not constrained by landform (*eg* backfilled pits, roads and tracks, site infrastructure), post-mine land use will be beef cattle grazing (land suitability Class 4 or better).
- In areas constrained by landform (*eg* spoil dumps, pits), the post-mine land use be notionally land suitability Class 5.

Rehabilitation objectives and approach for each disturbance type are described below.

Without firm proposals to develop the land post-mining for an alternative use such as industry, *eg* future mining, it is considered best to return the land to the existing land use, *ie* grazing and native vegetation. This both maintains options for future land use and limits liability for long-term management.

Pit and highwall areas

Objectives

- Post-mine land use is for re-contouring and for public access to be prevented or deterred (KBR 2012c).
- Water quality does not present a risk of environmental harm to surface waters or groundwater.
- Safety risk to people, fauna and stock is managed.

Rehabilitation approach

- Re-profiling to establish drainage (internally draining).
- Construct a bund (minimum 2 m high with 4 m base and located 10 m beyond the area potentially affected by any instability of pit highwall).
- Construct a 4 strand barbed wire fence behind the bund (if required).

Spoil dumps (external and internal to pits)

Objectives

- Post-mine land use is grassland and sparse woodland for beef cattle grazing.
- Dump slopes are geotechnically stable.
- Erosion rate is managed to levels that do not compromise post-mine land use.
- Run-off or seepage water quality does not present a risk of environmental harm.
- Landform does not present a risk to stock (poor drainage).

Rehabilitation approach

- Final design slope determined by geotechnical analysis.
- Re-profiling to drain internally, and where possible to pit.
- Ripping to between 0.5 - 1 m.
- Apply surface soil material (minimum of 300 mm when available).
- Scarify surface (immediately before seeding).
- Seed with sterile cover crop and seed of grass, groundcover, shrub and tree species representative of local grassland and sparse woodland communities.
- Significant weed species controlled.

Co-disposal dams

Objectives

- Post-mine land use is grassland and sparse woodland for beef cattle grazing.
- Erosion rate is managed to levels that do not compromise post-mine land use.
- Run-off or seepage water quality does not present a risk of environmental harm.
- Landform does not present a risk to stock (poor drainage).

Rehabilitation approach

- Final design slope determined by geotechnical analysis.
- Re-profiling to drain internally, and where possible to pit.
- Ripping to between 0.5 - 1 m.
- Apply surface soil material (minimum of 300 mm when available).
- Scarify surface (immediately before seeding).
- Seed with sterile cover crop and seed of grass, groundcover, shrub and tree species representative of local grassland and sparse woodland communities.
- Significant weed species controlled.

Mine infrastructure (MIA, ROM, CHPP, load out facility, powerlines and magazine)

Objectives

- Post-mine land use is grassland and sparse woodland for beef cattle grazing.

- Hazardous material is identified and managed.
- Erosion rate is managed to levels that do not compromise post-mine land use.
- Run-off or seepage water quality does not present a risk of environmental harm.

Rehabilitation approach

- Land contamination survey at time of closure, as per the *Draft guidelines for the assessment & management of contaminated land in Queensland* (Department of Environment 1998).
- Any contaminated material identified which has not already been addressed during mine operations, can either disposed of by a regulated waste contractor at a regulated waste facility, or buried within a co-disposal dam which would then be decommissioned and rehabilitated.
- Infrastructure will be dismantled and removed upon completion of mining activities.
- Re-profiling to establish drainage.
- Ripping to between 0.5 - 1 m.
- Apply surface soil material (minimum of 300 mm when available).
- Scarify surface (immediately before seeding).
- Seed with sterile cover crop and seed of grass, groundcover, shrub and tree species representative of local grassland and sparse woodland communities.
- Significant weed species controlled.

Roads, culverts, tracks, and rail lines

Objectives

Some access roads and culverts may be left for site access under written agreement. Where not required, rehabilitation objectives will be as follows.

- Post-mine land use is grassland and sparse woodland for beef cattle grazing.
- Erosion rate is managed to levels that do not compromise post-mine land use.
- Run-off or seepage water quality does not present a risk of environmental harm.

Rehabilitation approach

- Re-profiling to establish drainage.
- Removal of infrastructure (signage *etc*).
- Ripping to between 0.5 - 1 m.
- Scarify surface (immediately before seeding).
- Seed with sterile cover crop and seed of grass, groundcover, shrub and tree species representative of local grassland and sparse woodland communities.
- Significant weed species controlled.

Water supply, MAW and sediment dams

Objectives

Some dams may be left for stock watering under written agreement. If not required, dams will be breached and revegetated. Rehabilitation objectives are as follows.

- Post-mine land use is grassland and sparse woodland for beef cattle grazing/water storage for (beef) stock.
- Water quality (in the case of a dam being retained) does not present a risk to stock (cattle) nor present a risk of environmental harm to surface waters or groundwater and safety risk to people, fauna and stock is managed.

Rehabilitation approach

- De-silt dams as necessary and place sediment in a co-disposal dam.

If not required, dams will be:

- Breached and re-profiling to establish drainage.
- Scarify surface (immediately before seeding.
- Seed with sterile cover crop and seed of grass, groundcover, shrub and tree species representative of local grassland and sparse woodland communities.
- Significant weed species controlled.

Diversion of waterways

Two un-named ephemeral creeks that flow westwards into the Suttor River will be diverted. A small drainage diversion is planned to allow water to bypass the North Pit and flow to Kangaroo Creek. South Pit I will be bound to the north and south by drainage line diversions and a drainage line diversion will separate South Pit 1 from West Pit 1 (KBR 2012a). Rehabilitation of diversions will occur as part of the construction process (that is, diversions will be permanent).

Objectives

- Stable channels with capacity to contain design flows.
- In stream and riparian habitat values consistent with undisturbed section of the waterway upstream and downstream.
- Water quality (in the case of a dam being retained) does not present a risk to stock (cattle) nor present a risk of environmental harm to surface waters or groundwater and safety risk to people, fauna and stock is managed.

Rehabilitation approach

Design will reflect:

- Natural channel design elements that are appropriate to ephemeral creeks in central Queensland.
- Minimisation of disturbance to any remnant riverine vegetation.
- Minimising diversion length to reduce earthworks.
- Inlet and outlet alignment to reduce erosion.
- No adverse change in existing flood levels and velocities upstream of the diversion.
- No adverse change in existing flood levels, flow rates and velocities along downstream sections of the creek, particularly increased sediment loads.
- Temporary erosion control features during construction and in initial wet seasons.
- Stable, erosion resistant, long life benches and batters to the diversion which facilitate revegetation and maintenance activities.

4. Cumulative impacts

4.1 Introduction and approach

Cumulative impacts of the Byerwen Coal Project on land were assessed by considering impacts on good quality agricultural land (GQAL) and Strategic Cropping Land (SCL), which were considered the most appropriate values related to land. Byerwen Coal has identified future projects planned or underway in the region. Relevant projects considered were identified on the following basis:

- projects in the Bowen Basin or within 150 km of the Byerwen Coal Project
- projects in the Isaac Regional Council, Whitsunday Regional Council or Mackay Regional Council
  - for which an EIS is complete under either the *Environmental Protection Act* 1994 (EP Act) or *State Development and Public Works Organisation Act* 1971 (SDPWO Act)
  - for which an EIS process has commenced under the EP Act or SDPWO Act
- other projects of which Byerwen Coal is aware, including projects for which QCoal is a proponent or which are identified on government maps or websites
- known major infrastructure projects (*eg* power stations or water infrastructure) that are seeking approval or have obtained development approval other than through an EIS.

Chapter 34 Cumulative Impacts of the EIS provides the projects which met the above criteria for potential inclusion in cumulative impact assessments as at May 2012 and their proponents, including status, timing and a brief description. These projects are shown in **Figure 19**.

