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# GALILEE COAL PROJECT SUPPLEMENTARY EIS SOIL AND LAND SUITABILITY STUDY

Prepared for:

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# ABBREVIATIONS

| | |
|---|---|
| **AHD** | Australian Height Datum |
| **ANZMEC** | Australian and New Zealand Minerals and Energy Council |
| **APSDA** | Abbott Point State Development Area |
| **ASC** | Australian Soil Classification |
| **BER** | Aldrick, J.M. 1988. Soils of the Elliot River-Bowen Area, North Queensland, Queensland Department of Primary Industries Land Resource Bulletin QV88002, Brisbane |
| **CoA** | Commonwealth of Australia |
| **CNM** | Shields, P.G. 1984. Land Suitability Study of the Collinsville-Nebo-Moranbah Region, Queensland Department of Primary Industries, Bulletin QB84010, Brisbane. |
| **CSIRO** | Commonwealth Scientific and Industrial Research Organisation |
| **DEM** | Digital Elevation Model |
| **DEHP** | Department of Environment and Heritage Protection (QLD), formerly DERM |
| **DERM** | Department of Environment and Resource Management (QLD), now known as DEHP |
| **DHLGP** | Department of Housing, Local Government and Planning (QLD) |
| **DME** | Department of Minerals and Energy (QLD) |
| **DPI** | Department of Primary Industries (QLD) |
| **DSEWPC** | Department of Sustainability, Environment, Water, Population and Communities (QLD) |
| **DUSLARA** | Lorimer, M.S. 2005. The Desert Uplands: an overview of the Strategic Land Resource Assessment Project, Technical Report, Environmental Protection Agency, Queensland |
| **EC** | Electrical Conductivity |
| **EIS** | Environmental Impact Statement |
| **ESP** | Exchangeable Sodium Percentage |
| **GQAL** | Good Quality Agricultural Land |
| **ha** | Hectares |
| **IECA** | International Erosion Control Association |
| **$kg/m^3$** | Kilograms per cubic metre (a measure of density) |
| **mAHD** | Metres above Australian Height Datum |
| **MIA** | Mine Infrastructure Area |

# ABBREVIATIONS

| | |
|---|---|
| **Mt** | Megatonnes (1 x $10^6$ tonnes) |
| **Mya** | Million years ago |
| **NATA** | National Association of Testing Authorities |
| **SPP** | State Planning Policy |
| **TOR** | Terms of Reference |
| **TSF** | Tailings Storage Facility |
| **ZEB** | Isbell, R.F. and Murtha, G.G. 1970. Burdekin-Townsville Region Resources Series; Soils, Geographic Section, Department of National Development, Canberra |
| **ZCQ** | Gunn, R.H., Galloway, R.W, Pedley, L. and Fitzpatrick, E.A. 1967. Lands of the Nogoa-Belyando Area, Queensland, Land Research Series No. 18, Commonwealth Scientific and Industrial Research Association, Melbourne |
| **ZCI** | Christian, C.S., Paterson, S.J., Perry, R.A., Slatyer, R.O., Stewart, G.A. and Traves, D.M. 1953 Land Research Series No. 2, Commonwealth Scientific and Industrial Research Association, Melbourne |

# GLOSSARY

The following glossary provides a definition of technical terms used within this report. The definitions have been adapted from online glossaries and dictionaries, including webpages of: CSIRO: The Australian Soil Classification; Department of Primary Industries Soil Glossary (Victoria) and Department of Environment and Resource Management (Queensland).

| Term | Word Class | Definition |
|---|---|---|
| **A-horizon** | *n.* | Surface soil horizons which contain organic material. |
| **Alluvium** | *n.* | Sedimentary deposit made by rivers or streams. |
| **Anthroposol** | *n.* | Soil profile which has resulted from human activities which have significantly modified, mixed, truncated or buried original soil horizons, or have created new parent materials. |
| **B-horizon** | *n.* | Subsoil portion of the soil profile where silicate clay, iron, aluminium, humus, carbonates gypsum or silica have been concentrated alone or in combination. |
| **Batholith** | *n.* | An extensive plutonic mass that exceeds 100 $km^2$ in area. Batholiths are generally made up of multiple granitic intrusions that are generally less than 30 km in lateral extent. |
| **Bedrock** | *n.* | Solid rock underlying superficial surface materials. |
| **C-horizon** | *n.* | Layers below the solum that lack pedological development. Includes consolidated rock and sediments that are generally weak in strength. |
| **Cation** | *n.* | A positively charged ion. |
| **Chromosol** | *n.* | ASC soil profile with a strong texture contrast, where the upper B-horizon is neither strongly acidic nor sodic. |
| **Clear or abrupt soil horizon change** | *n.* | Horizon boundary less than 50 mm in thickness. |
| **Colluvium** | *n.* | Unconsolidated material at the base of a slope or cliff that has been deposited by gravity. |
| **Cuesta** | *n.* | A ridge formed by erosion or faulting of gently dipping sedimentary rocks. The landform has a steep escarpment face, with a gently sloping dip slope. |
| **Dip** | *n.* | The angle between a horizontal plane and an inclined surface or subsurface feature in a rock mass. |
| **Dregic** | *n.* | Anthroposol subgroup describing soils that have formed/ are forming on mineral materials that have been dredged through human actions, or deposited as slurry residues. |
| **Dyke** | n. | A tabular igneous rock that been intruded in the host rock at a vertical or near vertical angle. |
| **Ephemeral Watercourse** | *n.* | A watercourse which does not flow all the time. |
| **Rock strength testing failure mode** | *n.* | A=through intact rock, B=invalid test. |
| **Felsic** | *n.* | Igneous rock with a silica ($SiO_2$) content greater than 63 %. |
| **Gully erosion** | *n.* | Surface erosion caused by the concentration of water into clearly defined, large, narrow, and usually ephemeral channels. |
| **Gully headcut** | *n.* | The steep (often vertical or overhanging) upstream limit of a gully. |
| **Gypsum** | *n.* | A soft mineral composed of calcium sulfate dihydrate ($CaSO_4$ $2H_2O$ ). |
| **Hardsetting soils** | *n.* | Soils which set as they dry to form a hard, structureless surface layer. |

# GLOSSARY

| Term | Word Class | Definition |
|---|---|---|
| **Hortic** | *n.* | Anthroposol subgroup describing soils that have had additions of organic wastes that have been incorporated into the soil, and obliterated pre-existing pedological features. |
| **Intrusion** | *n.* | The emplacement of magma into a pre-existing rock. |
| **Igneous Rock** | *n.* | Rock formed from the cooling of magma or lava. |
| **Mafic** | *n.* | Igneous rock with a low silica content ($SiO_2$ between 45 % and 52 %) but typically high iron and magnesium content. |
| **Metasediments** | *n.* | A sedimentary rock that shows evidence of alteration through heat or pressure (metamorphism). |
| **Pedological/ pedologically** | *adj./ adv.* | Relating to soil formation by soil-forming processes |
| **Piping** | *n.* | Sub-surface erosion caused by the movement of water through dispersive subsoils. Also known as tunnelling erosion. |
| **Regolith** | *n.* | Unconsolidated material overlying bedrock that has been formed by weathering, erosion, transport and/or deposition of older materials. |
| **Rill erosion** | *n.* | Surface erosion caused by the concentration of sheet erosion into channels up to 30cm deep. |
| **Rudosol** | *n.* | ASC soil profile with negligible pedological development. |
| **Scalpic** | *n.* | Anthroposol subgroup describing soils that have formed/ are forming on land surfaces that have been created by humans by cutting away at previous soil with machinery. |
| **Shear zones** | *n.* | A zone of rock that has been deformed by stress |
| **Sheet erosion** | *n.* | Surface erosion whereby water removes approximately even layers of soil. |
| **Solum** | *n.* | Surface and subsoil that have undergone the same process of formation. |
| **Sodosol** | *n.* | ASC soil profile with a strong texture contrast and strongly sodic, but not strongly acidic, B horizon. |
| **Spolic** | *n.* | Anthroposol subgroup describing soils that have formed/ are forming on land surfaces that have been moved by earthmoving equipment. |
| **Strike** | *n.* | A line representing the horizontal expression of a planar rock mass feature (e.g. bed or fault), perpendicular to the dip. |
| **Strike-slip fault** | *n.* | A fault in which the principal direction of displacement is parallel to the strike of the fault plane. The fault plane is usually approximately vertical. |
| **Subsoil** | *n.* | See B-Horizon |
| **Tectonic** | *n.* | Structural deformation of the Earth's crust |
| **Texture contrast soil** | *n.* | Soil profile with a clear or abrupt change in texture between the A and B horizons. |
| **Topsoil** | *n.* | See A-Horizon |
| **Tunnel erosion** | *n.* | See Piping |
| **Urbic soil** | *n.* | Anthroposol subgroup describing mineral soils that are characterised by land fill of a predominantly mineral nature. |

# 1 INTRODUCTION

This section of the report provides an overview of the proposed Galilee Coal Project (the project). An overview of the soils and land suitability study and a summary of relevant legislation are also provided.

## 1.1 Project Description

The Galilee Coal Project (Northern Export Facility; also known as the China First Project) comprises a new coal mine located in the Galilee Basin, Queensland, approximately 30 km to the north of Alpha; a new rail line connecting the mine to coal terminal facilities; and use of coal terminal facilities in the Abbot Point State Development Area (APSDA) and port loading facilities at the Port of Abbot Point.

The mine will be a combination of 2 surface mines and 4 underground mines, with an ultimate export capacity of 40 Mtpa. The surface and underground mines will be supported by a purpose-built Mine Infrastructure Area (MIA). The raw coal will be washed for the export market with an overall product yield of 72%. The annual raw coal production will be 56 Mtpa to produce 40 Mtpa of saleable export product coal.

The preferred rail alignment option is to construct a new heavy haul, standard gauge rail link operating with 20,000 tonne (payload) unit size diesel electric trains. The rail easement will typically be between 60 m – 80 m wide, unless passing through major cuttings. The 40 Mtpa of export quality washed coal will be transported to the coal terminal using trains (locomotives and wagons) operating 24 hours per day, 6 days per week. Maintenance roads will be constructed within the railway easement along the length of the railway.

Other project components are anticipated to include:

- Connections to power and water supply services.
- Temporary and permanent workers' accommodation.
- Fencing, roads and access tracks.
- Airstrip capable of landing 20 seater aircraft.
- Stormwater and sewage services.
- Telecommunications.
- Borrow pits and quarries.
- Storage areas and depots.
- Waste facilities.

## 1.2 Soils and Land Suitability Study Aims and Objectives

### 1.2.1 Galilee Coal Project EIS Soils Assessment Data Gaps and Requested Information

Waratah Coal has previously submitted an EIS soils study for the project (Appendix 6 – Geology, Soils and Landforms, E3 Consult, October 2010). Government review and public consultation indicated several issues that were not adequately addressed in this initial study. These gaps and issues are indicated in Table 1.1, and are addressed in this supplementary EIS.

**Table 1.1 Summary of Government Review and Public Consultation Issues, Questions and Suggested Solutions**

| Ref.[1] | Submitter | Submission Issue | Section(s) of this Report where Issues are Addressed |
|---|---|---|---|
| Soils Assessment Issues | | | |
| f 4099 p103 | Barcaldine Regional Council | [Soils] 'are prone to erosion and dispersion'. Identify the extent of dispersive soils.<br>Provide details on erosion and dispersion, and the suitable landforms for the identified soil types | Section 2<br>Section 6<br>Appendix B<br>Figures 2.2, 2.3 and 2.6, Plans 1-8 |
| f 4104 p108 | DERM/DEHP | Mine site: the EIS does not adequately address soils and land suitability assessment requirements. The Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995) indicate that non-disturbance areas should be mapped at 1:250,000, with mine-disturbed areas mapped at 1:5,000.<br>Soil investigation of the entire mining lease area should be conducted at 1:100,000, with 25% of sites described in detail, as per Australian Soil and Land Survey Handbook (National Committee on Soil and Terrain, 2009) guidelines. | Section 6<br>Appendix A<br>Appendix B<br>Figures 2.1-2.5 |
| | DERM/DEHP | Mine site: geological cross-sections showing the relationship between mine components and geological formations has not been provided. The locations of the provided cross-sections are not shown.<br>West to east cross-section(s) identifying the mine footprint in relation to the geological formations should be provided. | Section 6 |
| f 4105 p109 | DERM/DEHP | Rail: The soil and land suitability assessment has not been conducted to an acceptable level of detail.<br>A soil and land suitability assessment should be provided in accordance with Soil Survey Methodology along Linear Features (DERM, draft working document, 2011), supplementing the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995). | Section 6<br>Appendix A<br>Appendix B<br>Figures 2.6, Plans 1-8 |
| f5 4092 p96 | Whitsunday Regional Council | Mine site: EIS-mapped soils are indicated as being prone to erosion and dispersion, and are unsuitable as topsoils. | Section 6<br>Figures 2.2 and 2.3 |

| Ref.[1] | Submitter | Submission Issue | Section(s) of this Report where Issues are Addressed |
|---|---|---|---|
| Impact Assessment Issues | | | |
| f 4100 p104 | DEEDI | The EIS does not adequately address the impacts on agricultural land use and good quality agricultural land, and relies on broad statements regarding potential impacts<br>There are numerous grazing properties with improved pastures adjoining the lease areas. It is recommended that further information is provided regarding the specific impacts of the project on adjoining landowners and associated agricultural activities.<br>A number of research programs assessing grazing productivity/activity in the Desert Uplands have been undertaken, including research on properties in the vicinity of the proposed mine site. It is recommended that the proponents provide additional information on the likely impact of the project on agricultural research programs in the area, particularly the impact of the project on long term data sets/monitoring relevant to grazing research.<br>The proponents are advised to contact DEEDI in relation to this matter.<br>Measures to mitigate adverse impacts to adjoining grazing properties resulting from the development should be included. | Section 3.4.1<br>Section 6<br>Table 3.1 |
| f 4101 p105 | DEEDI | The rail line has the potential to destroy the value and productivity of good quality grazing and farming lands. The proposed rail corridor has greater potential to destroy 'good' quality agricultural land than the mine development.<br>The impact of the rail line/s on the productivity and operation of agricultural properties must be considered cumulatively with the mine development impact. | Section 3.4.1<br>Section 3.5<br>Section 6<br>Table 3.1<br>Appendix B<br>Figure 2.6, Plans 1-8 |
| f 4013 p107 | DEEDI | The EIS acknowledges the sterilisation of agricultural land, including potential Class A land between KP25-KP85 and KP322-KP355<br>Further information should be provided on impacts that the development of the railway will have on landholders and agricultural activities that are occurring during all stages of the project. | Section 3.5<br>Section 6<br>Appendix B<br>Figure 2.6, Plans 1-8 |
| **Management / Mitigation Issues** | | | |
| f | DEEDI | (see Ref. 4100)<br>Measures to mitigate adverse impacts to adjoining grazing properties resulting from the development should be included | Section 3.4.1<br>Section 6<br>Table 3.1 |
| f 4051 p52 | DERM/DEHP | The EM plan does not provide sufficient detail regarding the management of topsoil for the project to ensure rehabilitation requirements are met<br>Topsoil management measures should be discussed in the SEIS and EM plan | Section 4<br>Section 6 |

| Ref.[1] | Submitter | Submission Issue | Section(s) of this Report where Issues are Addressed |
|---|---|---|---|
| p 4054 p55 | DERM/DEHP | The EM plan does not provide sufficient detail regarding the management and rehabilitation of subsidence. Subsidence management and rehabilitation should be discussed in the SEIS and EM plan | Section 3.4.2<br>Section 6 |
| f 4093 p97 | Barcaldine Regional Council | Soil dumps have a maximum height of 40 m above ground level.<br>Advise on the way in which impacts and final landforms will be managed | Section 5.1<br>Section 5.2<br>Section 6 |
| f 4094 p98 | Barcaldine Regional Council | Mitigation measures to manage post-mining topography and landscape are not described.<br>Details of mitigation measures for post-mining landforms are required | Section 5.1<br>Section 5.2<br>Section 6 |
| **Rehabilitation Issues** | | | |
| p 4053 p54 | DERM/DEHP | The EM plan only provides general post-mining land uses. The plan does not provide an indication of what 'grazing at low stock rates' is or justification that a tailings dam can be rehabilitated to this use. The EM plan lists 'native bushland' as the post-mining land use for several mining activities, but does not list post-mining land uses associated with areas of subsidence.<br>The EIS should provide an EM plan developed with consideration of the departmental guideline 'Rehabilitation requirements for mining projects' (DME, 1995), covering all domains on the mine site. The proposed post-mining land use must be clearly specified. | Section 3.3<br>Section 6<br>Appendix B<br>Figures 2.5 and 2.6, Plans 1-8 |
| f 4047 p48 | Barcaldine Regional Council | How long before progressive rehabilitation will occur? | (to be covered in Rehabilitation Plans) |
| p 4040 p41 | Capricorn Conservation Council | Little evidence and research into restoration of mine-disturbed land in QLD to 'stable and non-polluting condition'.<br>Evidence of successful rehabilitation of open-cut mines should be evaluated and presented for peer review | Section 5.1 |
| f 4048 P49 | Isaac Regional Council | Disturbed areas should be rapidly re-vegetated and stabilised to prevent dust and surface water pollution from the site exceeding pre-development levels at the property boundary. | (to be covered in Rehabilitation Plans) |

| Ref.[1] | Submitter | Submission Issue | Section(s) of this Report where Issues are Addressed |
|---|---|---|---|
| p 4012 p106 | DEEDI | Rehabilitation methods for agricultural land need to be well defined, planned from the start, and implemented at all phases of the mining process to have any chance of success.<br>If land is to return, or maintain, some value for agriculture, a rehabilitation program must be developed, process and milestones clearly identified and the program followed/enforced explicitly.<br>The project proponents are advised to consult with local farmers and graziers in order to understand and deliver the best long term outcomes for agriculture in the region – including maximising rehabilitation success | Section 5.2<br>Section 5.3<br>Section 6 |

1. f = fully addressed; p = partially addressed (i.e., issues relevant to this study) in this report

## 1.3 The Soils Study Area

This study assesses the geology, landform, geomorphology and soils at and around the mine site and rail corridor. The study area was defined as areas which could be directly or indirectly affected by any component of the project. Therefore, areas down-system (i.e., downslope, downstream or downwind) of potentially impacted areas, where erosion, sediment transport and sedimentation could occur, were also assessed.

## 1.4 Method of Assessment

The study detailed in this report forms the first part of a phased soils study – henceforth referred to as the “preliminary soils study”. This report is intended to provide a preliminary assessment based on review of available information. The proposed phases of the assessment are discussed below.

### 1.4.1 Study Method

Coffey undertook a phased, risk-based ‘top down’ approach to the preliminary soils study. This involved the following phases:

- Phase 1 – Detailed desktop assessment.

Additional information regarding Coffey’s preliminary study approach is included in Appendix A: Study Methodology.

### 1.4.2 Proposed Additional Studies

Coffey intends to carry out further phases to complete the soils study, as follows:

- Phase 2 – Preliminary site reconnaissance visit (optional, as discussed in Appendix A).
- Phase 3 – Interim targeted soils investigation.
- Phase 4 – Full targeted soils investigation in conjunction with geotechnical ground investigation work during the design phase of the project.

This proposed work will be a commitment of the project and, as such is discussed further in Section 6: Proposed Soils and Land Suitability Study Commitments.

## 1.5 Explanation of the Term ‘Soil’

The term ‘soil’ is used by geotechnical engineers and soil scientists to mean different things, as indicated in Table 1.2:

**Table 1.2 Definition of ‘Soil’**

| | Geotechnical Engineering ‘Soil’ or Regolith | Soil Science ‘Soil’ |
|---|---|---|
| Definition | All material above bedrock is assessed, and should properly be termed ‘regolith’ i.e., material with ‘soil strength’, generally with an unconfined compressive strength of below approximately 1 megapascal (MPa) | A recognisable profile must exist, i.e., several layers (horizons) sub-parallel to the ground surface, formed by physical, chemical and biological processes (Charman and Murphy, 2007) |
| Inclusions/Exclusions | Engineering soil/regolith includes soils with a recognisable profile | Not all regolith is soil as defined by soil scientists |

The common use of the term ’soil’ can be confusing, e.g., the widely accepted engineering term for compressible sediments is ’soft soils’, despite the fact that this material may not have developed a ‘soil profile’ as understood by soil scientists. This report mainly uses the term from a soil science perspective but has attempted to provide clarity if the geotechnical definition is being referred to.

## 1.6 Legislative Context and Standards

The SEIS geology, landform and soils assessment considered key statutory regulations governing land management relevant to the project. These have largely been discussed in the Galilee Coal Project EIS Geology, Soils and Landform Study, but are listed below for reference and to provide context for this study:

### 1.6.1 National Policies

- National Strategy for Ecologically Sustainable Development (COA, 1992). The object of this policy is to promote ecologically sustainable development. Several objectives for mine developments have been set within this policy. These include:
  - Repairing land so that its ongoing maintenance needs are consistent with those of equivalent unmined land under equivalent use.
  - Treating rehabilitation as an integral component of mine operation.
- Strategic Framework for Mine Closure (ANZMEC, 2000).

### 1.6.2 State Legislation

- *Minerals Resources Act 1989* (Qld). The objective of this act is to provide a framework to regulate tenure and royalty issues associated with exploration and mining for minerals. Under the *Environmental Protection and Other Legislation Amendment Act 2000*, provisions within the Mineral Resources Act regarding the environmental management of mines was transferred to the *Environmental Protection Act 1994*. Therefore, this act has not been widely considered within this assessment.
- *Nature Conservation Act 1992* (Qld). The objective of this act is the conservation of nature, including ecosystems and their constituent parts, and all natural and physical resources. This act is relevant to the project should the development impact upon the soils, geology and/or landforms within protected areas (listed under s. 14) that contribute to the biological diversity and integrity, or intrinsic or scientific value of that particular place.
- *Land Act 1994* (Qld). The objective of this act is to manage state land for the benefit of the people of Queensland based on the principles of sustainability, evaluation, development and community purpose.
- *Vegetation Management Act 1999* (Qld). Objectives of this act considered relevant to the project geology, landform and soil assessment include:

  1) ensuring that vegetation clearance does not cause land degradation; and

  2) managing environmental effects associated with land clearance.
- *Environmental Protection Regulation 2008* (Qld) (associated with the *Environmental Protection Act 1994* (Qld)). Objectives of this act relevant to the project are to assist the mining industry in achieving ecologically sustainable development and meeting environmental management responsibilities. Under this act, the various environmental impacts associated with mine activities are managed under licensing systems for environmentally relevant activities (ERAs) (s126-310.).

- *Sustainable Planning Act 2009* (Qld) (replacing the *Integrated Planning Act 1997*). The objective of this act is to achieve ecological sustainability by managing development processes, associated environmental effects, and streamlining the coordination of local, regional and state planning instruments. Several state planning policies which advance the purpose of this act and have objectives relevant to the project are discussed in detail below.
- *Strategic Cropping Land Act 2011* (Qld). The objectives of this act are to protect cropping land, manage the impacts of development of this land and preserve the productive capacity. This act is associated with State Planning Policy 1/12 (discussed below).

#### 1.6.3 State Planning Policies (SPP) and Associated Guidelines

- SPP1/92: Development and Conservation of Good Quality Agricultural Land. This planning policy is discussed further in Section 1.6.4.
- SPP 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide. This requires developments to minimise potential adverse impacts of flood, bushfire and landslide on people, property, economic activity and the environment. This policy is relevant to this study as direct or indirect modification to soils or landforms required for the development may adversely impact flood or landslide risk.