The majority of planned development in the region relates to coal mining projects and to a lesser extent development of infrastructure to support this development (rail and pipeline corridors). The most relevant impact to be considered (with respect to soils and land) is the change in the amount of land available for agricultural activities and the types of agriculture that can be supported. Cumulative land impacts were therefore assessed by quantifying the area of GQAL and SCL by each of the identified projects (with some exceptions, see below).

4.2 Methods

The potential impact area for each project was based on the project's MLs, project boundary or, for linear features, buffered lines. The areas of each land type potentially disturbed were summed across all projects and the contribution of the Byerwen project to the total potential disturbance of GQAL and SCL found.

Potential disturbance areas were restricted to the provided MLs, distinct project boundaries and buffers (for linear projects, see **Table 13** for details). At the scale of the assessment, these are considered to provide a suitable indication of potential areas to be disturbed by each project.

The areas covered by Exploration Permits for Coal (EPCs), Exploration Permits for Minerals (EPMs) and Mineral Development Licences (MDLs) have not been included as their areas are disproportionate to likely disturbance areas generated by the project. As a consequence, projects consisting of EPCs, EPMs, MDLs have been excluded from the assessment. These are:

- Anthony Project (EPM)
- Dysart East (MDL)
- Goonyella Riverside Mine (EPC)
- Goonyella Riverside Mine (MDL)
- Integrated Isaac Plains (EPC)
- Moranbah South (MDL)
- Sarum Project (EPC)
- Sonoma Project (EPC)
- Talwood Project (EPC)
- Wilunga Project (EPC)
- Winchester South (MDL).

The Conner's River Dam and Pipeline Projects have also been excluded from this assessment due to the project's cancellation in July 2012 (SunWater 2012).

In many cases the cumulative impact project areas overlapped. To obtain an accurate account of GQAL and SCL potentially affected by the projects, overlapping areas were accounted for within one project only (usually within the project of the larger extent). The areas of project overlay are shown in **Table 13**.

Strategic Cropping Land

Potential Strategic Cropping Land has been sourced as digital data from DEHP (Trigger Map for Strategic Cropping Land in Queensland v1.0). This data provides the location of potential strategic cropping land in Queensland (DERM 2012d).

Good Quality Agricultural Land (GQAL)

The following data has been used in this assessment in accordance with the criteria outlined within the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI & DHLGP 1993).

- Good Quality Agricultural Land -Central West Region (GQAL CWR) (DNRM 2012a).
- Collinsville Nebo Moranbah (CNM) Land Suitability Study (Shields *et al.* 1984 in DNRM 2012b).
- Soils of the Lower Burdekin Valley, North Queensland (Thompson *et al*. 1990).
- Plane Creek Sugar Cane Land Suitability Study (Wills and Baker 1988).
- GQAL in the Townsville area was identified from the mapping of Murtha (1975, 1982), and where required (*ie* in the pre-amalgamation Townsville City Council local government area) that of Murtha and Reid (1992, a re-print of the 1976 report).

The GQAL CWR has been used as the primary data source. However, it is noted that in the creation of the GQAL CWR, data by DNRM (a key data source) was omitted (Kelly Bryant (DNRM) *pers. comm.* 8 November 2012). Therefore, for the purpose of this assessment the omitted data (Collinsville Nebo Moranbah (CNM) Land Suitability Study (Shields *et al.* 1984 in DNRM 2012b)) has been converted to GQAL units and replaces the relevant section of the GQAL CWR digital dataset. Where digital GQAL data was not available, soil and land suitability mapping has been converted to GQAL units and digitised. Small sections of the project areas were not covered by available mapping and their cumulative impacts have not been assessed. These areas have been identified in **Table 13**.

4.3 Byerwen Project Contribution

Table 13 provides an assessment of the cumulative impacts of the identified projects (as provided by Byerwen Coal) on GQAL and SCL based on calculations of potential disturbance areas.

From **Table 13**, it can be seen that the cumulative impacts of the projects on GQAL and SCL are:

- 21,473 ha of SCL (SCL status to land to be disturbed is to be confirmed)
- 39,691 ha of Class A GQAL
- 353 ha Class B GQAL
- 100,970 ha of Class C GQAL
- 57,688 ha of Class D GQAL.

The percentage of the cumulative impacts on these land values attributable to the Byerwen Project (see **Section 2.2.2**) is:

- 6.2% of SCL (SCL status to land to be disturbed is to be confirmed)
- 4.0% of the Class A GQAL
- 0.0% of the Class B GQAL
- 2.5% of the Class C GQAL
- 4.6% of the Class D GQAL.

The Byerwen project's contribution to the cumulative impact on SCL and GQAL is minor and would be reduced by adoption of the mitigation strategies presented in this report.

Table 13: Cumulative impacts

Site*	Buffer applied+	Total area (ha)	Overlap area covered in other project#		Remaining after overlap removed (ha)	SCL[1]		GQAL (ha)†					
			Area (ha)	Project		SCL (ha)	Not SCL (ha)	A	B	C	D	Water	Outside of available GQAL mapping
Abbot Point Coal Terminal	4 km buffer	4,800.03			**4,800.03**		4,800.03			1,254.50		3,544.67	
Arrow Bowen Pipeline Project	15 m	1,841.78			**1,654.24**	126.08	1,528.17	130.11	56.58	1,156.17	309.66	1.72	6.42
			93.75	Bow Energy Gas Pipeline									
			0.27	Burton Project									
			17.18	Eaglefield Expansion									
			1.49	Ellensfield Coal Mine									
			10.47	Goonyella Riverside Mine ML									
			15.07	Moorvale Coal									
			44.68	Moranbah SCG Operations									
			4.62	Newlands Coal Extension									
Bow Energy Gas Pipeline	15 m	1,182.75			**1,088.88**	62.42	1,026.46	75.23	27.92	985.39		0.34	
			93.87	Arrow Bowen Pipeline Project									
Bowen Basin Coal Growth Caval Ridge		21,641.38			**21,508.20**	59.01	21,449.19	371.57		21,136.24			
			133.18	Moranbah SCG Operations									
Bowen Basin Coal Growth Daunia Mine		3,351.05			**3,351.05**	490.09	2,860.96	490.03		2,861.00			
Burton Project		5,058.38			**5,054.74**	128.03	4,926.71	374.83		471.43	4,208.42		
			3.64	New Lenton									
Central Queensland Gas Pipeline	15 m	1,350.10			**1,156.28**	110.06	1,046.23	135.26	1.14	998.47	21.13	0.28	
			0.12	Arrow Bowen Pipeline Project									
			33.60	Eagle Downs Coal Project									
			81.36	Moranbah SCG Operations									
			5.45	PL224 (and Grosvenor Coal)									
			73.28	Saraji East									
Central Queensland Integrated Rail	15 m	1,871.95			**1,637.88**	174.27	1,463.61	250.67	153.02	1,151.21	82.98		11.01
			12.83	Abbot Point Coal Terminal									
			0.09	Arrow Bowen Pipeline Project									
			213.94	Northern Missing Link									
			0.09	NQ Gas Pipeline									
			6.50	Twin Hills									
			0.62	Water For Bowen Project									
Clermont Coal Mine		2,055.52			**2,055.52**	793.88	1,261.64	820.31	48.37	1,186.87			
Cows Coal	Selected from ML data	211.30			**207.25**	140.36	66.89	76.79		130.44			
			4.05	Drake Coal Project									

Site*	Buffer applied+	Total area (ha)	Overlap area covered in other project#		Remaining after overlap removed (ha)	SCL[1]		GQAL (ha)†					
			Area (ha)	Project		SCL (ha)	Not SCL (ha)	A	B	C	D	Water	Outside of available GQAL mapping
Dalrymple Bay Coal Terminal	Sourced from NRA data	264.19			**264.19**	140.36	123.83				263.39		
Drake Coal Project		9,226.34			**9,226.34**	3,413.87	5,812.47	4,872.38		3,910.01	443.95		
Dudgeon Point Coal Terminal	4 km	4,799.98			**4,799.98**	362.84	4,437.14	601.62			4,196.70		
Eagle Downs Coal Project		4,551.37			**4,551.25**	360.98	4,190.28	3,032.78		1,518.47			
			0.12	Moranbah SCG Operations									
Eaglefield Expansion		3,580.20			**3,479.84**	1,289.88	2,189.96	975.30		2,341.57	162.99		
			97.48	Goonyella Riverside Mine ML									
			2.88	Wards Well Underground									
Ellensfield Coal Mine		3,386.87			**3,386.87**		3,386.87	15.80		25.39	3,345.67		
Goonyella Riverside Mine ML		14,604.13			**14,604.13**		14,604.13	122.46		6,604.44	7,877.23		
Grosvenor Coal		9,500.50			**219.61**		219.61			8.56	211.03		
			8,084.86	Moranbah SCG Operations									
			1,196.02	PL224									
Integrated Issac Plains ML		2,249.76			**1,313.05**		1,313.05			1,312.53	0.51		
			936.71	Moranbah SCG Operations									
Jax Project		1,950.37			**1,950.37**	408.96	1,541.41	877.09		1,073.28			
Jilalan Rail Yard	1 km	300.00			**300.00**	31.06	268.95	49.08			250.52		
Millennium Expansion Project		2,969.83			**2,872.41**		2,872.41			2,872.45			
			97.42	Moranbah SCG Operations									
Moorvale Coal		3,848.52			**3,848.52**		3,848.52			3,848.54			
Moranbah CSG Operation		53,190.03			**53,190.03**	2,362.90	50,827.12	10,405.84		26,454.07	16,330.12		
Nebo Moranbah Power Stations	500 m	150.00			**75.00**		75.00				75.00		
			6.09	Moranbah SCG Operations									
			68.91	PL224									
New Lenton		6,098.53			**6,098.53**		6,098.53	901.62			5,196.91		
Newlands Coal		6,707.14			**6,707.14**	4,111.12	2,596.02	5,127.77		571.36	1,008.01		
Newlands Coal Extension		11,695.70			**11,695.70**	296.78	11,398.92	290.30		4,350.31	7,055.04		
Northern Missing Link	15 m	214.03			**213.94**	27.00	186.94	72.87		93.80	47.27		
			0.09	Arrow Bowen Pipeline Project									
NQ Gas Pipeline	15 m	1,178.96			**1,155.89**	190.70	965.18	218.68	65.52	370.40	425.53		75.76
			0.09	Central Queensland Integrated Rail									
			1.63	Moranbah SCG Operations									
			21.36	PL224									
Olive Downs		1,635.77			**1,635.77**	235.07	1,400.70	235.20		1,400.59			
PL224		7,006.00			**7,006.00**	95.58	6,910.41	356.74		2,991.31	3,657.89		

Site*	Buffer applied+	Total area (ha)	Overlap area covered in other project#		Remaining after overlap removed (ha)	SCL[1]		GQAL (ha)†					
			Area (ha)	Project		SCL (ha)	Not SCL (ha)	A	B	C	D	Water	Outside of available GQAL mapping
Saraji East		9,334.47			**9,304.31**	2,144.94	7,159.36	2,544.39		6,759.87			
			30.16	Bowen basin Coal Growth Caval Ridge									
Sarsfield Project		1,208.21			**1,208.21**		1,208.21						1,208.21
Twin Hills		733.03			**733.03**		733.03		0.58	732.41			
Vermont Coal		4,908.43			**4,908.43**	2,588.511	2,319.92	2,741.71		2,166.74			
Wards Well Underground		5,638.34			**5,638.34**	1,000.278	4,638.07	3,120.16			2,518.18		
Water For Bowen Project	15 m	726.24			**721.70**	328.12	393.58	403.98		231.94			85.78
			3.93	Abbot Point Coal Terminal									
			0.62	Central Queensland Integrated Rail									
				Totals=	**203,623**	**21,473**	**182,150**	**39,691**	**353**	**100,970**	**57,688**	**3,547**	**1,370**

* Project location and boundary data provided by Byerwen Coal. EPC, EPM, MDL and Conner's River Dam and Pipeline data has been excluded from this assessment.

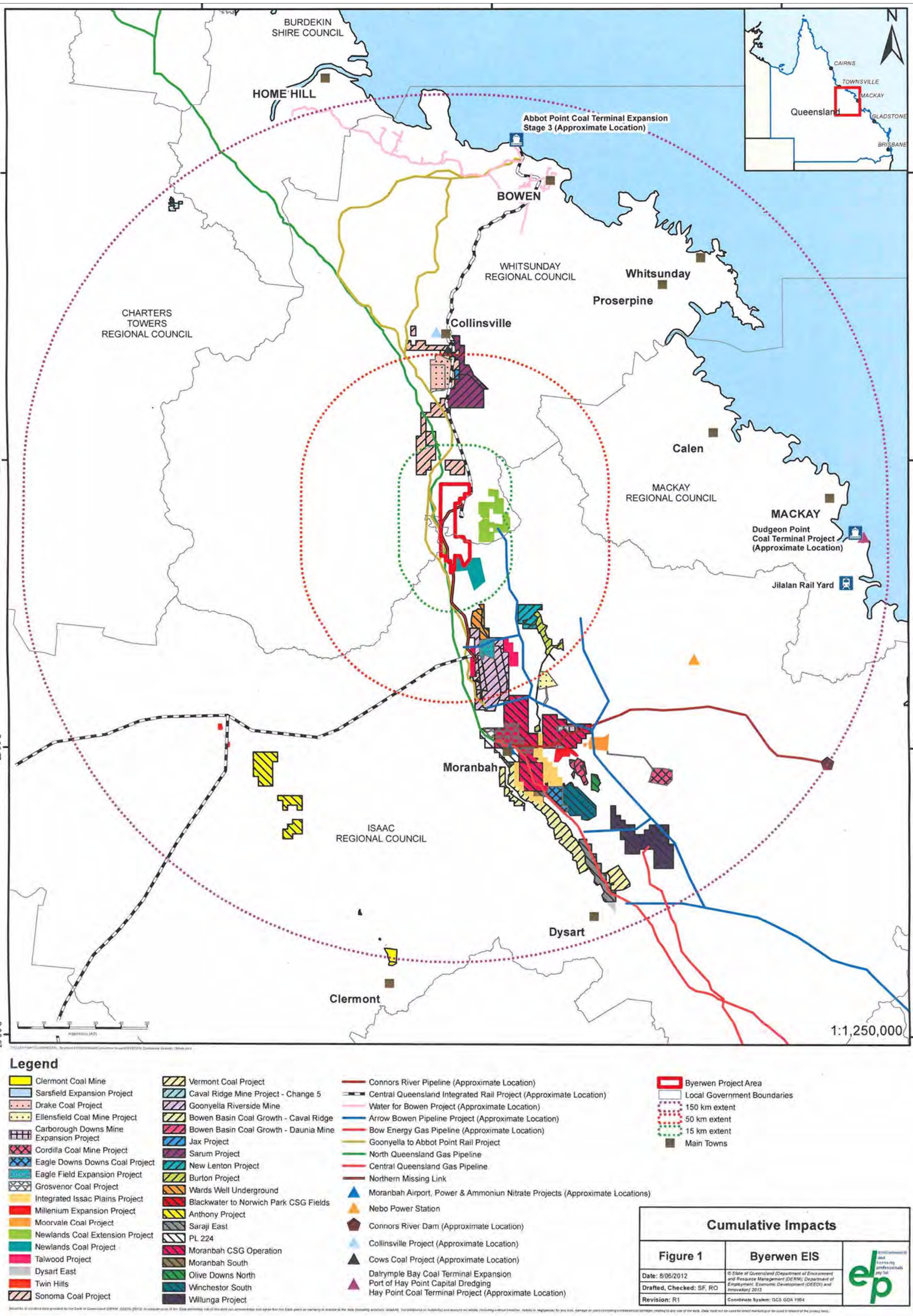
\+ Where polygon data was not available, buffers have been applied based on similar infrastructure areas.