#### 1.6.4 State Planning Policy SPP1/92: Development and Conservation of Good Quality Agricultural Land

Agricultural land is considered by the Queensland Government to be a finite resource that must be observed and managed for the longer term (SPP1/92). Agriculture is a fundamental land use in the project development area and, therefore, requires specific consideration in the EIS.

State Planning Policy 1/92 – Development and the Conservation of Good Quality Agricultural Land (SPP 1/92) was put in place to protect Good Quality Agricultural Land (GQAL) against competing land uses, and maintain the productivity of agricultural land uses into the future. SPP 1/92 has been jointly prepared by the Department of Housing, Local Government and Planning (DHLGP) and the Queensland Department of Primary Industries (DPI). It requires local governments to identify and protect GQAL through local planning schemes.

Four classes of agricultural land have been defined in Queensland, as defined in Table 1.3.

**Table 1.3 GQAL Descriptions**

| Class | Description |
|---|---|
| **Class A** | **Cropland** – Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels. Considered to be GQAL in all areas. |
| **Class B** | **Limited cropland** – Land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping. Considered to be GQAL in most areas. |
| **Class C** | **Pasture land** – Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment. Class C is subdivided into the following:<br>C1 – Land suitable for sown pastures with moderate limitations, considered to be GQAL when considered suitable for improved or high quality native pastures;<br>C2 – Land suitable for sown pastures with severe limitations, not considered to be GQAL;<br>C3 – Land suitable for light grazing of native pastures in inaccessible areas, not considered to be GQAL. |
| **Class D** | **Non-agricultural land** – Land is not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage. Not considered to be GQAL. |

Agricultural land classes are based on an assessment of the agricultural suitability of the land for specified agricultural uses.

### 1.6.5 SPP1/12: Protection of Queensland's Strategic Cropping Land

Under the Sustainable Planning Act and associated with the Strategic Cropping Land Act, a new statutory planning instrument was enacted in January 2012 to guide planning for strategic cropping. This is accompanied by a State Planning Policy, SPP 1/12: Protection of Queensland's Strategic Cropping Land. The Act and policy aim to address land-use competition issues, particularly between mining and agricultural industries, to ensure that cropping land resources are given the same consideration as other types of development. This will subsume SPP 1/92, and aims to ensure that local government planning schemes and regional plans recognise and conserve areas of the best agricultural land (defined as 'strategic cropping land') under the Strategic Cropping Land policy framework.

DERM (now DEHP) released a series of trigger maps as part of the policy framework. These maps indicate areas where strategic cropping land is expected to exist, based on available soil, land and climate information.

### 1.6.6 Land Suitability

Agricultural land suitability is a rating of the ability of land to maintain a sustainable level of productivity, which is dependent on the soil, topographic and climatic limitations. Factors such as the size of the assessed area are not included as they are not considered relevant to the quality of the resource (DPI/DHLGP, 1993). In this report, a preliminary assessment of the agricultural land use suitability has been made in accordance with classifications defined by DME (1995a). This requires a suitable post-mining land use to be assigned to an area, which is then given a land suitability ranking dependent on the limitations identified for that particular land use.

A summary of the class rankings for post-mining land-use suitability is presented in Table 1.4. Classes 1 to 3 encompass land considered to be suitable for significant improvement, class 4 comprises land which offers moderate potential for improvement, and class 5 consists of land that is considered unsuitable for improvement.

**Table 1.4 Post-Mining Land Suitability Classification (DME, 1995a).**

| Class | Description |
|---|---|
| **Class 1** | **Agricultural:** Suitable land with negligible limitations – land is well suited to the proposed use.<br>**Conservation:** Land is well suited for conservation use, possessed significant conservation benefits in the pre-mining environment, and is capable of being restored to this use post-mining. |
| **Class 2** | **Agricultural:** Suitable land with minor limitations – land is suited to the proposed use, but may require minor changes to sustain this use.<br>**Conservation:** Land is well suited for conservation use in that a significant component of the pre-mining conservation values can be restored post mining. |
| **Class 3** | **Agricultural:** Suitable land with moderate limitations – land is moderately suited to the proposed use, but may require significant inputs to sustain this use.<br>**Conservation:** Land possessed significant conservation value pre-mining. However, restoration of these values may not be feasible. However, the land may be restored to a form of conservation use which provides alternative conservation benefits. |
| **Class 4** | **Agricultural:** Land is marginally suited to the proposed use, and would require significant inputs to sustain this use. Such input verses benefits may not be justifiable.<br>**Conservation:** Land possessed limited conservation value pre-mining, and/or is incapable of being restored post mining to any alternative conservation use which provides similar benefits. The area could be restored to a stable form of use which does not impact the surrounding conservation value of the land. |
| **Class 5** | **Agricultural:** Land is unsuitable with extreme limitations.<br>**Conservation:** Lands contain no significant conservation value. |

### 1.6.7 Other Relevant Guidelines

DERM (now DEHP) has released a series of mining guidelines and policies on impact assessment and environmental management for the mining industry within the framework of the Environmental Protection Act. Of particular relevance to the geology, landform and soil assessment is the ‘Rehabilitation Requirements for Mining Projects’ (DERM, 2010) which provides information of the progressive and final rehabilitation requirements for mining projects operating in Queensland under the Environmental Protection Act.

Additionally, several of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995b) are of relevance to the geology, landform and soils assessment. These include:

- The Land Suitability Assessment Techniques guideline, which provides advice on the applicability and use of land suitability assessment techniques to determine pre-mining land suitability and post-mining land use potential.
- The Erosion Control guideline, which provides advice on the prediction, control and measurement of soil erosion and deposition on and from rehabilitated land.

The advice and recommendations given in this report are in accordance with *Best Practice Erosion and Sediment Control Manual* (International Erosion Control Association (IECA), 2008). This document is the standard Queensland guideline for erosion and sediment control, and provides an overview of how to manage erosion and sedimentation throughout the various planning and construction stages of the development. Several items within Book 5 (which provides guidelines on the management of erosion and sediment control on typical construction sites) are considered to be of relevance to this assessment. These include guidelines relating to:

- Management of soils (including dispersive soils).
- Implementation of erosion and sediment control measures.
- Site management and monitoring.
- Si te rehabilitation.

## 2 EXISTING ENVIRONMENT

This section provides a summary of the existing surficial geology, landforms and soils of the study area and responses to the following questions (although land suitability is discussed in Section 3, in conjunction with agricultural land class and strategic cropping land):

| Ref. | Submitter | Submission Issue |
|---|---|---|
| f 4099 p103 | Barcaldine Regional Council | [Soils] 'are prone to erosion and dispersion'. Identify the extent of dispersive soils.<br>Provide details on erosion and dispersion, and the suitable landforms for the identified soil types |
| f 4104 p108 | DERM/DEHP | Mine site: the EIS does not adequately address soils and land suitability assessment requirements. The Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995) indicate that non-disturbance areas should be mapped at 1:250,000, with mine-disturbed areas mapped at 1:5,000.<br>Soil investigation of the entire mining lease area should be conducted at 1:100,000, with 25% of sites described in detail, as per Australian Soil and Land Survey Handbook (National Committee on Soil and Terrain, 2009) guidelines. |
| f 4105 p109 | DERM/DEHP | Rail: The soil and land suitability assessment has not been conducted to an acceptable level of detail.<br>A soil and land suitability assessment should be provided in accordance with Soil Survey Methodology along Linear Features (DERM, draft working document, 2011), supplementing the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995). |
| f 4092 p96 | Whitsunday Regional Council | Mine site: EIS-mapped soils are indicated as being prone to erosion and dispersion, and are unsuitable as topsoils |

This section uses technical terms relevant to describing the geology, landform and soils of the study area. These are defined in the Glossary on pages x-xii.

For simplicity, the mine site has been split into 3 zones (generally known as physiographic provinces or areas) and the rail corridor has been split into 12 zones, each with appreciably different geological, landform and soils characteristics, as shown in Table 2.1:

**Table 2.1 Physiographic Areas of the Mine Site and Rail Corridor**

| **Physiographic Area** | | |
|---|---|---|
| **Mine Site** | **Location** | |
| Great Dividing Range | Northwest and Southwest Corners | |
| Lagoon Creek Valley | Central Plains | |
| Sedimentary Cuesta Uplands | Western Boundary | |
| **Rail Corridor** | **Marker Point Start** | **Marker Point Finish** |
| Coastal Zone | 0 | 21000 |
| Clark Ranges | 21000 | 60000 |
| Bowen River Valley | 60000 | 103000 |
| Leichhardt Range Foothills | 103000 | 125000 |
| Leichhardt Range | 125000 | 200000 |
| Suttor River Valley | 200000 | 232000 |
| Anakie Inlier | 232000 | 256000 |
| Mistake Creek Valley | 256000 | 329000 |
| Sandstone Uplands | 329000 | 360000 |
| Belyando River Valley | 360000 | 407000 |
| Sedimentary Cuesta Uplands | 407000 | 445000 |
| Lagoon Creek Valley | 445000 | 452941 |

The characteristics of each area are described in Table 2.2.

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**Table 2.2 Landscape Characteristics of Physiographic Areas of the Mine Site and Rail Corridor**

| Physiographic Area | MP_From | MP_To | Geology | Landform | Soils |
|---|---|---|---|---|---|
| **Mine Site** | | | | | |
| Great Dividing Range | | | Shallowly dipping Carboniferous, Permian and Triassic sedimentary sequences (including the coal-bearing Colinlea Sandstone and Bandanna Formation): the Dunda Beds and Clematis Sandstone to the west and Joe Joe Formation and Colinlea Sandstone to the east. Overlain by thin (i.e. up to 125 m deep) Tertiary sandstone and Tertiary/Quaternary colluvium and alluvium. | Rugged, steeply undulating north-south-trending cuesta scarp slopes of the Great Dividing Range in the northwest and southwest corners of the site (rising to over 500mAHD, just outside the study area) | Rudosols on rocky hills, with Tenosols at lower elevations. Kandosols on colluvial slopes and Chromosols (possibly Sodosols) on alluvial fans and lower slopes. |
| Lagoon Creek Valley | | | | Site falls gently towards the broad valleys of Sandy Creek and Lagoon Creek. Watercourses have formed a broad sandy plain, and have dissected the Tertiary sandstone and incised into the Tertiary/Quaternary colluvium, exiting the site at the northeast corner of the study area (below 320mAHD). | Kandosols associated with broad sandy alluvial/colluvial plains, with Sodosols (and possibly Chromosols) on lower slopes, Vertosols in low lying depressions close to Lagoon Creek and Tenosols along creeks. |
| Sedimentary Cuesta Uplands | | | | North-south-trending cuesta separated from the Great Dividing Range by the broad Lagoon Creek valley (with isolated hills rising to 350m-400mAHD adjacent to the corridor) | Red and Yellow Kandosols, with Chromosols on alluvial fans, Sodosols (and some Vertosols) associated with drainage depressions and Rudosols associated with higher elevation areas and adjacent to rocky outcrops |
| **Rail Corridor** | | | | | |
| Coastal Zone | 0 | 21000 | Tertiary and Quaternary colluvial and alluvial deposits on lower slopes of the predominantly igneous Clarke Ranges. | Poorly drained, gently sloping alluvial fans and colluvial slopes rising to about 100mAHD at the base of the Clarke Range | Sodosols (bleached A2, dispersive clay subsoils) and Chromosols dissected by stream channels, with small areas of Vertosols on alluvial margins. Soil depth typically decreases and percentage of gravels/stones increases with altitude. |

| Physiographic Area | MP_From | MP_To | Geology | Landform | Soils |
|---|---|---|---|---|---|
| Clark Ranges | 21000 | 60000 | Largely Permian intermediate and occasionally felsic volcanics forming the Clarke Ranges. Intruded by numerous dykes. Fractured by faults, one crossing the corridor at about MP 53650 (although others are shown on the Bowen Geological Map Sheet SF 55-3). | Corridor follows shallow-sloped valleys cutting through steep hills rising to over 500m (and over 800m in places), dissected by numerous watercourses, including the Bogie River | Shallow to moderately deep red Chromosols, often stony, with Rudosols on higher hillcrests and adjacent to rock outcrops |
| Bowen River Valley | 60000 | 103000 | Mafic to intermediate volcanics of the Lizzie Creek Volcanics, overlain by the sedimentary Permian Back Creek Formation (largely quarzose sandstones). Millaroo fault zone and Collinsville fault define the western and eastern margins of the valley (respectively). | Broad valley of the Bowen River, with valley margins dissected by tributary watercourses. Corridor skirts the western margins of the Collinsville open cut coal mine | Shallow Sodosols on margins of Clarke Range, with Rudosols on ridges, crests and adjacent to rock outcrops. Shallow sands and sandy loams extending west of Collinsville partially removed by Collinsville Mine. Deep Vertosols on broad valley floor, with deep Red Chromosols on terraces adjacent to Bowen River |
| Leichhardt Range Foothills | 103000 | 125000 | Sedimentary Back Creek Formation | Corridor skirts along the alluvial and colluvial footslopes of the Leichhardt Range | Gravel-strewn Sodosols |
| Leichhardt Range | 125000 | 200000 | Carboniferous and Permian intermediate to felsic intrusives (largely granites and granodiorites), with rhyolites and dacites of the Bulgonunna Volcanic Group | Corridor winds through the steeply undulating, dissected hills of the Leichhardt Range, which rises to over 500mAHD in places | Red and Yellow Kandosols. Rudosols on upper slopes, Tenosols on lower slopes and Chromosols/Sodosols on alluvial fans and undulating lowlands. Vertosols and Sodosols associated with Tertiary colluvial clays and Quaternary alluvium, with Chromosols on upper slopes. |
| Suttor River Valley | 200000 | 232000 | Tertiary and Quaternary colluvial and alluvial fan deposits | Colluvial slopes, alluvial fans and plains along the margins of the Leichhardt Range, falling to the broad valley bottom of the multi-thread Suttor River and its tributaries | Vertosols (with some Sodosols) along valley bottom adjacent to watercourses. Sodosols and Chromosols on undulating lowlands. Rudosols with Kandosols at higher elevations and adjacent to rocky outcrops. |
| Anakie Inlier | 232000 | 256000 | Metasediments (schist and phyllite) of the Anakie Metamorphic Group, with associated colluvial and alluvial deposits | Undulating slopes, dissected by tributaries of the Suttor River, rising to rounded hills over 350mAHD high | Vertosols and Sodosols in valleys, with Chromosols on upper slopes and Rudosols (with Kandosols) at higher elevations and adjacent to rocky outcrops. |

| Physiographic Area | MP_From | MP_To | Geology | Landform | Soils |
|---|---|---|---|---|---|
| Mistake Creek Valley | 256000 | 329000 | Folded and faulted sediments of the Drummond Group, overlain by Tertiary laterised sandstone, and Tertiary and Quaternary colluvial and alluvial deposits | Broad valley of Mistake Creek, sloping gently to the northwest, with occasional hills associated with resistant sandstone outcrops, rising to 250m-300mAHD | Kandosols associated with fringes of Akakie Inlier. Vertosols along valley bottoms, with Sodosols more common on deposits associated with the Drummond Group sedimentary rocks. Tenosols on slope aprons. |
| Sandstone Uplands 329000 | | 360000 | Folded and faulted sediments of the early Carboniferous Drummond Group, overlain by Tertiary laterised sandstone, and Tertiary and Quaternary colluvial and alluvial deposits | Structurally controlled uplands, with higher elevation areas corresponding to anticlinal uplift and upthrow side of faults. Corridor passes between the steep, undulating Mt Donnybrook (an anticlinal hill rising to over 500mAHD) and a subsidiary hill (the Nunnery? Over 350mAHD) | Sodosols associated with lower elevation colluvium and residual soils, Kandosols on higher elevation slopes, with Sodosols (possibly Vertosols) on saddle between Drummond Group anticlinal hills. |
| Belyando River | 360000 | 407000 | Colluvial deposits on hillsides, alluvial deposits in broad valley bottom. Occasional Carboniferous Drummond Group and Tertiary sedimentary rock outcrops | Corridor traverses side-slopes and tributary watercourses of Belyando River Valley, crossing the Belyando River at around 300mAHD | Sodosols on footslopes/lower alluvial fans of valley, Chromosols on upper alluvial fans, with Kandosols along higher elevation tributary valleys. Vertosols associated with tributary watercourses and along margins (backplains) of valley bottom. Tenosols along Belyando River and Sandy Creek valley bottoms. |
| Sedimentary Cuesta Uplands | 407000 | 445000 | Gently dipping Carboniferous/Permian sandstone sequences overlain by thin Tertiary sandstone. Corridor traverses along Colinlea Sandstone (a coal-bearing formation), underlain by the JoeJoe Formation | Corridor traverses along the dip-slope of a north-south-trending cuesta separated from the Great Dividing Range by the broad Lagoon Creek valley (with isolated hills rising to 350m-400mAHD adjacent to the corridor) | Red and Yellow Kandosols, with Chromosols on alluvial fans, Sodosols (and some Vertosols) associated with drainage depressions and Rudosols associated with higher elevation areas and adjacent to rocky outcrops |
| Lagoon Creek Valley | 445000 | 452941 | Thin Tertiary Sandstone and Tertiary/Quaternary colluvium overlying gently dipping sedimentary sequences. Quaternary alluvium along the Lagoon Creek valley bottom | Corridor drops gently down the lower dip-slope of the cuesta into the Lagoon Creek valley | Chromosols along lower slopes of cuesta, with Vertosols in low lying depressions close to Lagoon Creek, and Kandosols adjacent to the creek |

A breakdown of the characteristics of specific soil or land management units is included in Appendix B: Soil and Land Management Unit Characteristics. These units and their characteristics have been taken from existing soils, land management or land suitability studies (the method of assessment is explained in more detail in Appendix A: Method of Study). Characteristics include information on the following:

- Soil type, including soil assemblages and associated soils;
- Coffey's preliminary interpretation of soil order according to the ASC classification (Isbell, 2002);
- Typical landform;
- Soil characteristics that affect susceptibility to water erosion and wind erosion, and a susceptibility ranking, according to soil type and characteristics (the rationale for each classification is provided in Appendix B)
- Agricultural Land Class, used to define Good Quality Agricultural Land (GQAL);
- Land suitability limitations;
- Intended post-project land use, with soils or land management units assigned one of the following land uses according to the agricultural land use class, the published soil properties of that unit and the apparent land use (assessed from aerial photographs as well as information from the relevant soils or land systems manual) (with further details provided in Appendix B):
  - Unsuitable for agricultural use due to catchment values
  - Forestry or wildlife conservation areas
  - Low intensity grazing on native pasture
  - Grazing on native pastures with potential for some improvement
  - Limited improved pasture
  - Improved pasture
  - Sugar cane, rice, grain cropping possible, but better suited to improved pasture
  - Limited cropland requiring considerable improvement
  - Majority of locally grown crops
  - Sugar cane, grain and small crops
- Land suitability classification for the given land use (as per DME, 1995 guidelines).

# 3 PROJECT IMPACTS ON AGRICULTURAL LAND

The project will include activities which may impact the geology, landform and soils of study area. In particular, the potential impacts of the project on agricultural land and land identified as Good Quality Agricultural Land (GQAL) and Strategic Cropping Land (SCL).

This section provides responses to the following questions (the distribution and type of soils within the study area is discussed further in Section 2):

| Ref. | Submitter | Submission Issue |
|---|---|---|
| f 4104 p108 | DERM/DEHP | Mine site: the EIS does not adequately address soils and land suitability assessment requirements. The Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995) indicate that non-disturbance areas should be mapped at 1:250,000, with mine-disturbed areas mapped at 1:5,000.<br>Soil investigation of the entire mining lease area should be conducted at 1:100,000, with 25% of sites described in detail, as per Australian Soil and Land Survey Handbook (National Committee on Soil and Terrain, 2009) guidelines. |
| f 4105 p109 | DERM/DEHP | Rail: The soil and land suitability assessment has not been conducted to an acceptable level of detail.<br>A soil and land suitability assessment should be provided in accordance with Soil Survey Methodology along Linear Features (DERM, draft working document, 2011), supplementing the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995). |
| f 4100 p104 | DEEDI | The EIS does not adequately address the impacts on agricultural land use and good quality agricultural land, and relies on broad statements regarding potential impacts<br>There are numerous grazing properties with improved pastures adjoining the lease areas. It is recommended that further information is provided regarding the specific impacts of the project on adjoining landowners and associated agricultural activities.<br>A number of research programs assessing grazing productivity/activity in the Desert Uplands have been undertaken, including research on properties in the vicinity of the proposed mine site. It is recommended that the proponents provide additional information on the likely impact of the project on agricultural research programs in the area, particularly the impact of the project on long term data sets/monitoring relevant to grazing research.<br>The proponents are advised to contact DEEDI in relation to this matter.<br>Measures to mitigate adverse impacts to adjoining grazing properties resulting from the development should be included. |
| f 4101 p105 | DEEDI | The rail line has the potential to destroy the value and productivity of good quality grazing and farming lands. The proposed rail corridor has greater potential to destroy ‘good’ quality agricultural land than the mine development.<br>The impact of the rail line/s on the productivity and operation of agricultural properties must be considered cumulatively with the mine development impact. |
| f 4013 p107 | DEEDI | The EIS acknowledges the sterilisation of agricultural land, including potential Class A land between KP25-KP85 and KP322-KP355<br>Further information should be provided on impacts that the development of the railway will have on landholders and agricultural activities that are occurring during all stages of the project. |
| p 4054 p55 | DERM/DEHP | The EM plan does not provide sufficient detail regarding the management and rehabilitation of subsidence. Subsidence management and rehabilitation should be discussed in the SEIS and EM plan |

| Ref. | Submitter | Submission Issue |
|---|---|---|
| p 4053 p54 | DERM/DEHP | The EM plan only provides general post-mining land uses. The plan does not provide an indication of what 'grazing at low stock rates' is or justification that a tailings dam can be rehabilitated to this use. The EM plan lists 'native bushland' as the post-mining land use for several mining activities, but does not list post-mining land uses associated with areas of subsidence.<br>The EIS should provide an EM plan developed with consideration of the departmental guideline 'Rehabilitation requirements for mining projects' (DME, 1995), covering all domains on the mine site. The proposed post-mining land use must be clearly specified |

## 3.1 GQAL in the Study Area

Figures 2.4 and 2.6 Plans 1 to 8 show the distribution of different agricultural land class (GQAL) areas within the mine site and study area.

The mine site study area is characterised by Class C land: i.e., suitable for improved or native pastures. The CWR GQAL mapping was used for preliminary GQAL mapping. This assigns a GQAL class to soils/land systems units from the ZCQ (Gunn *et al*., 1967), ZEB (Isbell and Murtha, 1970) and BER (Aldrick, 1988) mapping. However, on occasion, Coffey suggests that the class is downgraded, as the described limitations are considered too severe to warrant a higher classification. For example, some Vertosols along the rail corridor have been classified as Agricultural Land Class A. However, they are typically described as being severely limited by lack of rainfall, high evaporation and low availability of suitable irrigation water. These soils are generally currently used for beef cattle grazing, rather than cropland. Coffey, therefore, considers it more realistic to define these areas as Class B (or lower). Coffey assigned GQAL classes to the DUSLARA (Lorimer, 2005) mapping based on the published soil and land use information. These tentative re-classifications will be investigated during the proposed soil investigation.

As an example, Unit GG6, in the ZEB study is defined as Class A in the CWR GQAL mapping, but this is a sodic duplex soil described as having very low fertility, is intermittently flooded, prone to waterlogging and with such dense clay subsoils that plant rooting is compromised. Coffey suggests that this unit is probably better suited for improved pasture with intensive management, and it has been reclassified as Class C1.

Coffey's preliminary assessment has indicated that there is no GQAL within the mine site, and the rail alignment runs through approximately 21 km of Class A or B agricultural land (just under 5% of the length), at the following MPs:

- Class A GQAL, between MPs 0-600, 870-2490, 2610-2900, 3270-3580 and 15480-15890.
- Class B GQAL between MPs 8500-9000, 10250-11100, 12730-13370,16560-16770, 17650-18020, 18400-18660, 18840-19060, 19810-20000, 20400-20600, 97680-103300, 228550-230420, 261830-263240 and 263240-268670.

These soils are predominantly Vertosols or Sodosols within the Coastal Zone, Bowen River Valley and Suttor River Valley, where rainfall quantities are typically sufficient to sustain productive cropland.

## 3.2 Strategic Cropping Land in the Study Area

DERM's (2010) Strategic Cropping Land (SCL) trigger mapping indicates that the distribution of SCL is broadly similar to GQAL Class A land. There is no SCL within the mine site, and the rail corridor intercepts SCL for about 2.5km (about 0.5% of its length) at the following MPs (shown in Figure 2.6, Plans 1-8):

- MPs 0-480, 10250-10400, 16600-16700, 85470-87120

As with published areas of GQAL and given the apparent limitations of soils within the study area, Coffey intends to observe the characteristics of soils within SCL areas in the field, to help evaluate whether these areas are suitable for cropping.

## 3.3 Land Suitability in the Study Area

The land suitability of the study area has been classified in accordance with DME (1995). This requires a suitable intended land use to be identified, then allocated a suitability ranking for that particular land use. Coffey has assigned a preliminary land use for each soil or land management unit within the study area using the available published maps covering the study area based on the agricultural land use class, the published soil properties of that unit and the apparent land use (assessed from aerial photographs and information from the relevant soils or land systems manual). A preliminary land suitability class for the intended land use was then assigned, based on published information regarding land use limitations, soil characteristics and land suitability (if available).

In some cases, as with GQAL classes, suitable land uses and the published land suitability class appeared to be ambitious given the associated soils, landform and limitations. For example, valley bottom land within the Bowen River Valley, to the west of Collinsville, is mapped as being suitable for irrigation cropping. However, areas are typically fragmented (which is not considered during published soil type-based classification) and do not appear to have previously been used for cropping. Coffey, therefore, considers that rainfall and soil limitations are such that a more pragmatic post-project land use would be improved pasture. An exception to this is within the Coastal Zone, where rainfall quantities are higher and less variable, making cropping a more realistic outcome.

As an indication, published grazing densities for the bioregion that includes the mine site indicates variable stocking rates averaging about 20 head of cattle per square mile (about 8 per 100 ha; Gunn *et al*., 1967), although slightly higher stock levels of between 8 and 16 head per 100 ha have been recommended for mine sites in central Queensland (Grigg, 2000; Grigg, *et al*., 2000).

Broad indicative intended land uses and land suitability classes for each mapped unit have been listed in Appendix B and mapped in Figure 2.5 and 2.6 Plans 1 to 8. These preliminary classifications will be investigated during the proposed soil investigation, and more specific information will be provided regarding the intended land use.

## 3.4 Potential Impacts of Mine Activities on Agricultural Land Use

The mine site does not contain GQAL or SCL. This section, therefore, assesses the potential impacts of the mine on grazing.

### 3.4.1 Potentially Impacting Mine Site Activities

Table 3.1 provides a sample of the intended format summarising potentially impacting project activities (descriptions taken from Galilee Coal Project EIS Volume 2, Chapter 1: Mine Project Description); together with the potential impacts of these activities on the geology, landforms and soils of the mine site; and recommendations for management and mitigation measures. As indicated in the table, it is intended that this impact assessment will be completed following the proposed fieldwork, once the preliminary mapping has been checked in the field. As per DEEDI's recommendation, Coffey intends to further investigate the potential impacts of the project on adjacent properties and research programmes during this stage of the project.

**Table 3.1 Summary of Potential Impacts of Mine Site Activities and Associated Management Measures**

| Mine Component | Potentially Impacting Activities | Potential Impacts on Land Use within Mine Site and Adjacent Property | Recommended Management and Mitigation Measures |
|---|---|---|---|
| Open Cut Mining | Removal of up to 100 m of deep Tertiary/Quaternary sediments, with total waste thickness of up to 120 m. The total open cut mine area is anticipated to be 7,451 ha. Some blasting of the deeper coal-bearing rock is likely to be required. | Rock stress release and slope failure, particularly in relatively weak overburden exacerbated by longwall subsidence (valley closure and upsidence) impacts.<br>The open cut boundary is along northern border of mine site, so there is potential for failures to extend into adjacent property. | Appropriate geotechnical design of the pits will reduce the likelihood of pit wall failure and impacts beyond the component footprint. |
| | | Significant, permanent landform modification, with excavations up to 120 m deep. | Management measures to mitigate the assessed potential impacts will be provided (as per the example given above) on completion of the proposed soils investigation. |
| | | Land degradation:<br>Dust from disturbance and blasting<br>Water erosion along the pit walls headcutting beyond the footprint, into adjacent properties, particularly as soils are likely to be sodic, dispersive and highly erodible. | |
| Underground Mining | Assessment of potentially impacting activities relating to the listed project components (as a minimum) will be provided (as per the example given above) on completion of the proposed soils investigation. | Assessment of potential impacts resulting from the assessed project activities will be provided (as per the example given above) on completion of the proposed soils investigation. | |
| Tallarenha Creek (Monklands) Dam | | | |
| Up to 5 dirty water dams for storage of mine dewatering water. | | | |
| Tallarenha/ Lagoon Creek Diversion | | | |
| Rejects and tailings disposal | | | |
| Power and telecommunication lines | | | |
| Infrastructure | | | |
| Decommissioning | | | |

### 3.4.2 Potential Subsidence Impacts

Surface impacts of longwall mining occur as the void created by coal extraction is allowed to collapse causing a subsidence trough to form. A rapid rate of coal extraction (with the longwall advancing at around 100 m per week) can result in a surface subsidence trough being extended at a similar rate. Subsidence can be expected to develop progressively with the extension of collapse, where roof material is allowed to fail behind workings, forming an uncontrolled, part-infilled 'goaf'. This prevents sudden, widespread failure'. Typically, the greatest surface impacts are experienced during development of the subsidence trough (Mine Subsidence Engineering Consultants (MSEC), 2007a). At this point, the strain on surface materials located on the fringes of the trough is at a maximum, since the newly created slopes are at their maximum curvature. Materials are initially subject to tensile strain as the subsidence wave moves through. Then, as it passes, the ground is subjected to compressive strain. The maximum extent of subsidence effects are typically contained within an area extending between 10° and 40° (from the vertical) beyond the longwall edge, generally referred to as the 'angle of draw' (Sydney Catchment Authority (SCA), 2007). Where local conditions are not well known, an angle of draw of 26.5° is typically used in areas of near-horizontal strata (MSEC, 2007a). Impacts outside the angle of draw (far-field impacts) have been recorded, particularly since the advent of accurate remote monitoring (SCA, 2007; Mills, 2011).

The amount of subsidence that results from longwall mining depends upon the width of a longwall panel (in this case, about 470 m wide), the depth at which mining takes place (up to 330 m deep in the D (Lower) Seam), the height of the worked coal seam (1 m – 6 m) and a variety of geotechnical factors. 80% of subsidence usually occurs within 2 months following mining (SCA, 2007; TEC, 2007), with very little subsidence occurring after a year (Hinchcliffe, 2003).

The mitigation or repair of subsided land adversely affected by coal mine subsidence usually consists of creating drainage channels, adding fill, recontouring the landscape, or pumping accumulated water (Hinchcilffe, 2003; IAO, 2011).

Information regarding the potential impacts and proposed management and mitigation measures is provided in Volume 2 – Appendices of this Supplementary Environmental Impact Statement. The likely specific subsidence impacts on the landforms and soils of the mine site will be assessed following the soils investigation and subsidence assessment proposed for subsequent phases of the project.

## 3.5 GQAL and SCL along the Rail Corridor

### 3.5.1 Potential Impacts of the Rail Corridor on GQAL and SCL

The rail corridor currently intercepts small areas of GQAL and Strategic Cropping Land (SCL). Just under 5% (21 km) of the rail corridor runs through land classified as GQAL and 0.5 % (2.5 km) classified as SCL.

This study has identified the following potential impacts:

**Loss of GQAL and Strategic Cropping Land**

Construction of the rail corridor may remove areas of GQAL and SCL temporarily and, in some instances, permanently from agricultural production. The construction phase disturbance footprint will be greater than the footprint required for infrastructure once operational.

**Fragmentation of GQAL and Strategic Cropping Land**

Construction of linear infrastructure can fragment agriculturally productive soils characteristic of GQAL or Strategic Cropping Land.

**Negative Changes to Physical and Chemical Properties of GQAL**

Compaction of clay soils can significantly impact long-term crop productivity. Topsoil disturbance during construction (i.e. through excavation, erosion or trafficking) may result in a long-term reduction in fertility levels within footprint areas, if effective management and rehabilitation measures are not successfully implemented. Soil properties of identified areas of GQAL and SCL will be assessed during the proposed soil investigation, to better assess potential impacts.

**Impeding Surface Flow of Irrigation Water on Levelled Paddocks**

Often cropping land is laser levelled to provide efficient flood irrigation relying on the gravitational flow of surface water. However, Coffey's preliminary study has not indicated that this will be an issue within the rail corridor, as the areas of GQAL do not appear to be improved in such a manner.

Potential impacts to GQAL and SCL specific to the different phases of the project will be assessed following completion of the proposed soil investigation, when more specific information regarding soil properties and characteristics has been collected.

**Protection of GQAL and Strategic Cropping Land along the Rail Corridor**

GQAL and Strategic Cropping Land should be managed by following the management recommendations below:

- Avoid fragmentation of running through cultivated paddocks, GQAL or Strategic Cropping Land.
- Excessive watering should be avoided to reduce leaching, rising groundwater and saline soils. Vertosols, in particular, have good water-holding properties. Hard-setting and surface-crusting soils should not be spray-irrigated to avoid exacerbating crust formation (Harris et al., 1999).
- Treated water should only be used if the water quality is comparable to that of typical irrigation water used in the locality.
- Existing access tracks should be used where possible. Where this is not possible, efforts should be made to reduce the impact of infrastructure and trafficking on paddocks and farming patterns e.g. running roads parallel to farming patterns.
- Any new or existing access tracks should be well-defined and construction traffic should remain within these boundaries.
- Temporary access tracks should be removed when no longer necessary, unless otherwise agreed with the landholder.
- Ground levels should be returned to pre-construction levels during rehabilitation, to avoid negative impacts on irrigation or concentration of drainage.
- Specialised backfilling techniques that incorporate specific compaction requirements over the full backfill profile maybe required.
- Rehabilitation should be sympathetic with the surrounding pre-disturbed land-use.
- Provision for ongoing maintenance programmes may be required to treat areas of differential settlement associated with buried infrastructure that interrupt the pre-existing surface water flow within intensively cultivated areas.

# 4 PRELIMINARY TOPSOIL MANAGEMENT AND MITIGATION RECOMMENDATIONS

This section provides management recommendations topsoil management. These recommendations provide a response to the following question:

| Ref. | Submitter | Submission Issue |
|---|---|---|
| f 4051 p52 | DERM/DEHP | The EM plan does not provide sufficient detail regarding the management of topsoil for the project to ensure rehabilitation requirements are met<br>Topsoil management measures should be discussed in the SEIS and EM plan |

## 4.1 Preliminary Topsoil Management Recommendations

The following section provides preliminary recommendations for management of soil to enable conservation of pre-disturbance characteristics, soil quality and to enhance rehabilitation potential.

### 4.1.1 Topsoil Stripping Management

Where possible, soil should be stripped in areas where disturbance is planned to provide material for rehabilitation. Prior to disturbance, the following management measures should be implemented:

- Quantify soil type, depth and resources.
- Establish handling best-practices suitable for the specific site conditions.
- Characterise the suitability of soil resources for rehabilitation works.
- Formulate project-specific stripping guidelines, including the nomination of appropriate depths, scheduling and location of areas to be stripped.

During soil stripping, the following management measures should be implemented to reduce degradation of soil structure:

- Restrict vehicular traffic to designated access tracks in areas where soils are to be stripped, where practicable.
- Traffic should also be excluded from soils that are sensitive to structural degradation and restricted to designated access tracks, where practicable.
- Reduce vegetation clearance.
- Use loaders and trucks, rather than scrapers, to reduce soil structure degradation.
- Stockpiling of soils in a manner that does not compromise the long-term viability of the soil resource, as discussed below.

### 4.1.2 Topsoil and Spoil Storage

During the project, soil will require short to long-term storage for use in later rehabilitation activities. Soils should be stockpiled in a manner that aids long-term viability of the soil resource, as follows:

- Project component-specific stockpile locations should be designated as beyond the boundaries of work areas. These areas should be clearly marked.
- Stockpiles should be located away from watercourses and drainage lines (IECA, 2008). They should not be located in areas which may dissect ecosystem corridors or damage adjacent vegetation.
- Natural soil, earthworks and sediment trap spoil should each be stored in separate stockpiles throughout the project according to soil type and salinity levels (IECA, 2008).

- Stockpiles should be generally no more than 2 m high, in order to reduce problems associated with anaerobic conditions and poor nutrient cycling (Victoria Department of Primary Industries (VDPI), 2004). Stockpiles that are anticipated to be *in situ* for several years require intensive management to avoid loss of fertility.
- Where long-term soil storage stockpiles are required, stockpiles should be fertilised and seeded to maintain soil structure, organic matter and microbial activity.
- Stockpiles should be constructed with a 'rough' surface to reduce erosion hazard, improve drainage and promote revegetation.
- Sediment control measures should be implemented, such as the installation of silt fences or bunds around stockpiles to control potential loss of stockpiled soil through erosion prior to vegetative stabilisation. Stockpiles containing contaminated or saline soils may require covering with suitable materials.
- Stockpiles should be deep-ripped to create aerobic conditions prior to reapplication of the stockpiled soil during rehabilitation.
- Where necessary, dispersive soil stockpiles may require specific treatment (e.g., addition of organic material or gypsum).

#### 4.1.3 Indicative Soil Stripping Depths

Viable topsoil is one of the most important factors in successful rehabilitation. Ideally, soils from stripped areas should be preserved for use in rehabilitation. The suitability of topsoil for rehabilitation purposes varies with physical and chemical properties. The use of unsuitable topsoil can reduce rehabilitation success and increase environmental degradation.

Topsoil resources are mainly confined to the near-surface A horizon materials and the upper part of the subsurface horizon. Subsoil is generally not suitable for use as topsoil. However in areas where stripping occurs, subsoil should be retained for use in reprofiling the soil. Topsoil and subsoil should be stored separately, as discussed above.

The Queensland Department of Transport and Main Roads Specification for Landscape and Revegetation (2011) has been used to rate soil suitability for rehabilitation, which indicates the following:

- Any soil material from sand to light clay is suitable, although amelioration may be required.
- Soils of medium to heavy clay texture are generally not suitable as they are too coarsely structured to maintain soil/seed contact, are very hard when dry and have low permeability. This can restrict vegetation re-establishment.

Indicative topsoil stripping depths for different soils will be provided following completion of the soils investigation.

# 5 POST-MINING REHABILITATION RECOMMENDATIONS

This section provides responses to the following questions:

| Ref. | Submitter | Submission Issue |
|---|---|---|
| f 4093 p97 | Barcaldine Regional Council | Soil dumps have a maximum height of 40 m above ground level.<br>Advise on the way in which impacts and final landforms will be managed |
| f 4094 p98 | Barcaldine Regional Council | Mitigation measures to manage post-mining topography and landscape are not described.<br>Details of mitigation measures for post-mining landforms are required |
| p 4040 p41 | Capricorn Conservation Council | Little evidence and research into restoration of mine-disturbed land in QLD to 'stable and non-polluting condition'.<br>Evidence of successful rehabilitation of open-cut mines should be evaluated and presented for peer review |
| p 4012 p106 | DEEDI | Rehabilitation methods for agricultural land need to be well defined, planned from the start, and implemented at all phases of the mining process to have any chance of success.<br>If land is to return, or maintain, some value for agriculture, a rehabilitation program must be developed, process and milestones clearly identified and the program followed/enforced explicitly.<br>The project proponents are advised to consult with local farmers and graziers in order to understand and deliver the best long term outcomes for agriculture in the region – including maximising rehabilitation success |

## 5.1 Open Cut Mine Rehabilitation Literature Review

There is a substantial body of literature discussing open cut mine rehabilitation best practice and case studies: government and academic groups that study this topic alone exist, including the Australian Coal Industry Research Program, and the University of Queensland's Queensland and New South Wales Coal Mine Rehabilitation Research Database. Coffey has reviewed a select number of available reports and articles to gain a focussed understanding of key suitable and unsuitable rehabilitation measures. Following our soils investigation, further specific reviews can be provided, if required.

It is critical to establish the post-mining land use during the early stages of the project, because of the necessity to incorporate this information into mine planning (Department of the Environment (DoE), 1998, Victoria Department of Primary Industries (VDPI), 2004). Plans should consider legal, climatic, topographic, soil type and distribution (including appropriate topsoil stripping depths), erosion control measures and community views. In general, the final land use should mimic the pre-mining use as closely as is practicable, to avoid permanent change of habitat, infrastructure or land-use practices. However, changes to post-mining land use may sometimes be more practical and beneficial to the local community, e.g., converting marginal, exhausted or degraded agricultural land to enhanced woodland or wetland habitat. In central Queensland, the majority of post-mining land use has historically been improved pasture (Grigg *et al.,* 2000), but the sown grasses have appreciably different characteristics from the pre-mining and remaining vegetation. Often surface stability concerns override pasture usefulness, for good reason, as the significant limitations can rapidly result in overgrazing and erosion. Stocking rates of between 10 and 16 head of cattle per 100 ha are considered realistic for remediated mine sites (Grigg, 2000; Grigg *et al.,* 2000).

Plans which take a whole-of-mine approach should be adopted to avoid piecemeal, inconsistent progressive rehabilitation (DoE, 1998, VDPI, 2004). Slopes should be designed with suitable gradients, profiles (typically convex-concave) and vegetation density to limit erosion. Landforms should blend into the surrounding landscape as far as is practicable (e.g., rounded, rather than angular, breaks in slope)

(DoE, 1998; VDPI, 2004). Long slopes should be avoided (typically no greater than 50m (DoE, 1998)), through construction of benches and contour banks, to reduce runoff reaching erosive velocities. Often, drainage outlet points will be required, rather than allowing the water to find its own way downslope. In general, revegetation is more successful and erosion can be effectively reduced on slopes of 10° or below. If steep slopes are unavoidable, management measures such as placement of hay mulch or creation of a rough surface (through e.g., placement of rock armouring) should be used. Basin listing (which uses tynes that lift and rip, rather than just using standard deep ripping practices) has been reported as successful at the Gregory Mine, near Emerald, to create erosion-limiting microtopography, rather than continuous rip lines (DoE, 1998).

Care should be taken that designed landforms are constructed as planned during mine closure (DoE, 1998). This is particularly important on higher value agricultural land. Spoil or waste rock dumps should be located away from other potential mine sites, to avoid sterilising those sites for future use, or necessitating double handling of waste. Where the pit cannot be filled, and a final void is unavoidable, beneficial uses and safety should be considered. Measures that should be considered include (DoE, 1998; VDPI, 2004):

- Benching or slope angle reduction of pit walls.
- Covering exposed coal or ore (in the former case, to help prevent ignition).
- Permanent bunds, ditches or other structures to reduce vehicle or pedestrian access (a practice that should also be adopted for underground mines).
- Construction of a sump in bedrock at the base of the void to collect drainage.
- Diversion of drainage away from the void to reduce the likelihood of flooding, unless the final landform design involves creation of a waterbody. In the latter case, consideration should be given to the feasibility of maintaining good water quality.
- Appropriate revegetation to reduce erosion and to enhance visual amenity.

In general, areas of the site subject to long-term heavy vehicle trafficking will require deep ripping to loosen the soil and provide conditions for viable revegetation (DoE, 1998). At sites where topsoil is in short supply, preference should be given to placing this material in areas which are prone to erosion, such as new watercourses or areas that require rapid or dense vegetation coverage. In addition, the predominance of sodic, saline soils within the central Queensland region may require covering with good quality topsoil for successful revegetation (Grigg *et al.,* 2000). The addition of gypsum to these soils promotes soil structure improvements and reduces erodibility, but has not been demonstrated to improve revegetation and can increase salinity. At the Goonyella Riverside Mine, central Queensland, the application of organic mulch was found to be appreciably more successful, reducing surface crusting and improving moisture retention (Highbeam Research, 2006). This study found that the best results were obtained when straw or sawdust was incorporated into the soil to a depth of 0.15m, at rates of 20 t/ha and 80 t/ha respectively. Similar results have been obtained during progressive rehabilitation at the Sarsfield Gold Mine, near Ravenswood, Queensland.

Often, topsoil is stockpiled for long periods of time, and nutrients are leached, weeds become established and microbial activity ceases. In these cases, this material may only be suitable for use as fill. Importing topsoil is not recommended to reduce the spread of weeds and diseases (VDPI, 2004). At the Nabarlek Mine, Northern Territory, surface material from the waste rock dump (which had become colonised by native vegetation) was found to be a better final cover (DoE, 1998). However, Grigg *et al*. (2000) note that waste and spoil material from mines in Central Queensland is often severely deficient in Nitrogen and Phosphorous (as are the natural soils (Highbeam Research, 2006)), and may require addition of fertiliser. Certain grass types can improve nitrogen deficiencies. Phosphorous can decline rapidly after application, and may require multiple re-applications.

Topsoil should only be placed just prior to revegetation to avoid creating long-term bare, erodible surfaces (DoE, 1998). Runoff and sediment schemes should be in place during this phase, to reduce down-system contamination with eroded sediment. Sowing or planting should be carried out when weather conditions are favourable. Mulch can be used to add organic content to the topsoil, retain moisture and reduce surface erosion.

Sown pasture within rehabilitated mines is often left ungrazed and may accumulate large volumes of dry matter, which limits pasture growth and can provide little protection against rill erosion (which occurs beneath the dry matter) (Grigg *et al*., 2000). It is recommended that erosion-prone soils are left ungrazed for 4-5 years, and then lightly grazed to reduce build-up of unsuitable dry matter, promote nutrient recycling and promote new growth and spread of pasture species. If possible, undisturbed adjacent land (whether grazed, woodland or other) should be used as a reference when monitoring the rehabilitated area, a practice used successfully at the Xstrata Mine, New South Wales (NSW Minerals Council, 2006). Appropriate pasture management with input from local landowners is frequently the key to successful rehabilitation in central Queensland (Grigg, 2000; Grigg *et al.,* 2000).

## 5.2 Recommendations for Mine Site Rehabilitation

A Mine Closure Plan should be designed and implemented in accordance with current legislative requirements, including current licence conditions (particularly the *Environmental Protection Act*, 1994), and taking experiences from similar mine sites (as reviewed in Section 5.1) into consideration.