\# Overlap has been accounted for within one project area only.

[1] Based on or contains data provided by the State of Queensland (Department of Natural Resource Management) Strategic Cropping Land data (Trigger Map for Strategic Cropping Land in Queensland v1.0) [2012].

† GQAL data based on or contains:

- Central West Region - Good Quality Agricultural Lands - CWR_GQAL (DNRM 2012a)
- Collinsville Nebo Moranbah (CNM) Land Suitability Study (DNRM 2012b)
- Soils of the Lower Burdekin Valley, North Queensland (Thompson *et al.* 1990)
- Plane Creek Sugar Cane Land Suitability Study (Wills and Baker 1988)
- GQAL in the Townsville area was identified from the mapping of Murtha (1975, 1982), and where required (*ie* in the pre-amalgamation Townsville City Council local government area) that of Murtha and Reid (1992, a reprint of the 1976 report).



PROJECT: Byerwen Coal Project - Land Technical Report TITLE: Byerwen Coal Project Cumulative Impacts T:_AAA\366\WOR\366203\366203_C Impacts_2012_09_21.wor	JOB NO: 366203 DATE: September 2012 SOURCE: NRA, ELP,	NRA Environmental Consultants NATURAL RESOURCE ASSESSMENT AND MANAGEMENT	Figure 19

Recommended print size: A3

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Appendix A:
2011 ‘On-ground’ assessment of Strategic Cropping Land on the Byerwen Coal Project mining leases

2011 On-ground Strategic Cropping Land Assessment

The Byerwen Coal Project is in a strategic cropping land (SCL) management area (the western cropping zone) and SCL 'trigger' maps show potential SCL within the project area. An 'on-ground' SCL assessment was conducted in June 2011 as part of the Byerwen Coal Project Soil and Land Assessment (NRA 2011). The soil and landscape observations and soil laboratory data from the soil and land assessment were used for the 'on-ground' SCL assessment. Areas of land that met all of the SCL assessment criteria were identified within the Byerwen project site. The 2011 on-ground SCL assessment was conducted before the release of the finalised SCL Guidelines (*ie* DERM 2011, released in September) and does not meet all the survey requirements in the Guideline specifically with respect to the intensity and type of field observations. Although the data collected is valid and the conclusions drawn are accurate to the intensity of survey effort, additional survey work would be needed to fully meet the current SCL assessment guidelines. The results of the 2011 'on ground' assessment are presented here to provide a basis for future studies. Note that this is only the results of the on-ground assessment, not the SCL assessment which also includes establishing a history of cropping.

Table 1 lists the eight criteria for 'on-ground' assessment of SCL in the western cropping zone and the methods used to address them. GIS analysis was used to assess the minimum area requirements (SCL areas must be greater than 100 ha and wider than 80 m). The assessment of the Byerwen project lands against western cropping area SCL criteria 2 to 8 is provided in **Table 2**.

Based on the NRA (2011) survey data (which may need to be augmented with additional data), approximately 1,902 ha of land on the Byerwen project site was tentatively identified as SCL. **Figure 1** (of this appendix) shows the distribution of the tentatively identified SCL.

Table 1: Strategic cropping land (western cropping zone) criteria and assessment method used by the 2011 'on-ground' assessment.

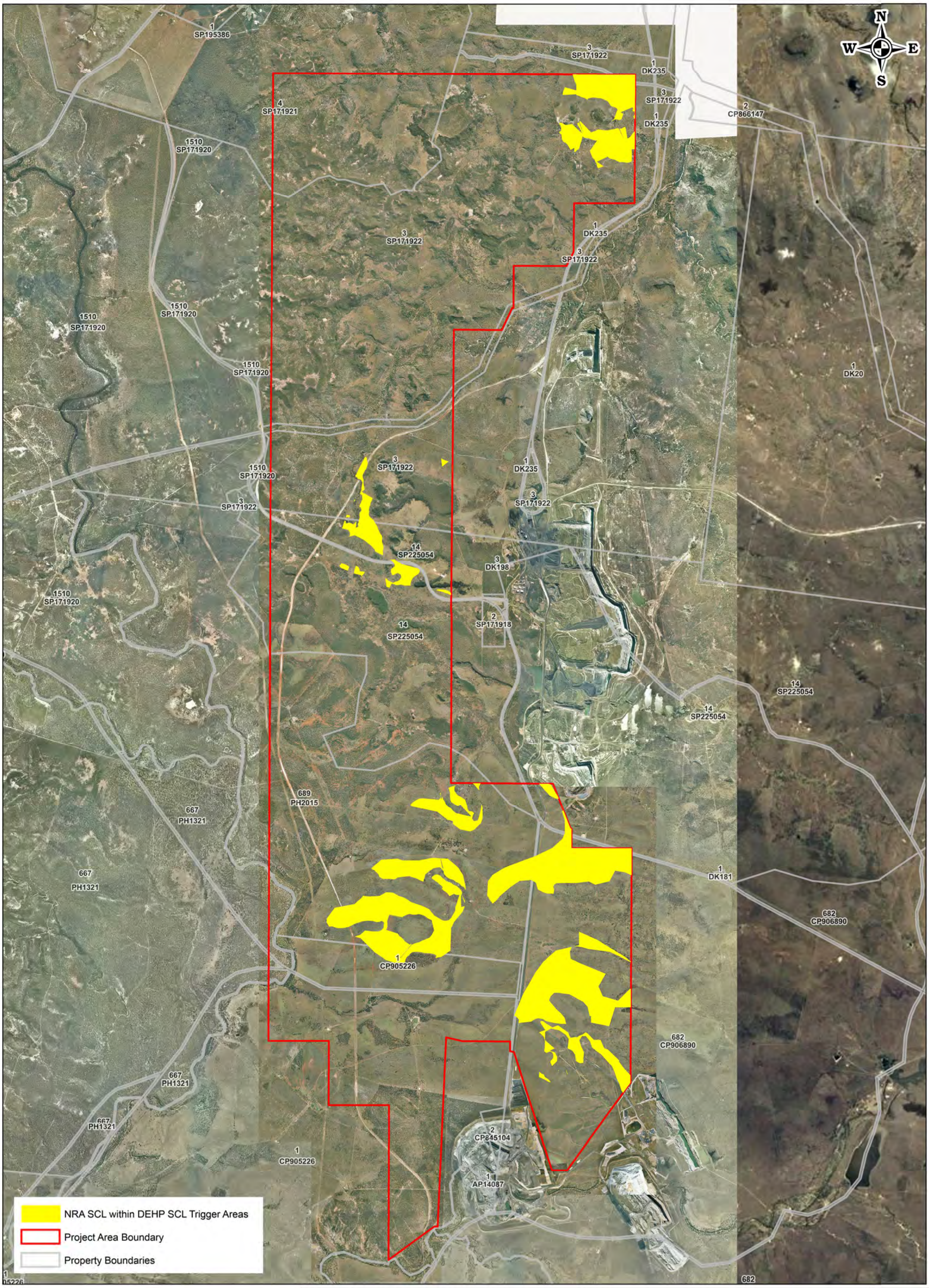
	Criterion	Assessment method
1	Slope is less than or equal to 3 per cent	Slope analysis (GIS), area calculation
2	The average density of rocks of greater than 60 mm diameter in the soil surface is less than or equal to 20%	Field observations and soil field descriptions
3	The average density of gilgai microrelief of greater than 500 mm depth is less than 50% of the land surface	Field observations and soil field descriptions
4	The soils depth is greater than or equal to 0.6 m	Assessed from soil field descriptions
5	The site has favourable drainage	Assessed from soil field descriptions
6	For non-rigid soils, the soil at 0.3 m and 0.6 m soil depth must be greater than pH 5.0 For rigid soils, the soil at 0.3 m and 0.6 m soil depth must be within the range of pH 5.1 to pH 8.9, inclusive	Assessed from laboratory data
7	Soil at 0.6 m or shallower contains a chloride content of less than 800 mg/kg	Assessed from laboratory data
8	The soil water storage of the soil is 0.1 m or greater to a soil depth or soil physico-chemical limitation of up to 1 m	Assessed from soil field descriptions and laboratory data