Following decommissioning of the project components, rehabilitation should be carried out where practicable, as follows:

### 5.2.1 Landform Rehabilitation

- Surface structures should be removed from the site.
- Where practicable (i.e., for small-scale activities) the land surface should be replaced to pre-construction levels. Mounding of soils to allow for settling may be required in some areas.
- Drainage lines and densities should be re-established, where practicable.
- Medium to long-term erosion control measures should be implemented.
- The area should be reprofiled to reduce future slope instability and erosion, and which does not require a greater level of maintenance than the pre-disturbance landscape. In general, batter slopes should not exceed 12°, unless the material is capable of safely sustaining higher slopes (DERM, 2011). Final void design should consider modelled valley closure and upsidence values.

### 5.2.2 Sustainable Land Use

- Post-mining land use of disturbed areas should be re-established to conditions with comparable management requirements of similarly-used non-mined land (DERM, 2011).
- Prior to reinstating soil profiles, the chemical properties of the topsoil, subsoil and waste stockpiles, and exposed surface soils should be tested. Appropriate ameliorants should be added, where necessary, to sustain the future proposed land use. Generalised acceptable soil chemistry properties have been defined in DERM (2011) as comprising:

  - 5 to 8.5 pH range;
  - Below 0.2 % chloride levels in saline areas (see Section 5.2.4: Rehabilitation of Saline Areas below);
  - Other chemical conditions as established by an assessment of local soil conditions (including the proposed soils investigation) and proposed future land use.
- Physical and biological soil properties should be restored to limits set from results of vegetation trials, regional studies or reference sites (DERM, 2011). Existing information regarding soil characteristics and rehabilitation at the site (e.g., this study; Golding 1999; URS, 2008) may be used to set these limits.

### 5.2.3 Soil Rehabilitation

- Imported material (e.g., rock track/road surfacing or sub-base) should be removed from the site, where practicable.
- In all locations, if practicable, soil should be replaced in the order in which it was excavated, soil profiles should be recreated and subsoil should not be present at the surface. Reference profiles should be established and used to aid this process. The physical and chemical properties of the site will be established during the proposed soils investigation
- Where topsoil is not locally available, intensive management of available subsoils should be implemented.
- Soils should be compacted or deep ripped to achieve pre-construction compaction levels, where possible.
- Where practicable, attempts should be made to reduce the degree of hardsetting of surface soils (particularly on reinstatement of clay-rich topsoils). Objectives should include increasing infiltration, organic content and moisture storage, and developing a more amenable environment for germination (Murphy *et al.,* 2007). This can be achieved by deep ripping and mulching, where necessary. Deep ripping of soils should only be attempted when they are neither too wet nor too dry, as this may induce compaction and resetting or dust creation respectively. Final surfaces should be moderately rough. Following rehabilitation, soils should be rested, and not used for heavy grazing until they have regained their structure (Grigg, 2000; Grigg *et al.,* 2000; Semple and Johnson, 2007).
- A planting and seeding plan should be established for re-establishment of vegetation, with stakeholder consultation. The planting plan should take into consideration the pH of the soils.

### 5.2.4 Rehabilitation of Saline Areas

Control of groundwater levels (which could cause soil salinity), through measures such as effective drainage of the waste and spoil heaps and reducing vegetation clearance in these areas, may prove more effective than the salinity management techniques discussed below.

- Saline soils are difficult to treat and thus have very poor rehabilitation potential. Rehabilitation measures include (DME, 1995b):
  - Retention or ponding of water on the surface to encourage leaching of the salts;
  - Establishment of deep-rooted, salt-tolerant vegetation.
- Saline soils should not generally be used as a surface cover or potential growth medium (DERM, 2011). However, in some cases, there may be no alternative but to accept saline material on the

surface of an area to be revegetated (DME, 1995b). In such cases, salt-tolerant, alkali-tolerant plants species can be established first, with more desirable, less-tolerant species established by subsequent planting and the application of organic matter to the surface.

## 5.3 Inspection, Monitoring and Maintenance Programme

Erosion is a natural process which is likely to occur throughout the life of the project. A baseline erosion monitoring program should be undertaken in the study area to establish pre-disturbance erosion rates. It is recommended that permanent 10 m x 20 m monitoring plots are established over a range of project activity areas, with reference sites designated in areas which will not be impacted by the project.

Disturbed and rehabilitated areas should be monitored regularly for both short and long-term adverse landform change, particularly in areas of intensive agriculture or areas which are particularly sensitive to erosion. Defects should be reported and remediated as soon as is practicable. Landform change can occur rapidly, especially during intense storms or prolonged rainfall. Inappropriate land management can also contribute to rapid change. Inspection of sensitive areas should be considered after each intense rainstorm. The monitoring inspection schedule should reflect the likely rate of change and the frequency of visits varied accordingly. Monitoring should also be carried out in accordance with the rehabilitation (warranty) period or at 3 monthly intervals for first year post construction and annually thereafter until rehabilitation is considered successful as per the established performance criteria. Site-specific assessments prior to commencement of tasks should indicate the frequency and timing of monitoring, if different from that stated.

Monitoring events should include:

- Location and type of erosion and slope instability (with photographic records of site visits).
- Soil tests (EC) in sensitive areas to assess operations-related salinity, in particular adjacent to waste and spoil heaps.
- Erosion rates.
- Effectiveness and integrity of erosion control measures.
- Runoff water quality.

Maintenance of defects observed during the monitoring should be routinely carried out, including:

- Repair of erosion control structures.
- Removal of sediment build-up behind erosion control measures involving damming of water, to maintain retention capacity.
- Reinstatement of eroded or unstable soil or landforms.
- Revegetation of areas where ground coverage is inadequate.

In addition to monitoring and maintenance, it is recommended that performance criteria are set to indicate successful rehabilitation. The main target should be to produce a stable, safe, non-polluting landform with self-sustaining soil fertility.

It is recommended that rehabilitation performance criteria should include:

- Creation of stable landforms which reduce erosion as far as is practicable. Erosion control measures must remain effective in the long-term.
- A safe landform which reduces the likelihood of accident and injury.

- A non-polluting environment which reduces suspended solids in runoff water to pre-disturbance levels, as far as is practicable.
- Self-sustaining soil fertility, such that nutrient cycling promotes consistent vegetation cover. The site should be self-sustaining for its designated land-use, as far as is practicable, with no management inputs required over and above those in adjacent undisturbed areas.
- Preservation of soil chemistry such that soil nutrient levels can support vegetation and pre-disturbance soil pH and EC levels can be achieved.

A holistic approach is recommended when defining and monitoring performance criteria within the context of this study. This will assist in the creation of a balanced rehabilitated landform and environment. The findings and recommendations of other specialist reports should also be considered.

Lessons learnt during initial phases of the project regarding the success of various erosion control measures should be assessed and incorporated into subsequent phases. This strategy should limit repetition of ineffective management and mitigation measures.

# 6 PROPOSED SOILS AND LAND SUITABILITY STUDY COMMITMENTS

This desktop soils and land suitability SEIS study has, by necessity, been required to make assumptions regarding the accuracy of published information. In addition, several scales of mapping have been used, some of which are not appropriate for the scale of the study. This report provides preliminary information upon which to base subsequent phases of work. The scope of these phases of work is discussed in Appendix A: Study Methodology.

This section summarises proposed commitments that will be met during subsequent phases of the study and Galilee Coal Project aimed at addressing questions (or elements of these questions) raised during government and public consultation that could not be answered during the desktop study (see Table 1.1), as follows:

- Provision of additional details regarding erodible and dispersive soils within the study area, including their characteristics and suitable landforms for identified soil types (Ref. 4099 and 4092);
- Soils investigation of the mine site and rail corridor, as per the scope set out in Appendix A: Study Methodology (Ref. 4104 and 4105).
- Provision of a geological map and cross-section of the mine site, showing the relationship between mine components and geological formations.
- The proposed soils investigation will include assessments of agricultural land within the mine site and areas classified as GQAL (Class A and B agricultural land) and SCL along the rail corridor. This information will then be used to assess potential impacts, including cumulative impacts, on these areas (Ref. 4100, 4101 and 4013).
- Potential impacts on properties adjoining the mine site will be further assessed once the soils investigation has been completed. It is intended that consultation with DEEDI regarding the research programmes near to the mine site will be carried out during this phase of the study (Ref. 4100).
- Following completion of the soils investigation, further information regarding topsoil management will be provided (Ref. 4051).
- Following completion of the soils investigation and subsidence assessment, further information will be provided regarding the likely impacts of subsidence on the soils and landforms of the mine site, and appropriate management and mitigation measures addressing these impacts (Ref. 4054).
- Following completion of the soils investigation, further information will be provided regarding impacts from and management of soil dumps and post-mining landforms (although this will be partially addressed by geotechnical investigations of the mine site during the design phase of the project) (Ref. 4093 and 4094).
- Following completion of the soils investigation, Coffey will provide further information regarding specific intended post-mining land uses and suitability (Ref. 4104, 4105 and 4053). If possible, it is intended that local landowners will be consulted, in order that their experiences can be taken into consideration, particularly regarding seasonal variability in rainfall, dry matter coverage and proven successful land use practices (e.g., grazing densities, removal of stock from pastures during dry months, pasture improvements and crop types) (Ref. 4053, 4012).

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## 7.5 GIS Metadata

| Information | Source | Date | Scale |
|---|---|---|---|
| Surface Geology | DEEDI's MERLIN Geological Database, with interpretation by Coffey from available 1:250,000 hard copy mapping and corresponding 1:100,000 digital maps | 2012 pre-release | 1:500,000<br>1:100,000 |
| Soils and Soils Assemblage Mapping[1] | Preliminary Australian Soil Classifications interpreted by Coffey from relevant DERM/DEHP Land Systems mapping | Various (see references for BER[2], CNM[2], DUSLARA, ZCI[2], ZCQ[2] and ZEB[2]) | BER and DUSLARA – 1:100,000<br>CNM – 1:250,000<br>ZCQ and ZEB – 1:500,000 |
| Agricultural Land Classification (GQAL) | Provided by Waratah Coal. Comprises GQAL interpretation of units from relevant Land Systems Map Units (BER, ZCQ and ZEB) | As per relevant Land Systems mapping | As per relevant Land Systems mapping |
| Strategic Cropping Land (SCL)[1] | Provided by Waratah Coal: DERM's 2011 Trigger Mapping | 2011 Un | known |
| Land Suitability | Interpreted by Coffey based on information in relevant reports | As per relevant Land Systems mapping | As per relevant Land Systems mapping |
| Mine Study Area | Digitised by Coffey based on extent of anticipated potential impacts | July 2012 | 1:100,000 |

| Information | Source | Date | Scale |
|---|---|---|---|
| Mine and Rail Components, | Supplied by Waratah Coal or downloaded from DERM/DEHP's QGIS website | July 2012 | 1:250,000 |
| Cadastre, Contours, Roads, Place Names and Watercourses[1, 3] | Provided by Waratah Coal or downloaded from DERM/DEHP's QGIS website | 2012 1 | :250,000 |
| Aerial Imagery | BingMaps | 2011 | Unknown |

1. Data supplied by DERM/DEHP is © State of Queensland (Department of Natural Resources and Mines). This data is based on or contains data provided by the State of Queensland (Department of Natural Resources and Mines) in July 2012. In consideration of the State permitting use of this data Coffey acknowledges and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.
2. Data for BER, CNM, ZCI, ZCQ and ZEB were supplied to Coffey by DERM/DEHP under Single Supply Licence SSL_2012_0715. DUSLARA data was supplied to Coffey by Waratah Coal.
3. Watercourses, roads, railways and place names were obtained from the DERM/DEHP QGIS website under Single Supply Open Licences.

# Figures

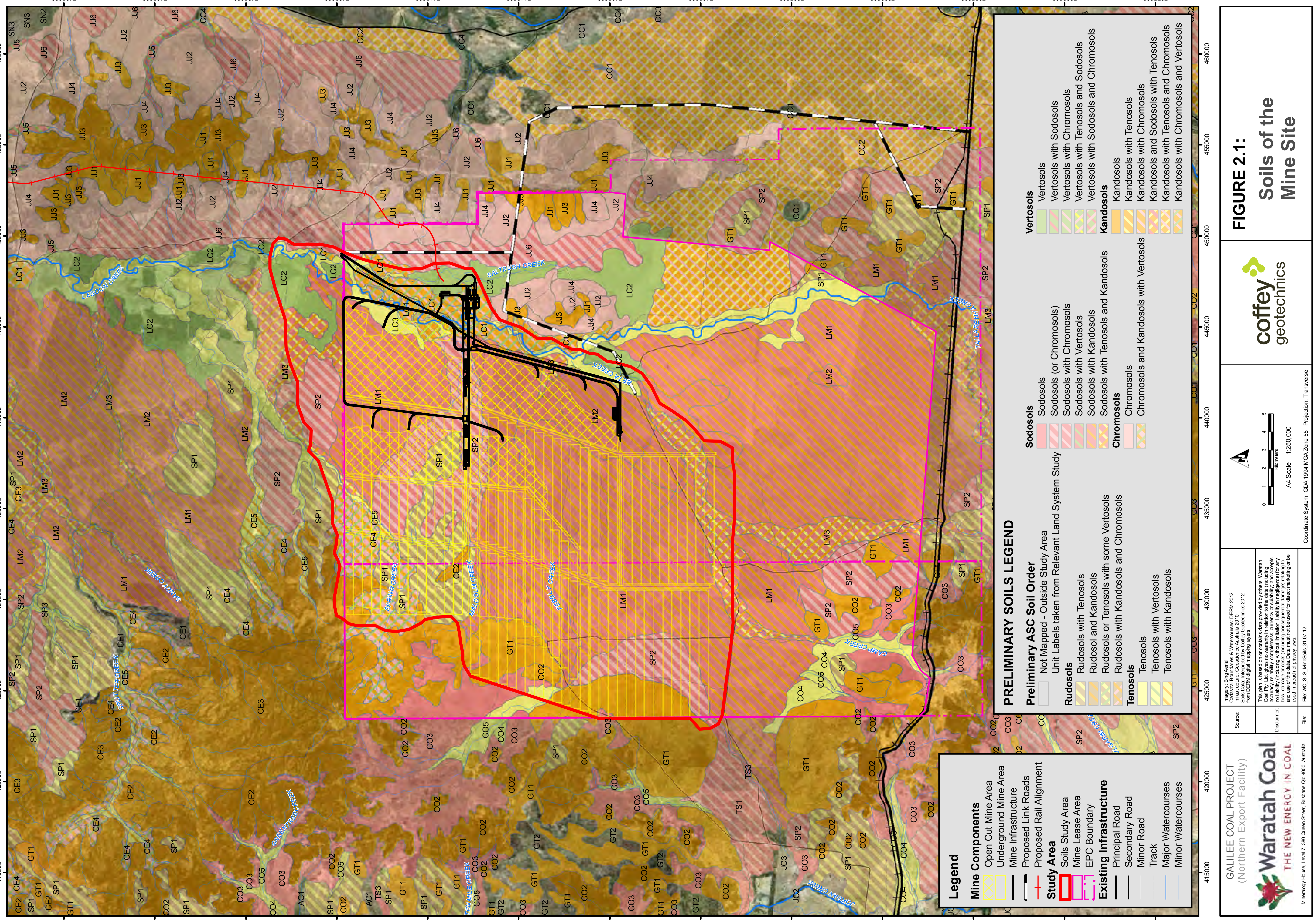


FIGURE 2.1:
Soils of the Mine Site
coffey geotechnics
Waratah Coal
THE NEW ENERGY IN COAL
GALILEE COAL PROJECT
(Northern Export Facility)
PRELIMINARY SOILS LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Mine Components
Open Cut Mine Area
Underground Mine Area
Mine Infrastructure
Proposed Link Roads
Proposed Rail Alignment
Study Area
Soils Study Area
Mine Lease Area
EPC Boundary
Existing Infrastructure
Principal Road
Secondary Road
Minor Road
Track
Major Watercourses
Minor Watercourses
A4 Scale 1:250,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
File: WC_SLS_MineSoils_31.07.12
Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia

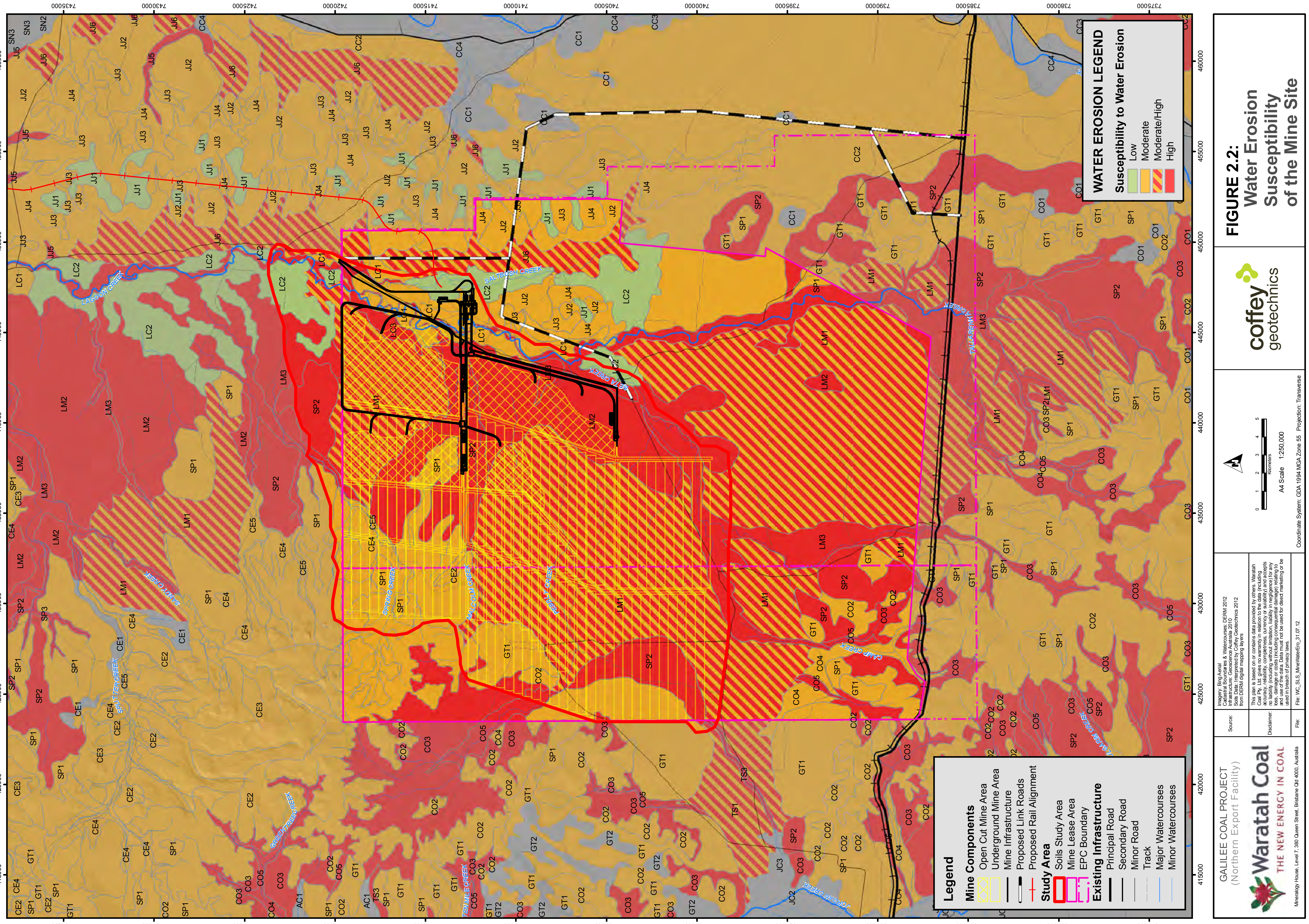
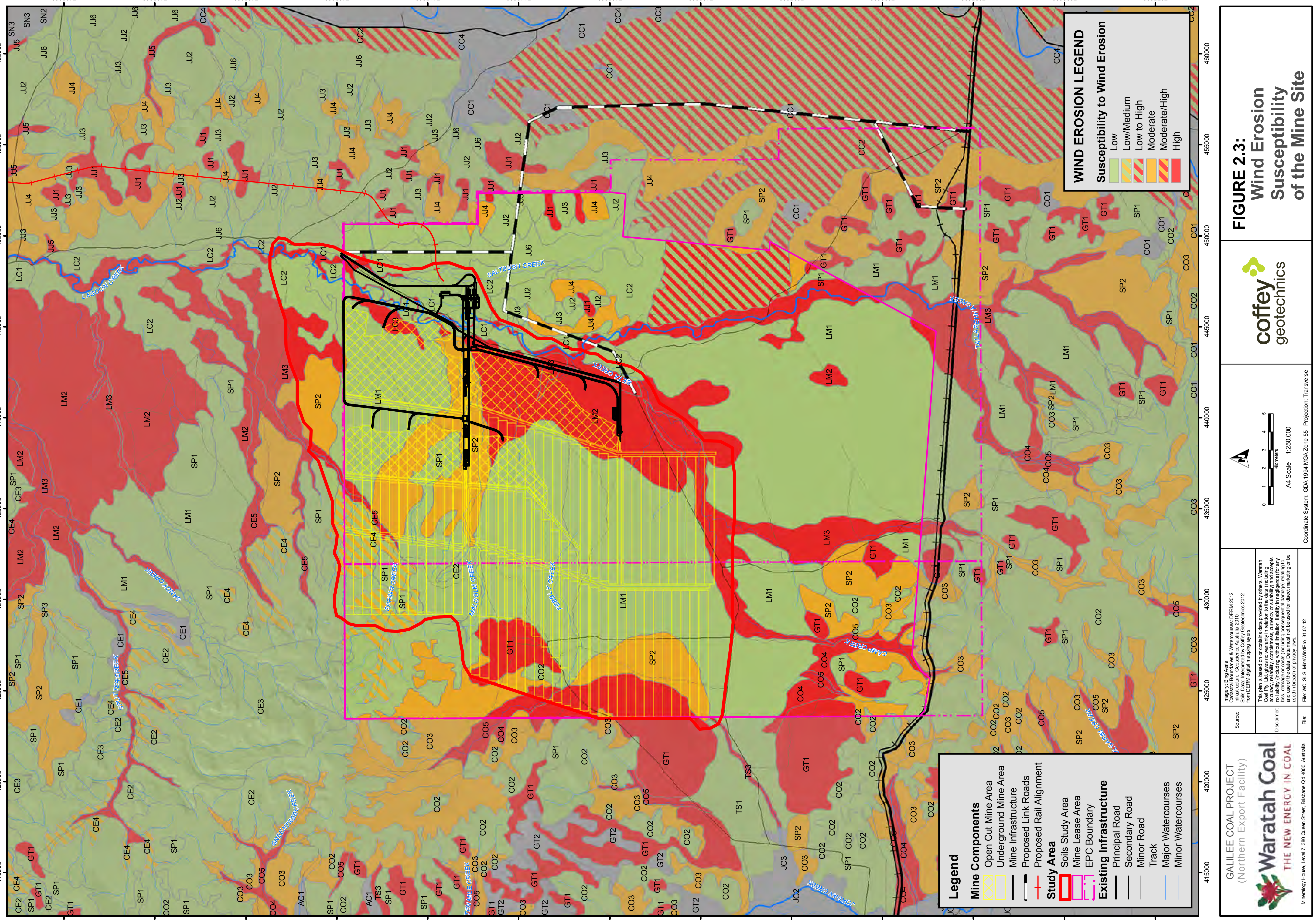