Table 2: Assessment of soil properties against strategic cropping land (SCL) 'on-ground' criteria 2 to 8

Soil (Profiles)	SCL?	Criterion 2 Rockiness	Criterion 3 Gilgai density	Criteria 4 Soil depth	Criteria 5 Favourable drainage	Criteria 6 Soil pH	Criteria 7 Chloride content	Criteria 8 Soil water storage (SWS)		
								SWS[*] (mm)	Issues	Assessment[#]
Rudosols	**No**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**-**	**-**	**Fail**
Profile 7	-	-	Pass	Pass	Pass	Pass	Pass	77	High ESP at 0.9 m	Fail
Sodosols	**No**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**-**	**-**	**Fail**
Profile 16	-	-	Pass	Pass	Pass	Pass	Pass	60	High ESP at 0.9 m	Fail
Profile 17	-	-	Pass	Pass	Pass	Not analysed	Not analysed	79	No data	Fail
Northern Kandosols	**No**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**-**	**-**	**Fail**
Profile 15	-	-	Pass	Pass	Pass	Pass	Pass	72	No issues	Fail
Central Kandosols	**Yes**	**Pass (some rockiness observed)**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**-**	**-**	**Pass**
Profile 1 (Red)	-	-	Pass	Pass	Pass	Pass	Pass	112	No issues	Pass
Profile 2 (Red)	-	-	Pass	Pass	Pass	Not analysed	Not analysed	100	No data	Pass
Profile 3 (Red)	-	-	Pass	Pass	Pass	Not analysed	Not analysed	92	No data	Fail
Profile 5 (Red)	-	-	Pass	Pass	Pass	Not analysed	Not analysed	114	No data	Pass
Profile 6 (Red)	-	-	Pass	Pass	Pass	Not analysed	Not analysed	92	No data	Fail
Profile 10 (Brown)	-	-	Pass	Pass	Pass	Not analysed	Not analysed	114	No data	Pass
Profile 21 (Brown)	-	-	Pass	Pass	Pass	Pass	Pass	118	No issues	Pass
Profile 23 (Brown)		-	Pass	Pass	Pass	Not analysed	Not analysed	118	No data	Pass
Central Dermosols	**No**	**Pass**	**Pass**	**Pass**	**Pass**	**Fail**	**Pass**	**-**	**-**	**Fail**
Profile 9	-	-	Pass	Pass	Pass	Fail	Pass	90	High ESP at 0.9 m	Fail
Southern Dermosols	**No**	**Pass**	**Pass**	**Pass**	**Pass**	**Fail**	**Pass**	**-**	**-**	**Fail**
Profile 11	-	-	Pass	Pass	Pass	Fail	Pass	88	High ESP & Cl at 0.9 m	Fail
Profile 13	-	-	Pass	Pass	Pass	Not analysed	Not analysed	92	No data	Fail
Profile 14	-	-	Pass	Pass	Pass	Pass	Pass	60	High ESP at 0.6 m High Cl at 0.9 m	Fail
Profile 25	-	-	Pass	Pass	Pass	Not analysed	Not analysed	108	No data	Pass
Profile 26	-	-	Pass	Pass	Pass	Fail	Pass	26	High ESP at 0.3 m High Cl at 0.9 m	Fail
Brown Vertosols	**No**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**-**	**-**	**Fail**
Profile 4	-	-	Pass	Pass	Pass	Pass	Fail	66	High Cl at 0.6 m	Fail
Profile 22	-	-	Pass	Pass	Pass	Not analysed	Not analysed	118	No data	Pass
Profile 27	-	-	Fail	Pass	Pass	Not analysed	Not analysed	119	No data	Pass
Profile 28	-	-	Pass	Pass	Pass	Not analysed	Not analysed	119	No data	Pass
Northern Dark Vertosols	**Yes**	**Pass (some rockiness observed)**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**-**	**-**	**Pass**
Profile 18	-	-	Pass	Pass	Pass	Pass	Pass	117	No issues	Pass
Profile 19	-	-	Pass	Pass	Pass	Not analysed	Not analysed	94	No data	Fail
Central Dark Vertosols	**No**	**Pass (some rockiness observed)**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**-**	**-**	**Fail**
Profile 8	-	-	Pass	Pass	Pass	Pass	Pass	84	No issues	Fail
Profile 29	-	-	Pass	Pass	Pass	Not analysed	Not analysed	95	No data	Fail
Southern Dark Vertosols	**Yes**	**Pass (some rockiness observed)**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**-**	**-**	**Pass**
Profile 12	-	-	Pass	Pass	Pass	Pass	Pass	106	No issues	Pass
Profile 24	-	-	Pass	Pass	Pass	Not analysed	Not analysed	116	No data	Pass

[*] Estimate of soil water storage based on the soil texture look-up table in DERM (2011). DERM (2011) states that SWS values estimated from the soil texture look-up table that are within ±15% of the threshold value (in this case 100 mm), or at the discretion of the proponent, must be supported by direct laboratory and field measured stored soil water. Laboratory and direct field measurement of SWS are beyond the scope of this study.

[#] When assessing the soils against Criterion 8 more weight was given to profiles with laboratory data, as limitations could not be identified in profiles lacking laboratory data.



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PROJECT: Byerwen Coal Project - Land Technical Report TITLE: Byerwen Coal Project (tentative) strategic cropping land based on NRA 2011 survey and trigger mapping T:_AAA\366\WOR\366203\366203_Byerwen NRA SCL_2012_11_08.wor	JOB NO: 366203 DATE: November 2012 SOURCE: NRA, ELP, DEHP, Google Earth	NRA Environmental Consultants NATURAL RESOURCE ASSESSMENT AND MANAGEMENT	Figure 1

Recommended print size: A3

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Appendix B:
Soils on the Byerwen Coal Project mining leases

Soils on the Byerwen Coal Project mining leases

A soil and land assessment was conducted of the Byerwen Project site in 2011 by NRA (NRA 2011). Ten soils were identified during the field survey (**Table 1**). The soils are described below and management issues identified for the soils are discussed in their descriptions.

It is considered that the dominant soils on the project site were encountered during the survey and are described below. However, an area on the south-western boundary was not accessible at the time of the survey. Previous soil mapping by Isbell and Murtha (1970) describes a soil in this area that is similar to the sodosols (land mapping unit GH24). This area has been tentatively mapped and assessed as containing sodosols.

Table 1: Soil groups on the Byerwen Coal Project mining leases

Soil Group	Brief Description	Profile IDs
Rudosols	Poorly developed soils (alluvium)	7
Sodosols	Texture contrast soils	16, 17
Northern Kandosols	Deep unstructured soils	15
Central Kandosols	Deep unstructured clayey soils	
– Red	Red form	1, 2, 3, 5, 6
– Brown	Brown form	10, 21, 23
Central Dermosols	Deep structure brown soils	9
Southern Dermosols	Deep structured brown soils	11, 13, 14, 25, 26
Brown Vertosols	Deep cracking soils in areas of gilgai	4, 20, 22, 27, 28
Northern Dark Vertosols	Deep cracking soils	18, 19
Central Dark Vertosols	Shallow cracking soils	8, 29
Southern Dark Vertosols	Deep cracking soils	12, 24

Rudosols

Rudosols were found in the centre of the project site. They appear to have a small distribution limited to the upper tributaries of Kangaroo Creek. These soils have fertility issues and become sodic below 0.3 m. Examples of moderate gully erosion were observed in these soils.

Profile/s: 7(S)
Description
Surface: firm, very few coarse fragments (2-6 mm, angular).