FIGURE 2.2: Water Erosion Susceptibility of the Mine Site



WIND EROSION LEGEND
Susceptibility to Wind Erosion
Low
Low/Medium
Low to High
Moderate
Moderate/High
High
FIGURE 2.3:
Wind Erosion Susceptibility of the Mine Site
coffey geotechnics
Legend
Mine Components
Open Cut Mine Area
Underground Mine Area
Mine Infrastructure
Proposed Link Roads
Proposed Rail Alignment
Study Area
Soils Study Area
Mine Lease Area
EPC Boundary
Existing Infrastructure
Principal Road
Secondary Road
Minor Road
Track
Major Watercourses
Minor Watercourses
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Mineralogy House, Level 7, 300 Queen Street, Brisbane Qld 4000, Australia
A4 Scale 1:250,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
File: WC_SLS_MineWindEro_31.07.12

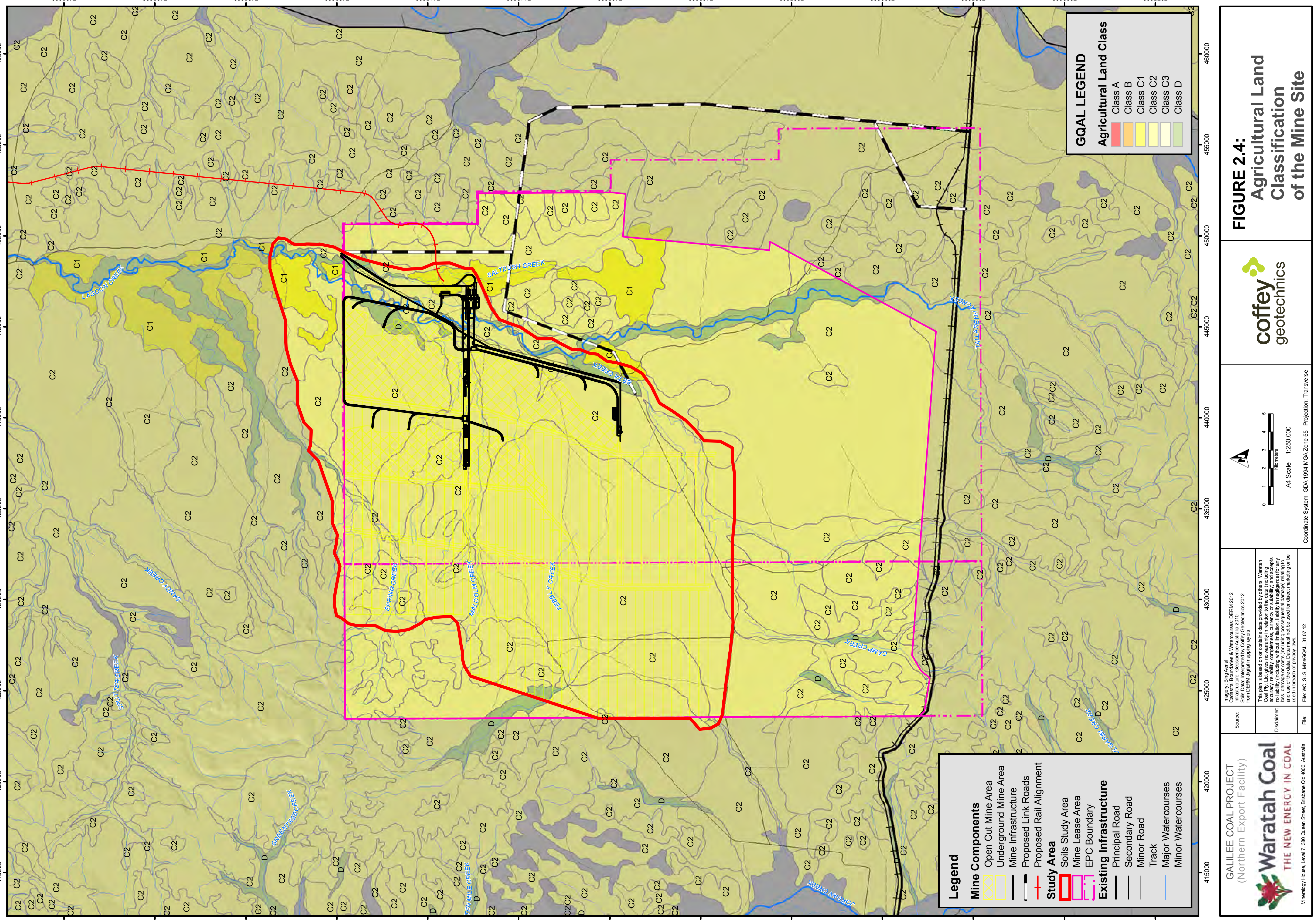
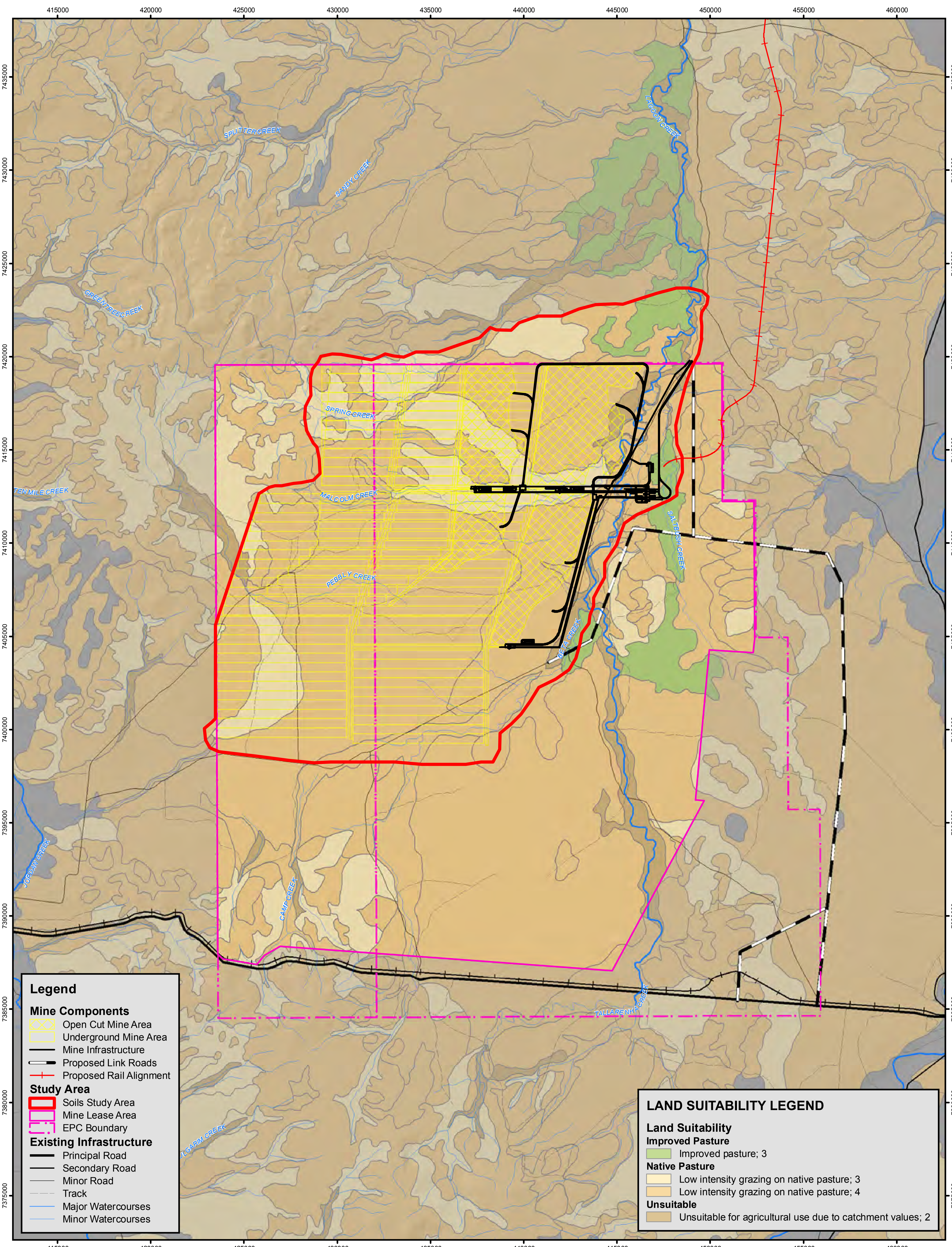



FIGURE 2.4: Agricultural Land Classification of the Mine Site




GALILEE COAL PROJECT
(Northern Export Facility)

Waratah Coal
THE NEW ENERGY IN COAL

Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia

Source: Imagery: Bing Aerial
Cadastral Boundaries & Watercourses: DERM 2012
Infrastructure: Geoscience Australia 2010
Soils Data: Interpreted by Coffey Geotechnics 2012
from DERM digital mapping layers

Disclaimer: This plan is based on or contains data provided by others. Waratah Coal Pty. Ltd. gives no warranty in relation to the data (including accuracy, reliability, completness, currency or suiability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for disect marketing or be used in breach of privacy laws.

File: File: WC_SLS_MineL_Suit_31.07.12

0 1 2 3 4 5 Kilometers
A4 Scale 1:250,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse

coffey geotechnics

**FIGURE 2.5:**

**Land Suitability of the Mine Site**

**Physiographic Area**
- Coastal Zone
- Clark Ranges
- Bowen River Valley
- Leichhardt Range Foothills
- Leichhardt Range
- Suttor River Valley
- Anakie Inlier
- Mistake Creek Valley
- Sandstone Uplands
- Belyando River
- Sedimentary Cuesta Uplands

**Wind Erosion Susceptibility**
- L
- L/M
- L/H
- M
- M/H
- H

**Water Erosion Susceptibility**
- L
- M
- M/H
- H

**Soil Type**

Refer Legend on Map Sheets

**GQAL & SCL**
- SCL
- A
- B
- C1
- C2
- C3
- D

**Intended Land Use For Land Suitability Classification**
- Unsuitable for agricultural use due to catchment values
- Forestry or wildlife conservation areas
- Low intensity grazing on native pasture
- Grazing on native pastures with potential for some improvement
- Limited improved pasture
- Improved pasture
- Sugar cane, rice, grain cropping possible, but better suited to improved pasture
- Limited cropland requiring considerable improvement
- Majority of locally grown crops
- Sugar cane, grain and small crops

GALILEE COAL PROJECT
(Northern Export Facility)

Waratah Coal
THE NEW ENERGY IN COAL

Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia

Source: Imagery: Bing Aerial
Cadastral Boundaries & Watercourses: DERM 2012
Infrastructure: Geoscience Australia 2010
Soils Data: Interpreted by Coffey Geotechnics 2012 from DERM digital mapping layers

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File: File: WC_SLS_RailLS_Comb - 13.07.12

N

0 1 2 3 4 5
Kilometers

A4 Scale 1:250,000

Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse

coffey geotechnics

**FIGURE 2.6:**
**Rail Corridor**
**LEGEND**

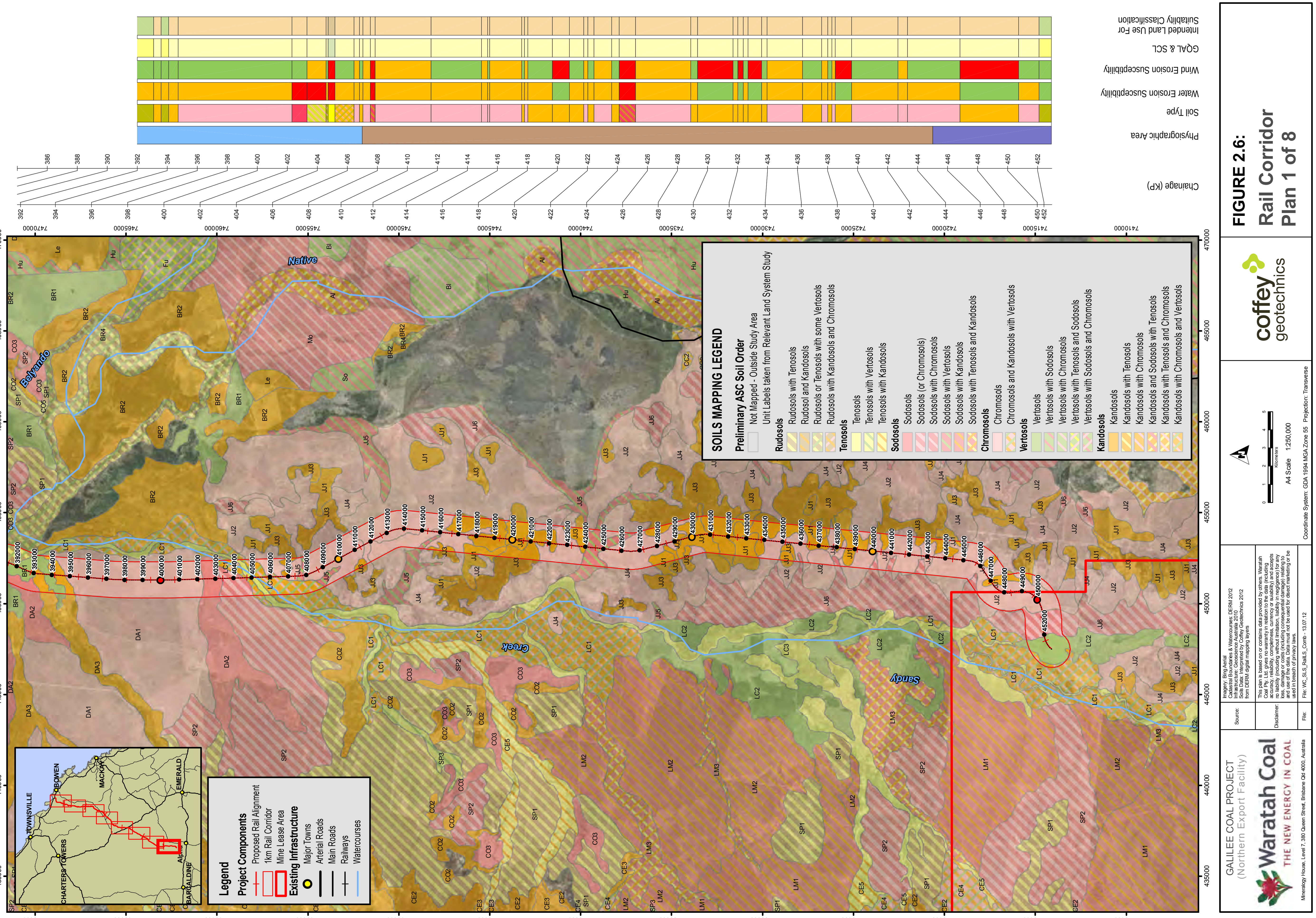



FIGURE 2.6: Rail Corridor Plan 1 of 8

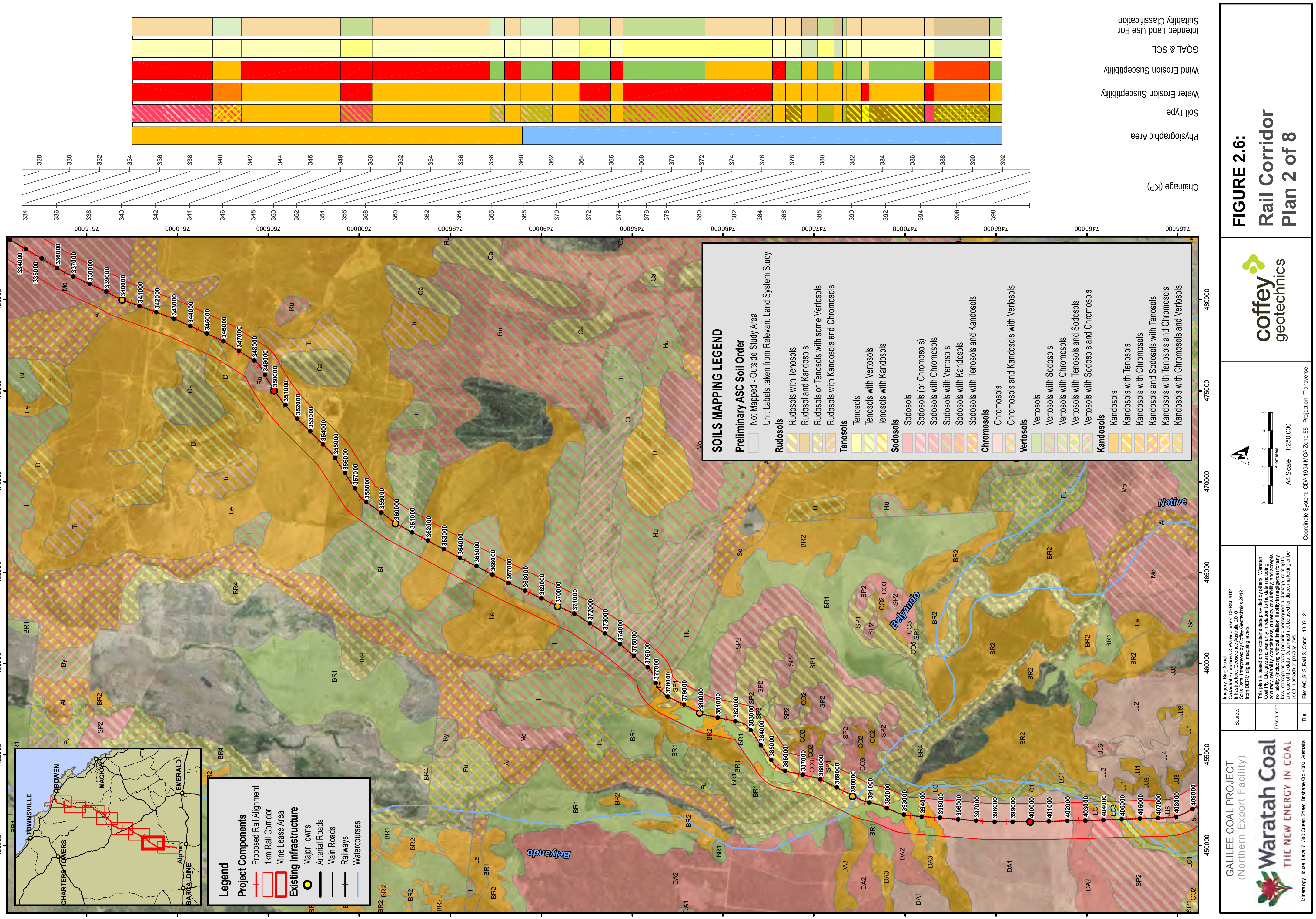


FIGURE 2.6:
Rail Corridor
Plan 2 of 8
Chainage (KP)
Physiographic Area
Soil Type
Water Erosion Susceptibility
Wind Erosion Susceptibility
GQAL & SCL
Intended Land Use For
Suitability Classification
SOILS MAPPING LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE
Belyando
Native
A4 Scale 1:250,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
coffey geotechnics
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL

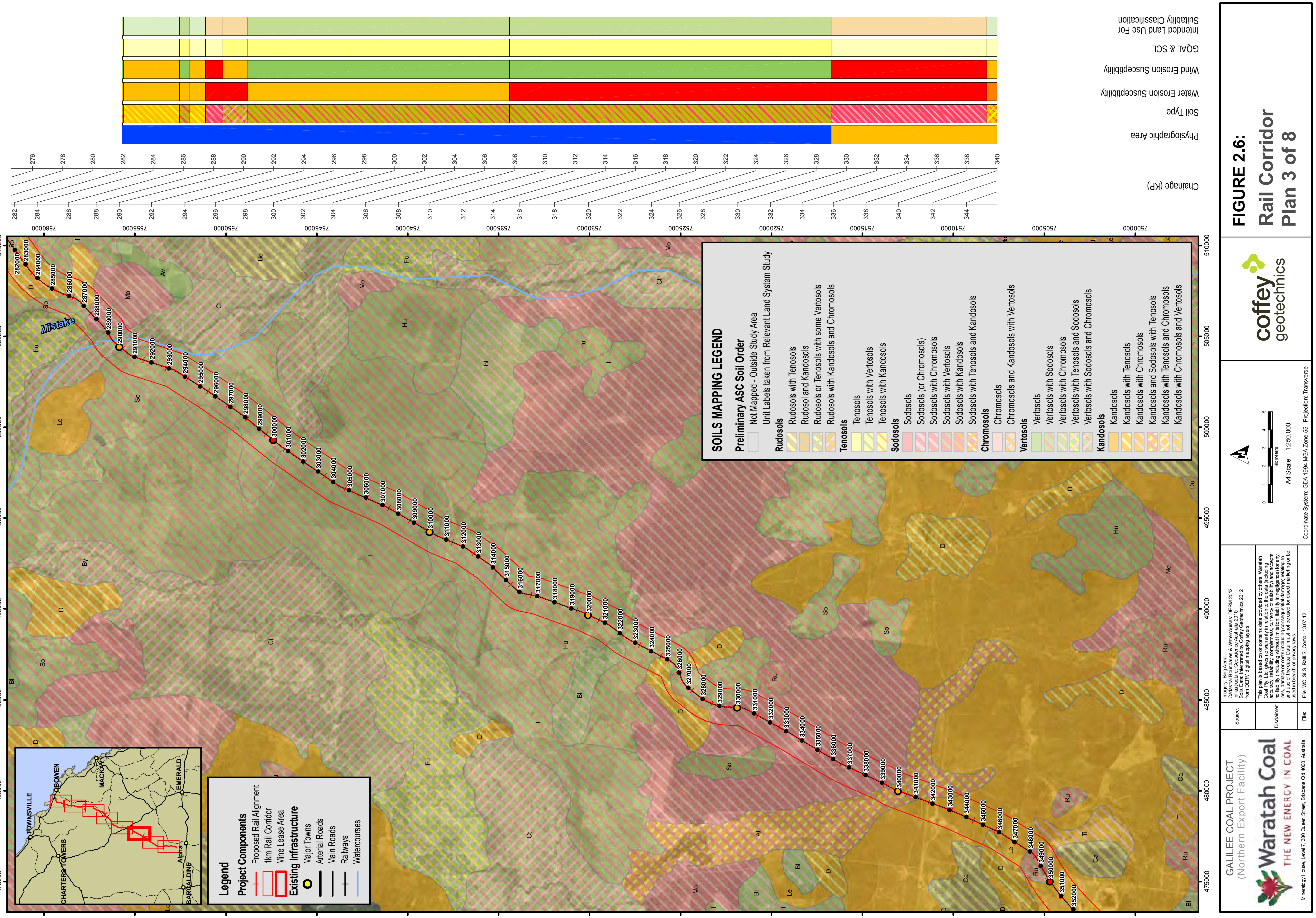
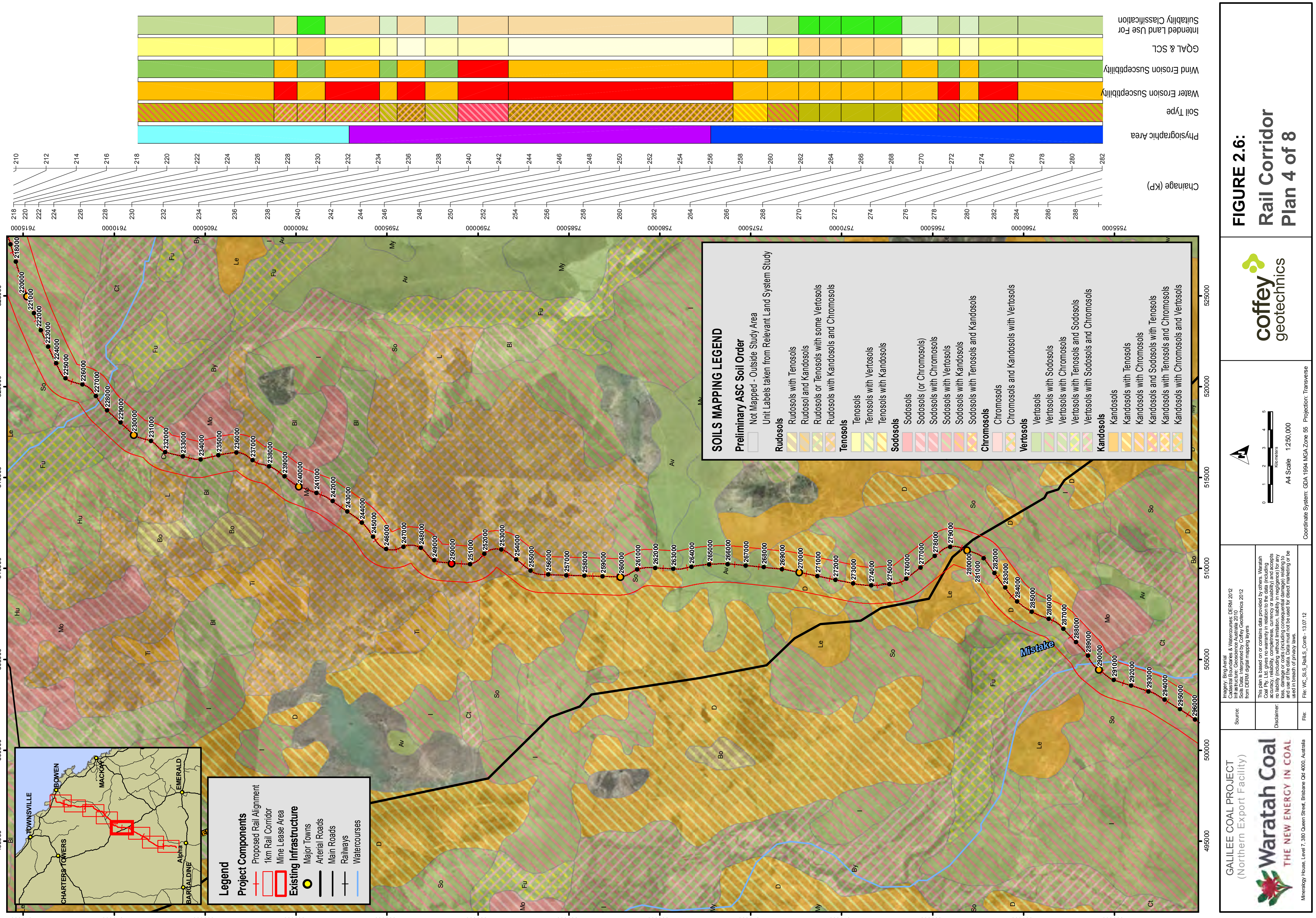
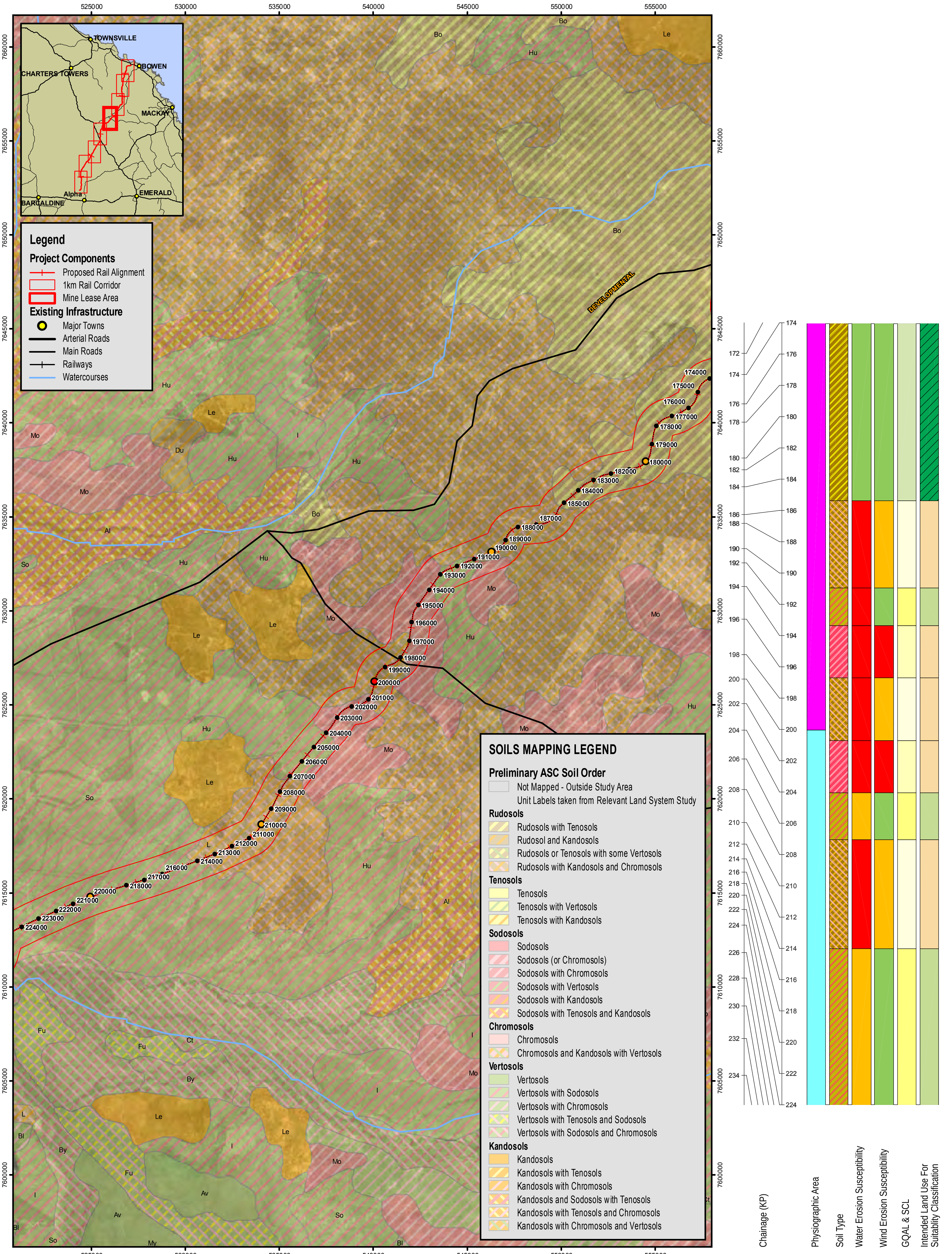


FIGURE 2.6:
Rail Corridor
Plan 3 of 8
Physiographic Area
Soil Type
Water Erosion Susceptibility
Wind Erosion Susceptibility
GQAL & SCL
Intended Land Use For Suitability Classification
Chainage (KP)
SOILS MAPPING LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
Mistake
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE
coffey geotechnics
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia
A4 Scale 1:250,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
File: WC_SLS_RailLS_Comb - 13.07.12


Suitability Classification Intended Land Use For
GQAL & SCL
Wind Erosion Susceptibility
Water Erosion Susceptibility
Soil Type
Physiographic Area
Chainage (KP)
SOILS MAPPING LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE
Mistake
A4 Scale 1:250,000
Kilometers
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
coffey geotechnics
FIGURE 2.6:
Rail Corridor
Plan 4 of 8
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia
File: WC_SLS_RailLS_Comb - 13.07.12




GALILEE COAL PROJECT
(Northern Export Facility)

Waratah Coal
THE NEW ENERGY IN COAL

Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia

Source: Imagery: Bing Aerial; Cadastral Boundaries & Watercourses: DERM 2012; Infrastructure: Geoscience Australia 2010; Soils Data: Interpreted by Coffey Geotechnics 2012 from DERM digital mapping layers

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File: WC_SLS_RailLS_Comb - 13.07.12

A4 Scale 1:250,000

Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse

coffey geotechnics

**FIGURE 2.6:**
**Rail Corridor**
**Plan 5 of 8**

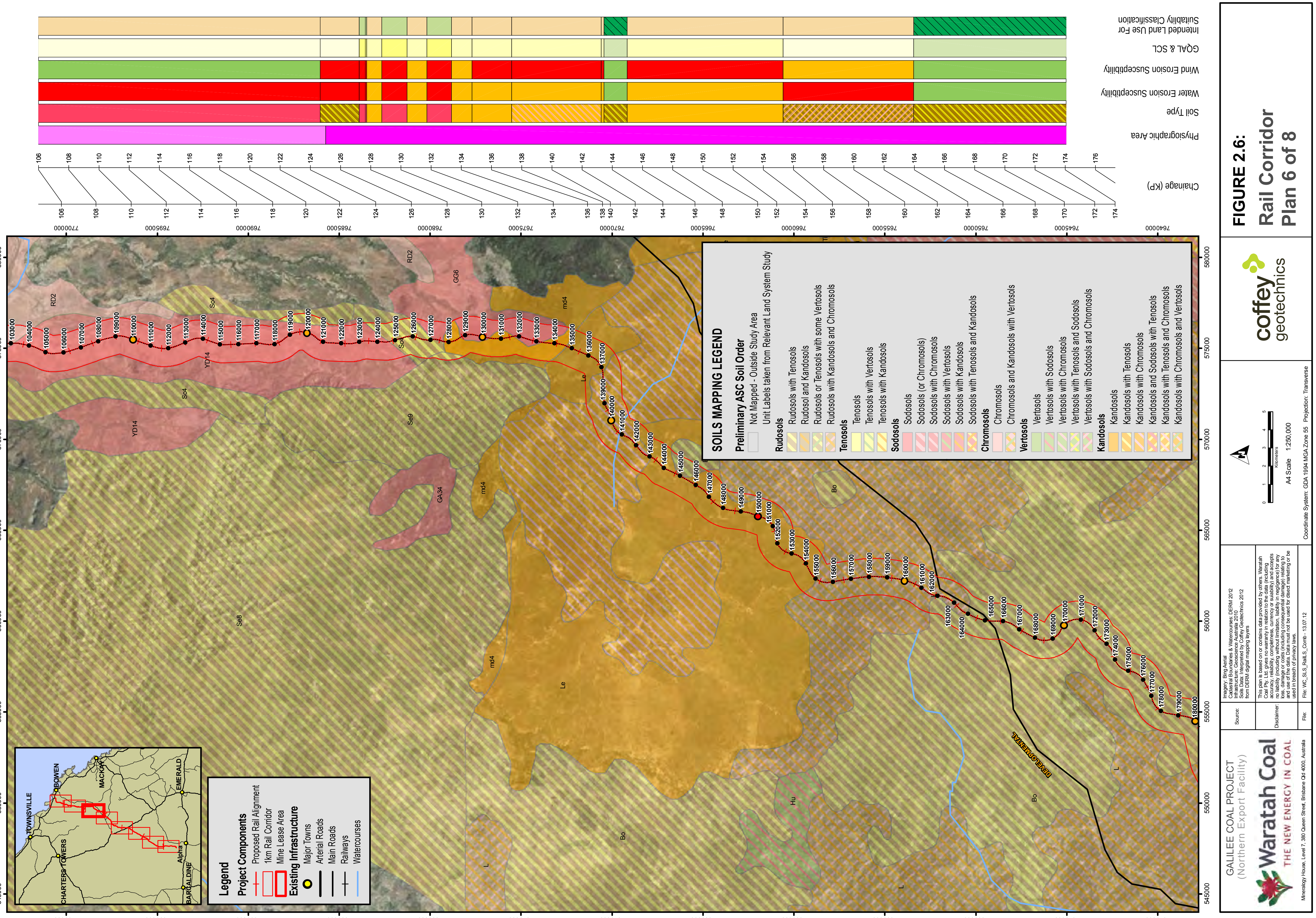
FIGURE 2.6:
Rail Corridor
Plan 6 of 8
Chainage (KP)
Physiographic Area
Soil Type
Water Erosion Susceptibility
Wind Erosion Susceptibility
GQAL & SCL
Intended Land Use For Suitability Classification
SOILS MAPPING LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE
A4 Scale 1:250,000
Kilometres
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
coffey geotechnics
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL

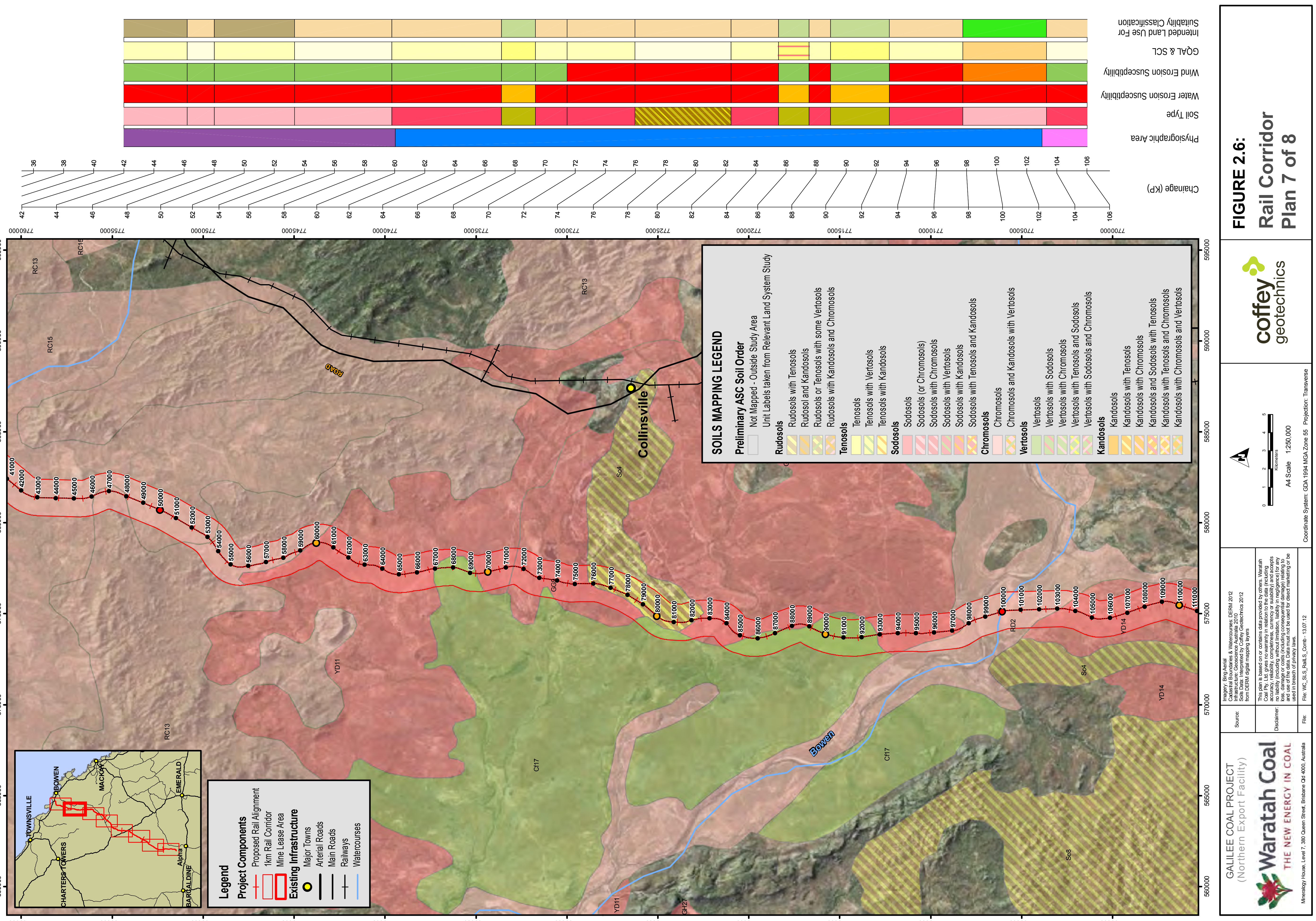
FIGURE 2.6:
Rail Corridor
Plan 7 of 8
coffey geotechnics
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Source: Imagery: Bing Aerial
Cadastral Boundaries & Watercourses: DERM 2012
Infrastructure: Geoscience Australia 2010
Soils Data: Interpreted by Coffey Geotechnics 2012 from DERM digital mapping layers
A4 Scale 1:250,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
SOILS MAPPING LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
Collinsville
Bowen
Chainage (KP)
Physiographic Area
Soil Type
Water Erosion Susceptibility
Wind Erosion Susceptibility
GQAL & SCL
Intended Land Use For Suitability Classification
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE

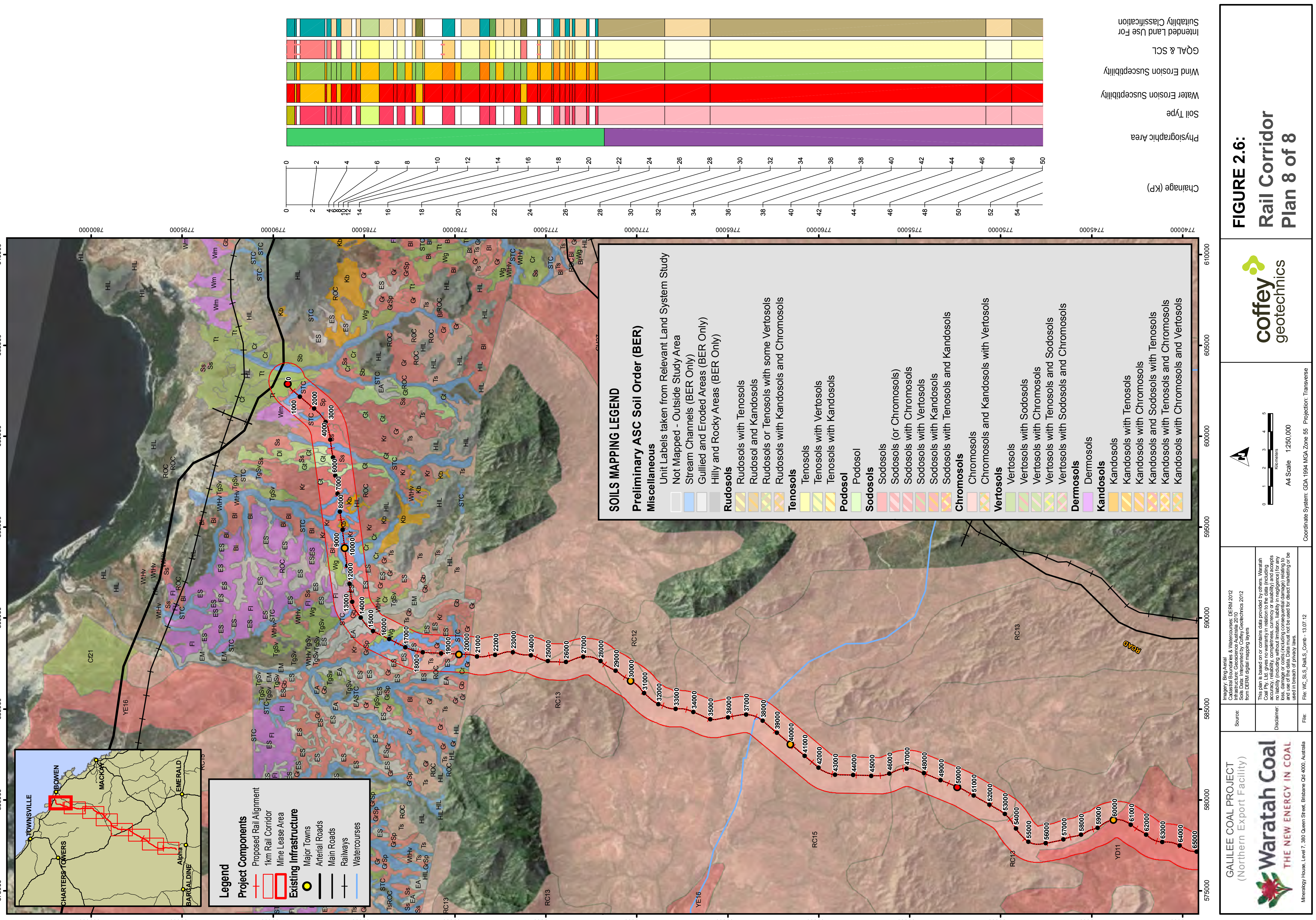
FIGURE 2.6:
Rail Corridor
Plan 8 of 8
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
coffey geotechnics
SOILS MAPPING LEGEND
Preliminary ASC Soil Order (BER)
Miscellaneous
Unit Labels taken from Relevant Land System Study
Not Mapped - Outside Study Area
Stream Channels (BER Only)
Gullied and Eroded Areas (BER Only)
Hilly and Rocky Areas (BER Only)
Rudosols
Rudosols with Tenosols
Rudosols and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Podosol
Podosol
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Dermosols
Dermosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
Chainage (KP)
Physiographic Area
Soil Type
Water Erosion Susceptibility
Wind Erosion Susceptibility
GQAL & SCL
Intended Land Use For Suitability Classification
A4 Scale 1:250,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE

# Appendix A

**Study Methodology**

## METHOD OF ASSESSMENT

Coffey is using a phased approach to the Soils Study, involving the following:

**DESKTOP ASSESSMENT**

**Phase 1.1 – Collation and Review of Available Existing Studies, Information, Data, Relevant Legislation and Mapping.**

The initial phase of the desktop analysis involved collating available information related to geology, landform and soils within the study area. This included review of publically available EIS studies, reports, articles and maps.

A detailed desktop assessment was conducted to review existing information on soils and variables that influence soil properties and characteristics, including geology, landform (including topography and geomorphological processes), drainage and vegetation. The ultimate aim was to produce a preliminary ground model showing the relationship between soil types and other variables, in order to assess the soil characteristics of the study area.

All digital mapping data used for this study was provided by Waratah Coal or DERM/DEHP, under appropriate license agreements from data owners. Descriptions for mapping units were obtained from associated datasets.

The following data sets were used for mapping, description and assessment of the study area:

- Colour aerial photography provided by Waratah Coal, BingMaps (2011) and GoogleEarth (2011) imagery.
- Topographic data provided by Waratah Coal and downloaded from DERM/DEHP's QGIS website, which is detailed around the mine site, and less detailed elsewhere in the study area.
- The following soils and land systems digital mapping:

**Table A1.1 Soils and Land Systems Digital Mapping used for Phase 1.1 Desktop Study**

| Project Component | Report/Map Title (Date) | Author | Scale |
|---|---|---|---|
| Rail Corridor | Soils of the Elliot River - Bowen Area, North Queensland (BER) (1988) | Aldrick, J.M. | 1:100,000 |
| | Land Suitability Study of the Collinsville-Nebo-Moranbah Region (CNM) (1984) | Shields, P.G. | 1:250,000 |
| | Survey of the Burdekin-Townsville Region Soils (ZEB) (1970) | Isbell, R.F. and Murtha, R.G. | 1:1,000,000 |
| (Hard copy only) | Survey of the Townsville–Bowen Region, North Queensland (ZCI) (1950) | Christian, C.S. *et al.* | 1" to 4 miles |
| Mine and Rail Corridor | The Desert Uplands: an overview of the Strategic Land Resource Assessment Project (DUSLARA) (2005) | Lorimer, M.S. | 1:100,000 |
| | Lands of the Nogoa-Belyando Area, Queensland (ZCQ) (1967) | Gunn, R.K. *et al.* (CSIRO) | 1:500,000 |
| | Good Quality Agricultural Land Mapping (CWR) (date unknown – provided by Waratah Coal) | Unknown M | erged land systems mapping |
| | Strategic Cropping Land Mapping (2012) | DERM | Unknown |

The available soils mapping was not at a suitable scale for the study area. Coffey's ultimate aim is to use the above information and future fieldwork to check and map variables at a scale appropriate for the size of the study area and to meet the Terms of Reference (Queensland Government Coordinator General, 2009).