Surface to 15 cm BGL: olive brown, clay loam (sandy), weak consistency, massive, no mottles, no coarse fragments, field pH 6.5; abrupt transition to

15 cm to 40 cm BGL: dark greyish brown, light clay, firm consistency, massive, no mottles, no coarse fragments, field pH 6.5; diffuse transition to

40 cm to 80 cm BGL: brown, clay loam (sandy), firm consistency, massive, no mottles, no coarse fragments, field pH 6.5; diffuse transition to

80 cm to 120+ cm BGL: greyish brown, clay loam (sandy), firm consistency, massive, no mottles, no coarse fragments, field pH 7.

Erosion: moderate gully erosion was observed in these soils (gully depth <1.5 m)
Geology: mainly Qr^f (mapped) / alluvium (observed)
Rigid: yes
Existing soil mapping:
AAS – Bz9 (no similar soil described)
Isbell & Murtha (1970) – Sb10 (no similar soil described)

MEDT Results for Profile 7

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	Dispersion After 20 hrs
0.1–0.2	Moderate slaking	Near complete dispersion	Near complete dispersion
0.4–0.5	Complete slaking	Near complete dispersion	Near complete dispersion
0.7–0.8	Complete slaking	Complete dispersion	Complete dispersion

Management issues as identified from analysis of samples from Profile 7

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	OK	Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Very Low	OK	Low K	OK	OK	Sodic	Yes
0.6-0.7	OK	Very Low	OK	Low K	OK	Low Ca:Mg Ratio	Sodic	Yes
0.9-1.0	OK	Low	OK	Low K	OK	Low Ca:Mg Ratio	Strongly Sodic	Yes

Sodosols

Sodosols were found either side of Kangaroo Creek and down-slope of the sandstone bluffs through the central and northern regions of the project site. These soils have fertility issues below 0.3 m, and are sodic below 0.6 m. Magnesium enhanced sodicity may also be an issue below a depth of 0.3 m. Moderate to severe gully erosion was observed where these soils had been disturbed.

Profile/s: 16(S), 17
Profile Description
Surface: firm, no coarse fragments.

Surface to 5–15 cm BGL: brown to dark reddish brown sand, weak to firm consistency, massive, no mottles, no to few coarse fragments (20–60 mm) of weathered sandstone, field pH 6.5–7; clear transition to

5–15 cm to 35–50 cm BGL: brown to strong brown clayey sand, firm consistency, massive, no mottles, very few coarse fragments (2–6 mm) of sandstone, field pH 5.5; abrupt transition to

35–50 cm to 130+ cm BGL: grey light clay, strong consistency, moderately structured (lenticular peds), many distinct orange mottles, no coarse fragments, field pH 6.

Erosion: moderate sheet and moderate to severe gully erosion (gullies deeper than 3 m) observed
Geology: mainly Ts^S (mapped) / sandstone and alluvium (observed)
Rigid: yes
Existing mapping:
AAS – Bz9 (sandy dupex soils)
Isbell & Murtha (1970) – Sb10 (no similar soil described)


Gully erosion in area of disturbed sodosols.

MEDT Results for Profile 16

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	Dispersion After 20 hrs
0.1–0.2	No slaking	No dispersion	No dispersion
0.4–0.5	Immediate complete slaking	No dispersion	No dispersion
0.7–0.8	Complete slaking	Slight dispersion	Moderate dispersion

Management issues as identified from analysis of samples from Profile 16

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Very Low	OK	Low K	OK	Low Ca:Mg Ratio	Non-sodic	Yes
0.6-0.7	OK	Very Low	OK	OK	OK	Low Ca:Mg Ratio	Sodic	Yes
0.9-1.0	OK	Medium	OK	OK	OK	Low Ca:Mg Ratio	Strongly Sodic	Yes

Northern Kandosols

These soils are typical on the elevated areas of sandstone in the north of the project site. The surface material is acidic and the soil has fertility issues below 0.6 m. None of the analysed samples reported significant ESP or Mg enhanced sodicity.

Profile/s: 15
Profile Description
Surface: Loose, no coarse fragments

Surface to 40 cm BGL: dark reddish brown loam, loose, single grain/massive, no mottles, very few coarse fragments (2–6 mm, nodules), field pH 5.5; clear transition to

40 cm to 70 cm BGL: dark red clayey loam, weak consistency, massive, no mottles, very few coarse fragments (2–6 mm, nodules), field pH 6; gradual transition to

70 cm to 110 cm BGL: dark red clayey loam, firm consistency, massive, no mottles, common coarse fragments (2–6 mm, nodules), field pH 6; clear transition to

110 cm to 130 cm BGL: yellow brown light clay, very firm consistency, massive, no mottles, abundant course fragments (6–20 mm, nodules), field pH 6.

Erosion: no significant accelerated erosion observed
Geology: Ts^s (mapped) / sandstone (observed)
Rigid: yes
Existing mapping:
AAS – Bz9 (sandy red earths)
Isbell & Murtha (1970) – Sb10 (red massive sand earths)

MEDT Results for Profile 15

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	Dispersion After 20 hrs
0.1–0.2	No slaking	No dispersion	No dispersion
0.4–0.5	Moderate slaking	No dispersion	No dispersion
0.7–0.8	Slight slaking	No dispersion	No dispersion

Management issues as identified from analysis of samples from Profile 15

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	Acidic	Very Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.6-0.7	OK	Very Low	OK	OK	OK	Low Ca:Mg Ratio	Non-sodic	Yes
0.9-1.0	OK	Very Low	OK	OK	OK	Low Ca:Mg Ratio	Non-sodic	Yes

Central Kandosols

The central kandosols occur in two forms – brown and red. These soils are similar and inter-related and are treated as one unit. The red kandosols are dominant on the elevated, better drained areas and the brown kandosols are more common on areas of lower elevation. These soils may have fertility issues below 0.6 m, and magnesium enhanced sodicity may be an issue below 0.9 m.

Central Kandosols – Brown Form

Profile/s: 10, 21(S), 23
Profile description
Surface: firm, no coarse fragments.

Surface to 5–10 cm BGL: dark brown to dark reddish brown, loam to light clay, loose to weak consistency, massive, no mottles, no coarse fragments, field pH 6–6.5; clear to gradual transition to

5–10 cm to 20–30 cm BGL: strong brown to dark red, light clay to medium clay, weak to firm consistency, massive, no mottles, no to few coarse fragments (2–6 mm, nodules), field pH 6–6.5; clear to gradual transition to

20–30 cm to 80–90 cm BGL: dark brown to dark red, medium clay, firm to very firm consistency, massive to weak structure (polyhedral), no mottles, no to common coarse fragments (2–6 mm, sub-rounded nodules), field pH 6–7.5; clear to gradual transition to

80–90 cm to 100+–120+ BGL: strong brown, medium clay, firm consistency, massive to weak structure (polyhedral), no mottles, common coarse fragments (2–6 mm, sub-rounded nodules), field pH 8.

Erosion: no significant accelerated erosion observed
Geology: mainly Tb and TQr^f (mapped) / limited duricrust and lateritic gravels (observed)
Rigid: yes
Existing soil mapping matches:
AAS – Mz18 (deep slightly acid loamy red earths)
Isbell & Murtha (1970) – mb21 (red massive loamy earths)

MEDT Results for Profile 21

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	Dispersion After 20 hrs
0.1–0.2	Slight slaking	No dispersion	No dispersion
0.4–0.5	Slight slaking	No dispersion	No dispersion
0.7–0.8	Slight slaking	No dispersion	No dispersion

Management issues as identified from analysis of samples from Profile 21

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Low Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.6-0.7	OK	Very Low	OK	OK	OK	Low Ca:Mg Ratio	Non-sodic	Yes
0.9-1.0	OK	Very Low	OK	Low K	OK	Low Ca:Mg Ratio	Non-sodic	Yes

Central Kandosols – Red Form

Profile/s: 1(S), 2, 3, 5, 6
Profile Description
Surface: soft to firm, no to common coarse fragments (20-60 mm, sub-rounded).

Surface to 30–40 cm BGL: dusky red to dark reddish brown to very dark brown, clay loam to light clay, weak to firm consistency, massive (moist), no mottles, no to (infrequently) many coarse fragments
(20–60 mm, sub-rounded, nodules), field pH 6–6.5; clear to gradual transition to

30–40 cm to 80–100 cm BGL: dusky red to dark red to dark brown, light clay to medium clay, weak to very firm consistency, massive (moist), no mottles, no to many coarse fragments (20-60 mm, sub-rounded, nodules), field pH 6–7.5; clear to gradual transition to

80–100 cm to 110+–140+ cm BGL: dusky red to dark red to red, light clay to medium clay, weak to firm consistency, massive (moist), no mottles, no to many coarse fragments (20-60 mm, sub-rounded, nodules), field pH 6.5–8.

Erosion: no significant accelerated erosion observed.
Geology (observed): limited duricrust and lateritic gravels
Geology (mapped): mainly Tb and TQr^f
Rigid: yes
Existing mapping:
AAS – Mz18 (deep slightly acid loamy red earths)
Isbell & Murtha (1970) – mb21 (red massive loamy earths)

MEDT Results for Profile 1

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	After 20 hrs
0.1–0.2	Moderate slaking	Slight dispersion	Slight dispersion
0.4–0.5	Moderate slaking	No dispersion	No dispersion
0.7–0.8	Moderate slaking	No dispersion	No dispersion

Management issues as identified from analysis of samples from Profile 1

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.6-0.7	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.9-1.0	OK	Very Low	OK	OK	OK	OK	Non-sodic	No

Central Dermosols

Central dermosols have a limited distribution in the centre of the project site in association with the central kandosols, central vertosols, rudosols, and chromosols. These soils have fertility issues and become sodic below 0.3 m.

Profile/s: 9(S)
Profile description
Surface: firm, no to few coarse fragments (2–20 mm, sub-rounded to sub-angular).

Surface to 15 cm BGL: dark brown, light clay, firm consistency, massive (moist), no mottles, no coarse fragments, field pH 6; clear transition to

15 cm to 30 cm BGL: strong brown, light clay, firm consistency, strong structure (polyhedral), no mottles, no coarse fragments, field pH 6; clear transition to

30 cm to 90 cm BGL: yellowish brown, medium clay, very firm consistency, strong structure (polyhedral), no mottles, few coarse fragments (2–6 mm, rounded nodules), field pH 8; abrupt transition to

90 cm to 120+ BGL: dark yellowish brown, medium clay, very firm consistency, strong structure (polyhedral), no mottles, no coarse fragments, field pH 8.5.

Erosion: no significant accelerated erosion observed
Geology: Tb and Qr^f, (mapped) / none (observed)
Rigid: yes
Existing soil mapping matches:
AAS –Kb11 (deep clay soils)
Isbell & Murtha (1970) – Ce7 (deep brown clays)

MEDT Results for Profile 9

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	After 20 hrs
0.1–0.2	Moderate slaking	No dispersion	No dispersion
0.4–0.5	Moderate slaking	Near complete dispersion	Near complete dispersion
0.7–0.8	Complete slaking	Complete dispersion	Complete dispersion

Management issues as identified from analysis of samples from Profile 9

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Very Low	OK	Low K	OK	OK	Sodic	No
0.6-0.7	OK	Low	OK	Low K	OK	OK	Sodic	No
0.9-1.0	OK	Low	OK	Low K	OK	OK	Strongly Sodic	No

Southern Dermosols

The southern dermosols occur in association with the southern dark vertosols and central kandosols in the southern part of the project site. The soils have fertility issues and are sodic (including Mg enhanced sodicity) below 0.3 m.

A small area of southern dermosols on Suttor Creek Station had been cultivated for cotton. This ceased some years ago due to the loss of a large part of the cultivated area to the Suttor Creek coal mine, which is understood to have made cultivation uneconomical.

Profile/s: 11(S), 13, 14(S), 25, 26(S)
Profile Description
Surface: firm, none to few coarse fragments (sub-rounded 6–20 mm).

Surface to 10–40 cm BGL: dark brown to dark reddish brown, loam to clayey loam, loose to weak consistency, single grain to strong structure (lenticular/polyhedral), no mottles, few coarse fragments (2–60 mm, rounded, nodules), field pH 6.5 to 7; clear transition to

10–40 cm to 60–80 cm BGL: strong brown to reddish yellow, light clay to medium clay, firm to very strong consistency, moderate structure (lenticular/ polyhedral), no to few mottles (distinct yellow), no to few coarse fragments (2–6 mm, sub-rounded, nodules and siltstone/sandstone), field pH 6.5 to 8; clear transition to

60–80 cm to 100–120+ cm BGL: brownish yellow to strong brown, light to medium clay, weak to very strong consistency, moderately structured (lenticular/ polyhedral), no to few black or grey mottles, no to few coarse fragments (6–20 mm, sub-rounded) of nodules and siltstone/sandstone, field pH 8–8.5.

Erosion: no significant accelerated erosion observed
Geology: Qr, Pwt, Qr^b, Tb (mapped) / siltstone and other sedimentary rocks (observed)
Rigid: yes
Existing soil mapping matches:
AAS – CC33 (deep brown clays)
Isbell & Murtha (1970) – Cd12 (deep brown clays)

MEDT Results for Profile 11, 14 and 26

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	Dispersion After 20 hrs
Profile 11			
0.1–0.2	Slight slaking	No dispersion	No dispersion
0.4–0.5	Slight slaking	No dispersion	No dispersion
0.7–0.8	Slight slaking	No dispersion	No dispersion
Profile 14			
0.1–0.2	Slight slaking	No dispersion	No dispersion
0.4–0.5	Moderate slaking	Moderate dispersion	Moderate dispersion
0.7–0.8	Moderate slaking	Slight dispersion	Moderate dispersion
Profile 26			
0.1–0.2	Complete slaking	Near complete dispersion	Near complete dispersion
0.4–0.5	Complete slaking	Near complete dispersion	Near complete dispersion
0.7–0.8	Moderate slaking	Near complete dispersion	Near complete dispersion

Management issues as identified from analysis of samples from Profiles 11, 14 and 26

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
Profile 11								
0.0-0.1	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Medium	OK	Low K	OK	OK	Sodic	Yes
0.6-0.7	OK	High	OK	Low K	OK	OK	Strongly Sodic	Yes
0.9-1.0	OK	High	OK	Low K	OK	Low Ca:Mg Ratio	Strongly Sodic	Yes
Profile 14								
0.0-0.1	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Very Low	OK	Low K	OK	Low Ca:Mg Ratio	Sodic	Yes
0.6-0.7	OK	Low	OK	Low K	OK	Low Ca:Mg Ratio	Strongly Sodic	Yes
0.9-1.0	OK	High	OK	Low K	OK	Low Ca:Mg Ratio	Strongly Sodic	Yes
Profile 26								
0.0-0.1	OK	Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Medium	OK	Low K	OK	Low Ca:Mg Ratio	Strongly Sodic	Yes
0.6-0.7	OK	Medium	OK	OK	OK	Low Ca:Mg Ratio	Strongly Sodic	Yes
0.9-1.0	OK	High	OK	Low K	OK	Low Ca:Mg Ratio	Strongly Sodic	Yes

Brown Vertosols

Brown vertosols occur in areas of melonhole gilgai and are typically associated with the central kandosols. These soils are strongly sodic (including Mg enhanced sodicity) and saline below 0.3 m.

Profile/s: 4(S), 20, 22, 27, 28

Profile Description

Surface: cracking, soft to hard (typically firm), no to very few coarse fragments (2–6 mm, rounded). Melonhole gilgai present, typically deeper than 500 mm and covering ~ 50% of area.