Literature regarding the following topics was also reviewed:

- Potential impacts and management of longwall subsidence.
- Post-mining landform rehabilitation and management, including an evaluation of the success of other rehabilitated open-cut mines.

**Phase 1.2 – Preliminary Soils Mapping**

Geology, elevation, slope, project components/activities and then soils were mapped and managed using a Geographic Information System (GIS) geodatabase. The preliminary maps and associated data were then reviewed to identify any trends and anomalies between the layers. Typically, greater importance was placed on existing soils mapping at a larger scale (i.e., in order of confidence: DUSLARA, BER, ZCQ, ZEB, CNM and ZCI (see Table A1.1 for acronym definitions)). Aerial imagery was used to assist this process.

A preliminary assessment of soils units was then made with regard to the following:

- Preliminary matrix of soil properties (by soil type) that will influence erosion potential (including dispersion) and agricultural productivity (i.e., answering those questions raised by government agencies and other respondents during the public consultation, rather than a full EIS-level impact assessment).
- Location of Good Quality Agricultural Land (GQAL) (requiring definition of the Agricultural Land Class using descriptions in the relevant Land Systems Studies Manuals), Strategic Cropping Land (using DERM's 2012 digital mapping) and mapping of different classes of land suitability (as per DME, 1995).

**FIELD INVESTIGATIONS**

**Phase 2 – Preliminary Field Reconnaissance**

A field reconnaissance survey of parts of the study area may be carried out prior to the full soils investigation. The reconnaissance will involve a drive-through and walkover with a soil scientist/geologist and geomorphologist.

The aim of the site reconnaissance would be to provide the following information:

- To gain a visual appreciation of the soils, geology and land characteristics of the study area.
- Ground-truthing of the preliminary ground model based on visual observations of undisturbed ground and existing soil profile exposures (e.g., along creek banks and road cuttings).
- Gain a better understanding of site conditions and access, thus reducing the possibility of delays due to unforeseen conditions or access.
- Reduce the scope of the fieldwork phase, as ground observations made during the preliminary fieldwork would be used as part of the soil survey.
- Gain information to help assess and plan the interim and full soils investigations requirements.
- Test pit locations were selected by targeting areas identified as having specific soil attributes from the desktop review and preliminary mapping and confirmed during the preliminary field visit.

This phase of the project is not strictly necessary, but will aid Coffey in planning the next fieldwork phases.

***Soils Field Investigation***

**Phase 3 – Interim Field Investigations**

Coffey soils investigation team propose to conduct the interim soils investigation prior to the summer rainy season in mid-late 2012. This ground investigation is intended to provide DERM-specified information for the mine site, and an interim level of information for the rail corridor. Additional information will be obtained during Phase 4, to avoid unnecessary access issues and landowner confrontation

A total of 47 test pits are proposed for the mine site and 25 for the rail corridor, excavated to the C2 or R horizon. Test pit locations will be recorded using a hand-held GPS receiver with an accuracy of ±5-10 m. Test pits will be backfilled following sampling and logging to limit permanent environmental damage.

Soil profiles will be photographed, logged and described in accordance with the Guidelines for Surveying Soil and Land Resources (2nd Ed, McKenzie et al., 2008), the National Committee on Soil and Terrain (2009) and the Australian Soil Classification (Isbell, 1996; 2002). Landscape position, vegetation, ground surface features and substrate material (where evident) will also be recorded at each site to assist in mapping.

Samples from each soil horizon will be collected, and submitted to the NATA-accredited ALS and Coffey Information Laboratories for physical and chemical analysis. Field soil logs and laboratory test results will be included in Coffey's final report.

Test pit observations will be supplemented by hand auger holes or hand-dug pits to provide detailed profiles. Soil profiles will be assessed as per the test pit methodology detailed above, but It is not anticipated that these locations will be sampled. A total of 57 hand-augered or hand-dug sites are proposed for the mine site, and 30 for the rail corridor. In addition, further general mapping observations will be made (e.g., existing soil exposures and undisturbed ground) supplementing the Phase 2 Preliminary Field Reconnaissance, with a total of 120 observations proposed within the mine site and 45 observations along the rail corridor.

**Phase 4 – Targeted field investigations**

It is anticipated that a detailed geotechnical ground investigation will be carried out during the design phase of the project. These investigations typically involve densely-spaced test pits and/or boreholes, both of which would provide suitable information for the soils investigation. The Phase 4 targeted field investigation would be carried out in conjunction with these geotechnical investigations, to provide additional soils data.

It is intended that a Coffey Soil Scientist would be present at key locations, in order to assess the following:

- Difference in soil logging methodology, such that the geotechnical test pitting not observed can be converted to soil science logging.
- Check that the sampling procedure is as per relevant guidelines.

**Phase 5 – Assessment and Reporting**

Once the soils assessment has been conducted and results assessed, soils will be grouped according to parent material and position in the landscape (as per DERM, 2011)

**Proposed Soil Survey Density and Rationale**

There is a difference in DERM's issues and recommendations regarding the density of investigation sites. Table A1.2 indicates the separate scopes that address these different viewpoints, with a rationale for Coffey's preferred approach in the following sections. It is intended that discussions with Waratah Coal and DERM/DEHP will be conducted and an investigation programme mutually agreed.

**Table A1.2 Soil Survey Observation Density**

| Project Component | DERM "Issue" Density | DERM "Recommendations" Density | Coffey Preferred Density |
|---|---|---|---|
| Mine<br>Total area: 105,550ha | As per Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995) | As per Australian Soil and Land Survey Handbook (National Committee on Soil and Terrain, 2009) guidelines | See given rationale below.<br>Investigation sites may be located down-system of the area of disturbance (if required), such that indirect impacts can be assessed. |
| Assumed undisturbed area: 65,550ha | Undisturbed areas (assuming current land use is grazing): 1:250,000<br>1 observation per $cm^2$ of map = 262 observation sites, 66 detailed observations (25%) | Entire mine lease area: 1:100,000<br>0.25 – 1 observation per $cm^2$ of map = 264 – 1055 observation sites, 66 – 264 detailed observations (25%) | Undisturbed areas (assuming current land use is grazing): 1:100,000<br>Approximately 0.04 observations per $cm^2$ of map = 25 – 30 observation sites, 7 detailed observations (25%) sufficient to check existing 1:100,000 DUSLARA mapping |
| Assumed area disturbed by underground mining[1]: 28,000ha | Disturbed areas: 1:5,000<br>1 observation per $cm^2$ of map = 8,000 observation sites, 2,000 detailed observations (25%) | | Disturbed areas: 1:100,000<br>Approximately 0.25 observations per $cm^2$ of map = 40 – 70 observation sites, 15 detailed observations (25%) |
| Assumed area disturbed by above ground mining and associated activities[1]: 12,000ha | | | Heavily disturbed areas: 1:100,000<br>Approximately 1 observation per $cm^2$ of map = 100-120 observation sites, 25 detailed observations (25%) |
| Rail<br>Total length: 468km<br>Breakdown of cut/fill, structures, relatively undisturbed sections not yet known | Not stated | Entire rail line at 1:50,000 – 1:100,000 as per Soil Survey Methodology along Linear Features (DERM, draft working document, 2011), Table 1 (for rail lines with predominantly surface disturbance):<br>1 observation per 500m – 1km = 468 – 936 observation sites, 234 – 468 detailed observations (50%) | Indicative scale of 1:250,000, with sensitive, variable or highly disturbed sections mapped at a larger scale, where appropriate.<br>1 observation per 1km – 10km, depending on soil variability and proposed construction technique Approximately 100 observation sites (an average of 1 every 4.7km), 25 detailed observations (25%) concentrated in areas of high disturbance; areas of strategic cropping land or GQAL; and areas where soils mapping or land systems mapping does not exist. |

1 Assumes that the area of disturbance is approximately 20km by 20km, comprising about 30% land directly disturbed by above-ground mining and associated activities, and 70% land disturbed by underground mining.

Coffey has assessed the available information regarding DERM requirements, existing information and the requirements of the Terms of Reference. The latter indicates that the objective of the EIS is to:

- Identify and assess the potential impacts of the project, and explain how these potential impacts may be avoided or mitigated; and
- To provide stakeholders with sufficient information to understand these potential impacts and the proposed mitigation measures.

Coffey has considered these objectives (and other requirements of the Terms of Reference) while scoping the soils investigation. The given scope is subject to change on completion of the desktop study, should ground conditions differ or the proposed area of disturbance change from those currently anticipated. Our recommendations reflect the guidelines mentioned by DERM and contained within the Terms of Reference, which are advisory only, and not intended to prescribe mandatory standards and practices. These guidelines are open to interpretation and negotiation with DERM/DEHP.

***Mine Site***

The National Committee on Soil and Terrain (2009) indicate that for large scale surveys, adjustments should be made to take account of the size and complexity of the area and existing and proposed land use. Their specifications are also for investigations which are attempting to demonstrate the suitability of a proposed land use, rather than for assessing potential environmental impacts. IECA (2008) indicates that where soils mapping or land systems mapping is already available, providing valuable relevant information, the scope of a soils investigation can be reduced such that, in some cases, a separate soil survey is not necessary. While the latter case is not practical for the purposes of this study, it is also not practical for the investigation findings to be overly detailed and complex, such that it becomes difficult for impacts to be assessed or for stakeholders to understand the study outcomes.

Recently, DERM/DEHP accepted an EIS for a nearby coal mining project in the Galilee Basin. The soils investigation involved the use of a relatively dense investigation grid (over 500 data points), but the proposed development at that location impacts a greater proportion of the site, which is preliminarily assessed to have more variability in soil types than the China First site.

The Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995) indicate that the undisturbed areas of the lease area should be mapped at a sufficient level to characterise the broad land resource conditions of the areas surrounding the mine site. Coffey proposes to conduct sufficient observations to check the existing 1:100,000 DUSLARA soils mapping in these areas.

The disturbed area of the mine site can be split into 2 sections: that which will be heavily disturbed due to open cut mining and construction of associated facilities and structures; and that which will be disturbed as a result of underground mining and related subsidence. In accordance with National Committee on Soil and Terrain (2009) and DME (1995) recommendations, Coffey considers that the heavily disturbed section requires a greater density of observation sites than the less-disturbed area, as the impacts are anticipated to be appreciably lower in the latter section. This is reflected in our proposed investigation scope.

***Rail Corridor***

Although soils along the rail corridor will be variable along the alignment, the rail construction will probably have a lower impact on the soils than, say, a buried pipeline. We are aware of Queensland EIS pipeline projects that DERM/DEHP has accepted that have an average investigation spacing of 1 observation per km, rather than the recommended 1 site per 250 m – 500 m. A similar EIS study for a rail corridor used ASRIS soils mapping at a scale of 1:2,000,000 and did not involve collection of fieldwork data, with the assumption that a soil survey would be carried out prior to construction. This is in contrast to DERM (draft 2011) guidelines for linear features such as rail corridors which require at least 1 observation per km with 50% observed in detail, with one or more detailed profile descriptions in 80% of mapped units.

Coffey considers that the number of observations should be based on the variability of soils and the proposed level of disturbance, in order to provide information for assessment of potential impacts. This is reflected in our proposed investigation scope.

The soil survey for this study will be carried out in accordance with Australian Soil and Land Survey Handbook (National Committee on Soil and Terrain, 2009) guidelines and the Australian Soil Classification (Isbell, 2002).

In all cases, it is intended that the soil investigation sites will not be grid-spaced; locations will be chosen during the desk study to ground truth the preliminary mapping by conducting observations at sites which are anticipated to be within or at the boundary of different soil units. Figures A1 and A2 Plans 1-8 show tentative locations for the proposed test pitting. Locations for other methods of observation (e.g. hand augering, hand-dug pits and general observations) will be decided following the Phase 2 Preliminary Field Reconnaissance and during planning of the Phase 3 Interim Field Investigation.

**Sampling**

Chemical laboratory testing will comprise the following:

- pH
- Electrical Conductivity (EC)
- Moisture content
- Cation Exchange Capacity (CEC)
- Exchangeable cations (calcium, sodium, magnesium and potassium)
- Exchangeable Sodium Percentage (ESP)
- Total nitrogen and phosphorous

Physical laboratory testing will comprise the following:

- Particle size distribution (including hydrometer testing of fines)
- Dispersivity (Emerson Testing)
- Atterberg Limits

Split samples will be assessed at the laboratory as part of the QA/QC procedures. Results of this are considered acceptable for uses in this study and are included in the laboratory certificates.

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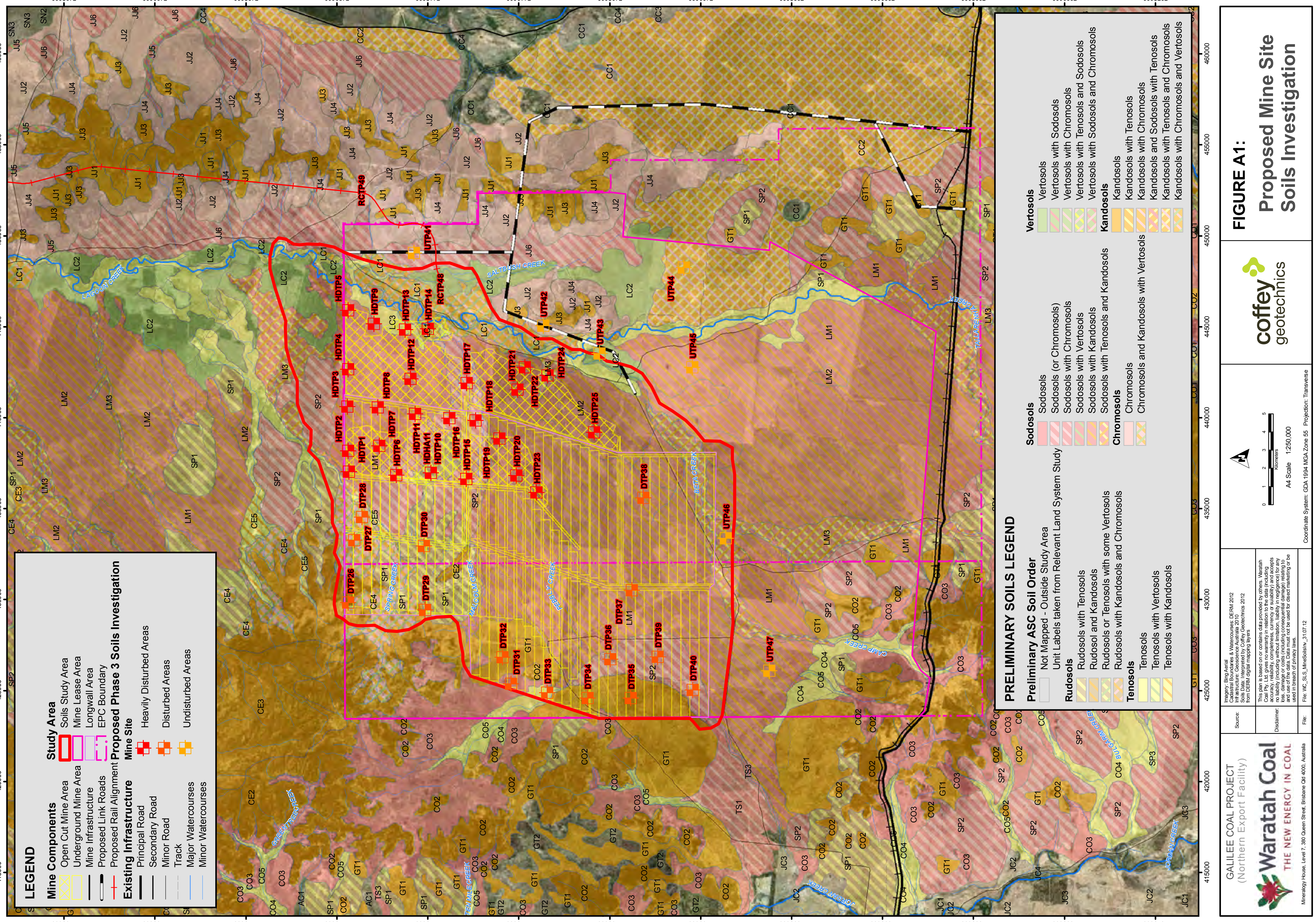

LEGEND
Mine Components
Open Cut Mine Area
Underground Mine Area
Mine Infrastructure
Proposed Link Roads
Proposed Rail Alignment
Existing Infrastructure
Principal Road
Secondary Road
Minor Road
Track
Major Watercourses
Minor Watercourses
Study Area
Soils Study Area
Mine Lease Area
Longwall Area
EPC Boundary
Proposed Phase 3 Soils Investigation
Mine Site
Heavily Disturbed Areas
Disturbed Areas
Undisturbed Areas
PRELIMINARY SOILS LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
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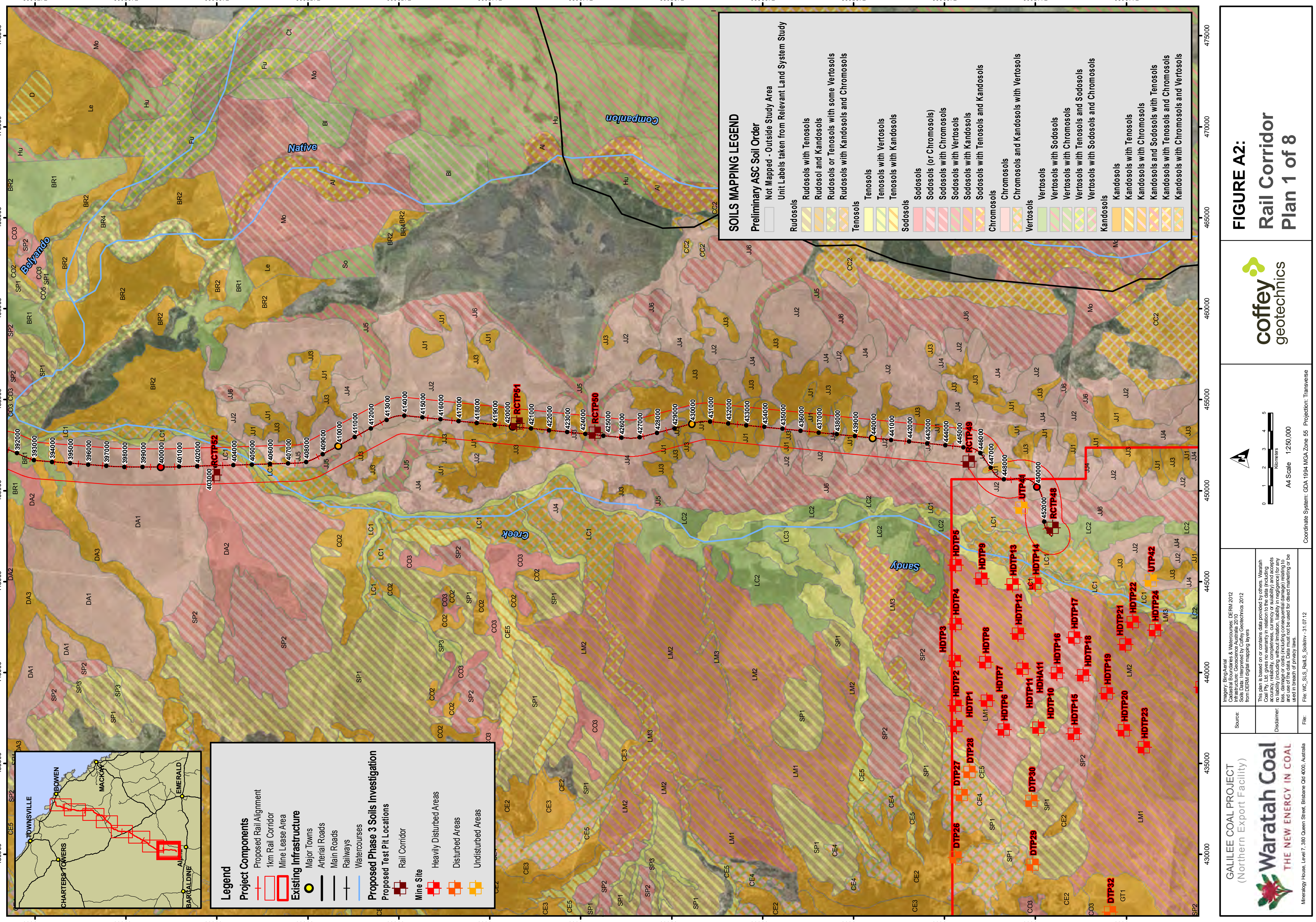
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
A4 Scale 1:250,000
Kilometres
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
coffey geotechnics
FIGURE A1:
Proposed Mine Site
Soils Investigation
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia



SOILS MAPPING LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
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Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
Proposed Phase 3 Soils Investigation
Proposed Test Pit Locations
Rail Corridor
Mine Site
Heavily Disturbed Areas
Disturbed Areas
Undisturbed Areas
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
BARCALDINE
Native
Companion
Belyando
Sandy
Creek
FIGURE A2:
Rail Corridor
Plan 1 of 8
coffey geotechnics
A4 Scale 1:250,000
Kilometres
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia
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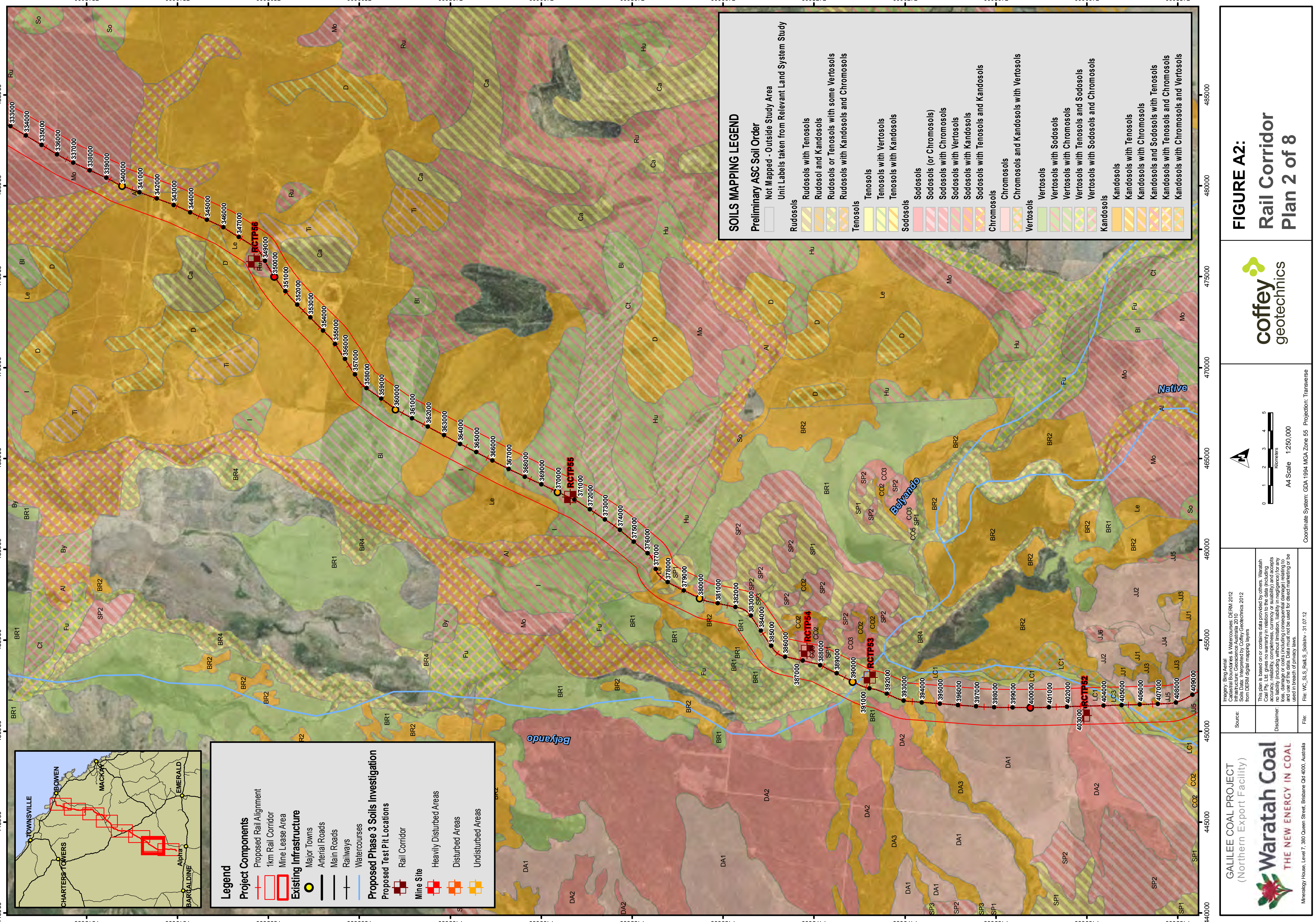