Surface to 5–10 cm BGL: dark yellowish brown to dark brown, light clay, loose to firm consistency, massive (moist) to moderate structure (lenticular), no mottles, no coarse fragments, field pH 6.5–8; transition to

5–10 cm to 15–30 cm BGL: dark yellowish brown to strong brown, light clay to medium clay, very weak to firm consistency, massive (moist) structure, no to few distinct yellow mottles, no coarse fragments, field pH 7.5 – 8.5; transition to

15–30 cm to 40–100 cm BGL: yellowish brown to strong brown, medium clay to medium heavy clay, firm to very firm consistency, massive (moist), no to few common yellow or grey mottles, no coarse fragments, field pH 8.5–9; transition to

40–100 cm to 120+ BGL: yellowish brown to dark yellowish brown to strong brown, medium clay to medium heavy clay, firm consistency, massive, no mottles, no coarse fragments, field pH 8–9.

Erosion: no significant accelerated erosion observed
Geology: mainly Tb and TQr^{f} (mapped) / no outcrop observed
Rigid: no
Existing soil mapping matches:
AAS – Mz17 (brown cracking clays with slight to moderate gilgai microrelief (sub-dominant))
Isbell & Murtha (1970) – mb21 (no similar soil described)

MEDT Results for Profile 4

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	Dispersion After 20 hrs
0.1–0.2	Moderate slaking	Moderate dispersion	Moderate dispersion
0.4–0.5	Moderate slaking	No dispersion	No dispersion
0.7–0.8	Moderate slaking	No dispersion	No dispersion

Management issues as identified from analysis of samples from Profile 4

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Medium	OK	OK	OK	OK	Strongly Sodic	Yes
0.6-0.7	OK	Very High	OK	OK	OK	OK	Strongly Sodic	Yes
0.9-1.0	OK	Extreme	OK	OK	OK	Low Ca:Mg Ratio	Strongly Sodic	Yes

Northern Dark Vertosols

The northern dark vertosols occur mainly in the north-eastern part of the project site. These soils are sodic (with Mg enhanced sodicity) below 0.3 m and have fertility issues throughout the profile.

Profile/s: 18(S), 19

Profile Description

Surface: self-mulching to cracking, few to common coarse fragments (sub-angular, 6–20 mm).

Surface to 10–15 cm BGL: dark grey to dark yellowish brown, light clay, very weak to weak consistency, massive (moist) to strong structure (lenticular), no mottles, very few to few coarse fragments (2–20 mm), field pH 7 to 8.5; abrupt transition to

10–15 cm to 50–80 cm BGL: dark greyish brown to dark yellow brown, medium clay to medium heavy clay, firm to strong consistency, strong structure (polyhedral), no mottles, very few to few coarse fragments (2–20 mm, basalt), field pH 8.5–9, transition to

50–80 cm to 80+–130+ cm BGL: dark brown to dark yellow brown, medium clay to medium heavy clay, strong consistency, massive (moist) to strong structure (polyhedral), no mottles, very few to few coarse fragments (2–20 mm, basalt), field pH 8–8.5.

Erosion: active minor gully erosion (<1.5 m deep) observed

Geology: Tb, Qr^c, Pwt (mapped) / basalt (observed)

Rigid: no

Existing mapping:

AAS – Kb11 (shallow mostly dark clays)

Isbell & Murtha (1970) – Ce7 (dark medium to shallow cracking clays)

Gully erosion observed in northern dark vertosols.

Management issues as identified from analysis of samples from Profile 18

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	OK	Low	OK	OK	OK	Low Ca:Mg Ratio	Non-sodic	Yes
0.3-0.4	OK	Low	OK	Low K	OK	Low Ca:Mg Ratio	Sodic	Yes
0.6-0.7	OK	Medium	OK	Low K	OK	Low Ca:Mg Ratio	Sodic	Yes
0.9-1.0	OK	Low	OK	OK	OK	Low Ca:Mg Ratio	Sodic	Yes

Central Dark Vertosols

The central dark vertosols are shallow cracking clays that occur in association with the rudosols, sodosols, central dermosols, and central kandosols. These soils appear to be stable and have minor fertility issues below 0.3 m.

Profile/s: 8(S), 29
Description:
Surface: firm, cracking, no to few coarse fragments (rounded 60–200 mm). Note that areas of these soils often had many (20–50%) coarse fragments (60–200 mm) on the surface.

Surface to 5 cm BGL: very dark greyish brown to olive brown, light clay to medium clay, weak consistency, massive (moist) to moderate structure (lenticular), no mottles, no coarse fragments, field pH 6.5 to 7; abrupt to clear transition to

5 cm to 15 cm BGL: very dark brown, medium heavy clay, very firm consistency, massive (moist), few mottles (faint grey), no coarse fragments, field pH 7.5, gradual transition to

15 cm to 70–80 cm BGL: dark brown to dark grey medium heavy clay, firm consistency, massive (moist) to strong structure (polyhedral), no mottles, no to few coarse fragments (6–20 mm, rounded) of basalt, field pH 7.5–8.5; abrupt to clear transition to

70+–80+ cm BGL: fresh or weathered basalt.

Erosion: no significant accelerated erosion observed
Geology (observed): Qr^f, Qr^b, Qa, Tb (mapped) / basalt (observed)
Rigid: no
Existing mapping:
AAS – Kb11 (shallow mostly stony dark clays)
Isbell & Murtha (1970) – Ce7 (dark medium to shallow cracking clays)

MEDT Results for Profile 8

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	Dispersion After 20 hrs
0.1–0.2	No slaking	No dispersion	No dispersion
0.4–0.5	No slaking	No dispersion	No dispersion

Management issues as identified from analysis of samples from Profile 8

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	OK	Very Low	OK	OK	OK	OK	Non-sodic	No
0.3-0.4	OK	Very Low	OK	Low K	OK	OK	Non-sodic	No
0.6-0.7	OK	Low	OK	Low K	OK	OK	Non-sodic	No

Southern Dark Vertosols

The southern dark vertosols occur in association with the southern dermosols and the central kandosols. Typically they are deep clays that form a cracking surface. Magnesium enhanced sodicity may be an issue in these soils.

Profile/s: 12(S), 24
Profile Description
Surface: soft to cracking, no coarse fragments.

Surface to 10–15 cm BGL: olive grey to brown, clay loam (sandy) to light clay, very weak to weak consistency, massive (moist) to weak (polyhedral), no mottles, no coarse fragments, field pH 6.5 to 7; clear transition to

10–15 cm to 70–80 cm BGL: olive grey to dark yellow brown, light medium clay to medium clay, firm consistency, massive (moist) to moderate (polyhedra), no mottles, no coarse fragments, field pH 8, clear transition to

70–80 cm to 100+–120+ cm BGL: olive grey to yellow brown, medium clay to medium heavy clay, firm to very firm consistency, massive (moist), no mottles, no coarse fragments, field pH 7.5–8.5.

Erosion: no significant accelerated erosion observed
Geology: Qa, Tb, Qr[b], Pwt (mapped) / basalt (observed)
Rigid: no
Existing mapping:
AAS – Ke19 (deep dark grey or dark brown cracking clays)
Isbell & Murtha (1970) – Ce9 (dark medium to shallow cracking clays)

MEDT Results for Profile 12

Depth (m BGL)	Slaking After 2 hrs	Dispersion After 2 hrs	Dispersion After 20 hrs
0.1–0.2	No slaking	No dispersion	No dispersion
0.4–0.5	No slaking	No dispersion	No dispersion
0.7–0.8	No slaking	No dispersion	No dispersion

Management issues as identified from analysis of samples from Profile 12

Depth (m BGL)	Soil Acidity	Salinity Class	Fertility CEC	Fertility K	Fertility Ca	Fertility Ca:Mg Ratio	Sodicity	ME Sodicity
0.0-0.1	OK	Very Low	OK	OK	OK	OK	Non-sodic	Yes
0.3-0.4	OK	Very Low	OK	OK	OK	OK	Non-sodic	Yes
0.6-0.7	OK	Very Low	OK	OK	OK	OK	Non-sodic	Yes
0.9-1.0	OK	Low	OK	Low K	OK	OK	Non-sodic	Yes

References

Isbell, R.F. & Murtha, G.G. 1970. *Soils – Burdekin – Townsville Region (Queensland) Resource Series*. Department of National Development, Geographic Section, Canberra.

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