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Disturbed Areas
Undisturbed Areas
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE
RCTP56
RCTP55
RCTP54
RCTP53
RCTP52
Belyando
Native
FIGURE A2:
Rail Corridor
Plan 2 of 8
coffey geotechnics
A4 Scale 1:250,000
Kilometers
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia
Source:
Imagery: Bing Aerial
Cadastral Boundaries & Watercourses: DERM 2012
Infrastructure: Geoscience Australia 2010
Soils Data: Interpreted by Coffey Geotechnics 2012 from DERM digital mapping layers
Disclaimer:
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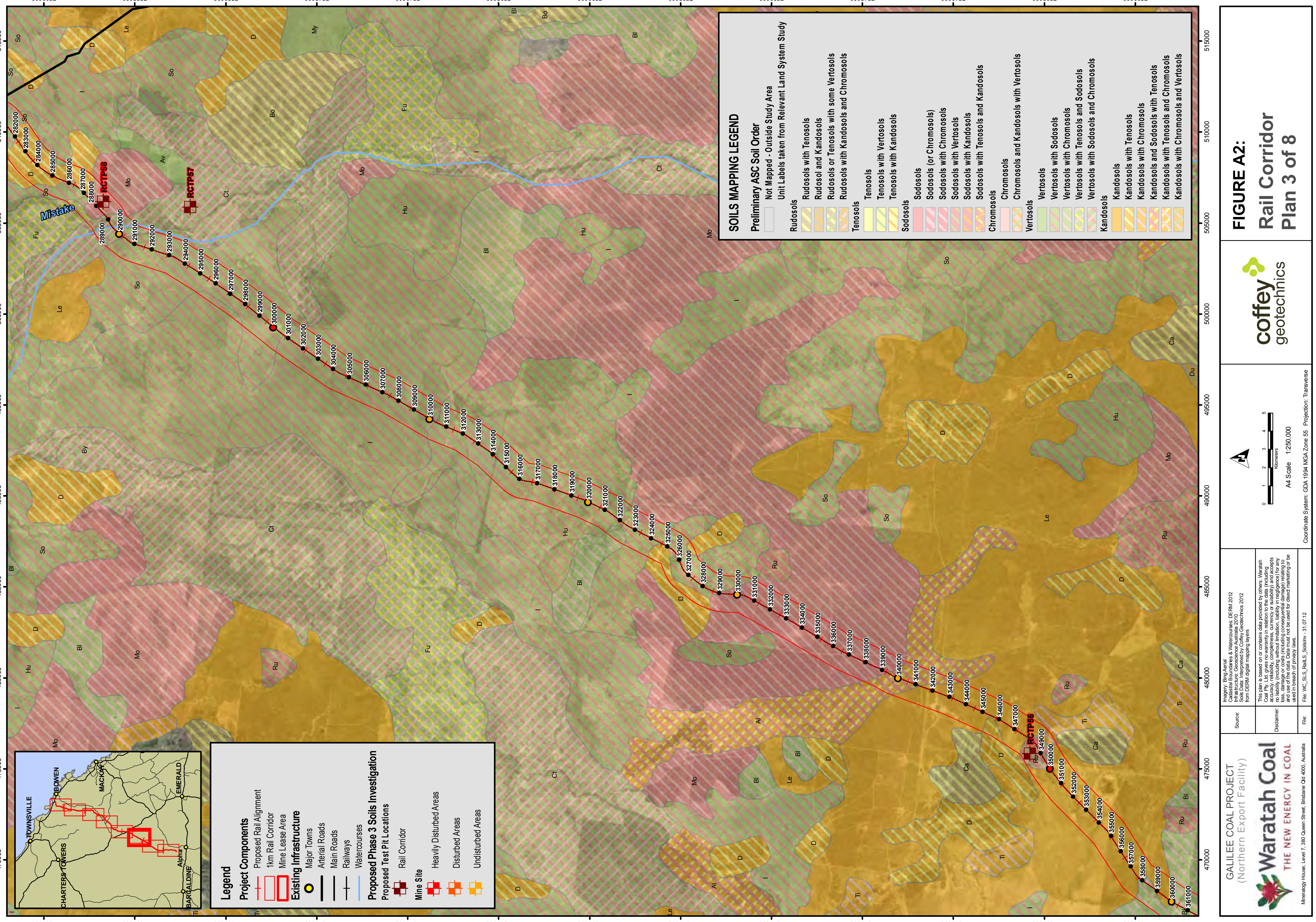
FIGURE A2:
Rail Corridor
Plan 3 of 8
SOILS MAPPING LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
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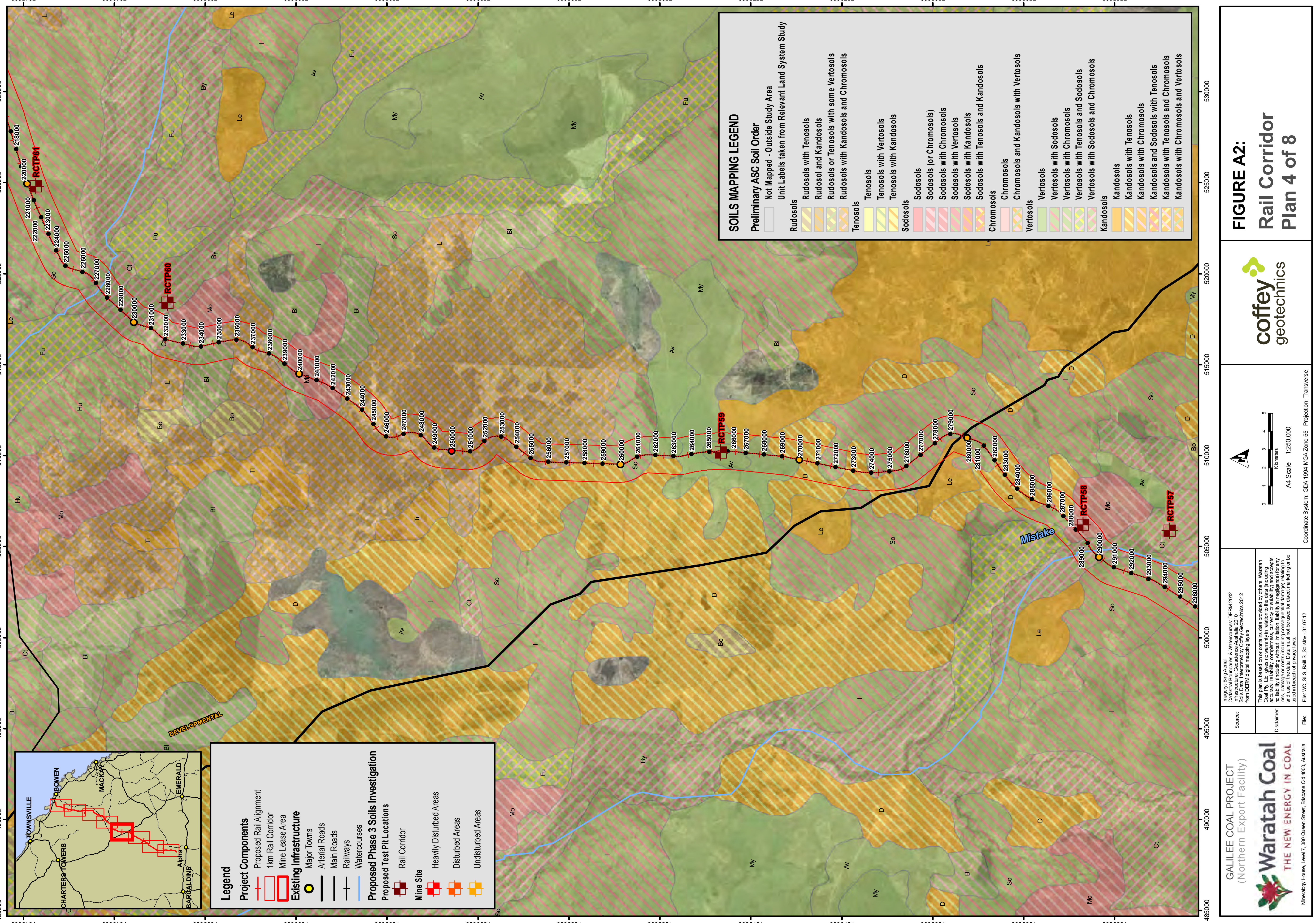

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TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE
RCTP61
RCTP60
RCTP59
RCTP58
RCTP57
Mistake
DEVELOPMENTAL
FIGURE A2:
Rail Corridor
Plan 4 of 8
coffey geotechnics
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia
Source: Imagery: Bing Aerial; Cadastral Boundaries & Watercourses: DERM 2012; Infrastructure: Geoscience Australia 2010; Soils Data: Interpreted by Coffey Geotechnics 2012 from DERM digital mapping layers
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A4 Scale 1:250,000
Kilometres
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse

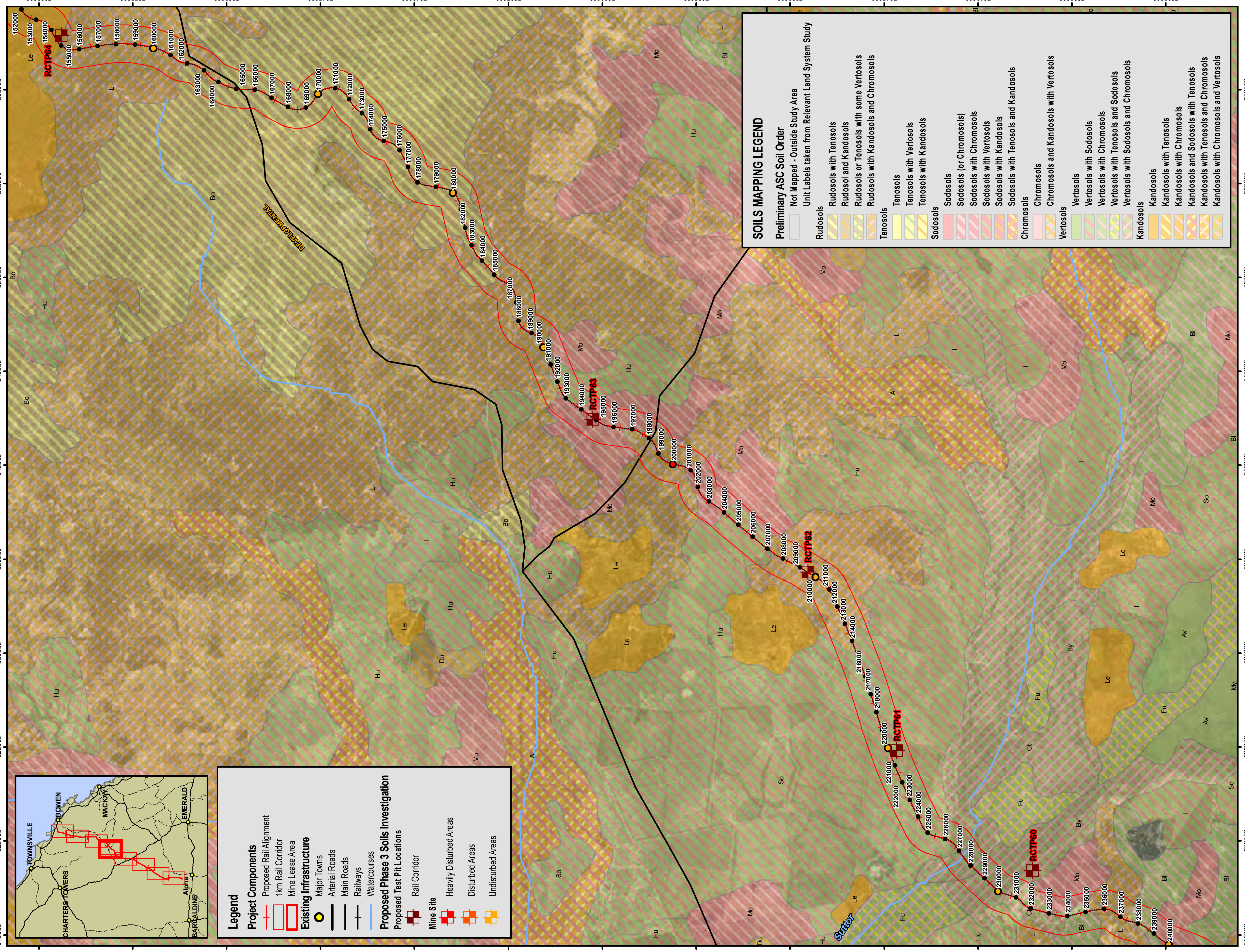


FIGURE A2:
Rail Corridor
Plan 5 of 8

coffey geotechnics

GALILEE COAL PROJECT (Northern Export Facility)

Waratah Coal
THE NEW ENERGY IN COAL

Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia

Source: Imagery: Bing Aerial; Cadastral Boundaries & Watercourses: DERM 2012; Infrastructure: Geoscience Australia 2010; Soils Data: Interpreted by Coffey Geotechnics 2012 from DERM digital mapping layers

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File: WC_SLS_Rail5_Soils - 31.07.12

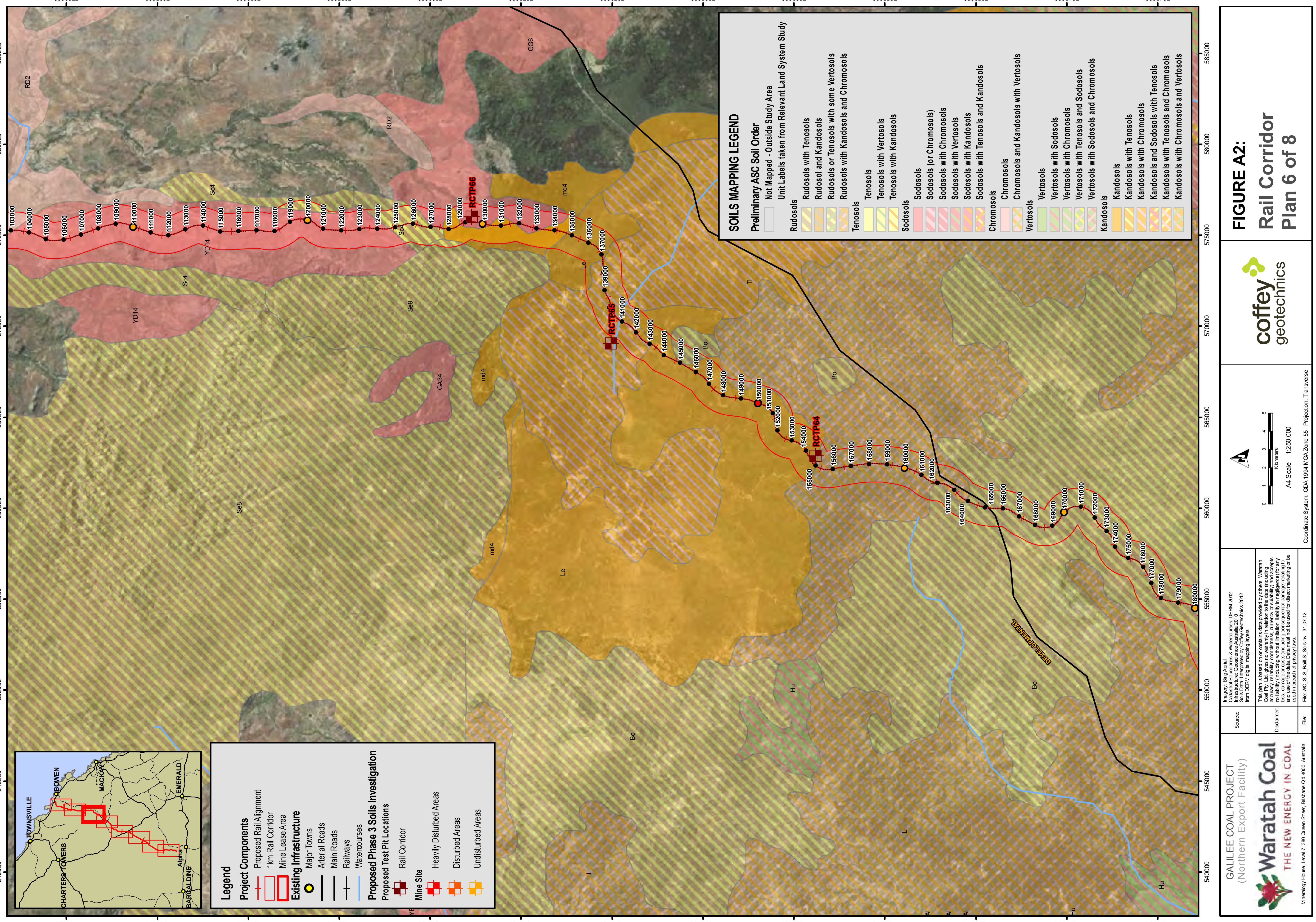

FIGURE A2:
Rail Corridor
Plan 6 of 8
SOILS MAPPING LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
Proposed Phase 3 Soils Investigation
Proposed Test Pit Locations
Rail Corridor
Mine Site
Heavily Disturbed Areas
Disturbed Areas
Undisturbed Areas
RCTP64
RCTP65
RCTP66
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE
A4 Scale 1:250,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
coffey geotechnics
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
Mineralogy House, Level 7, 380 Queen Street, Brisbane Qld 4000, Australia

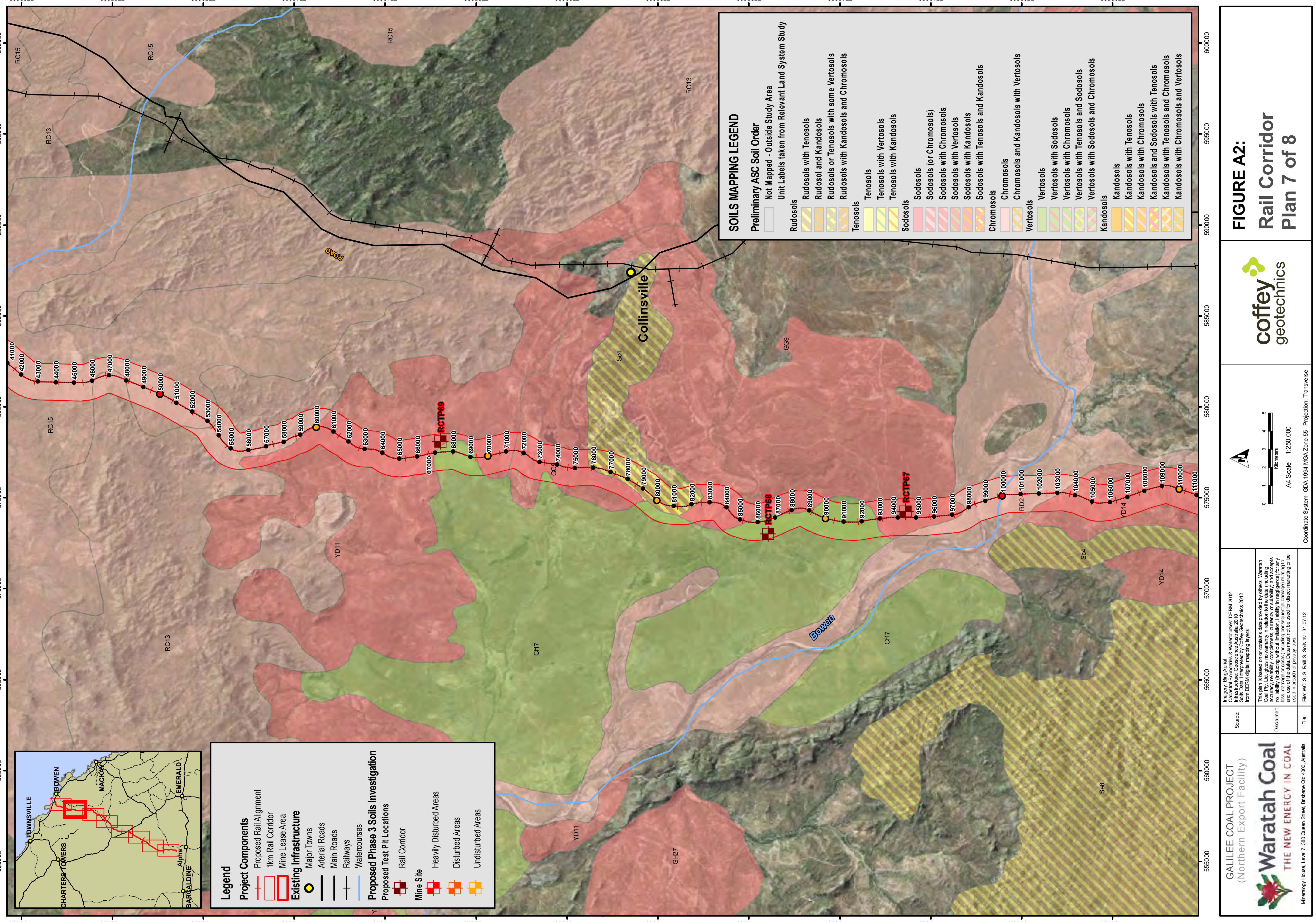
FIGURE A2:
Rail Corridor
Plan 7 of 8
SOILS MAPPING LEGEND
Preliminary ASC Soil Order
Not Mapped - Outside Study Area
Unit Labels taken from Relevant Land System Study
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
Proposed Phase 3 Soils Investigation
Proposed Test Pit Locations
Rail Corridor
Mine Site
Heavily Disturbed Areas
Disturbed Areas
Undisturbed Areas
Collinsville
Bowen
RCTP69
RCTP68
RCTP67
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE
A4 Scale 1:250,000
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
coffey geotechnics

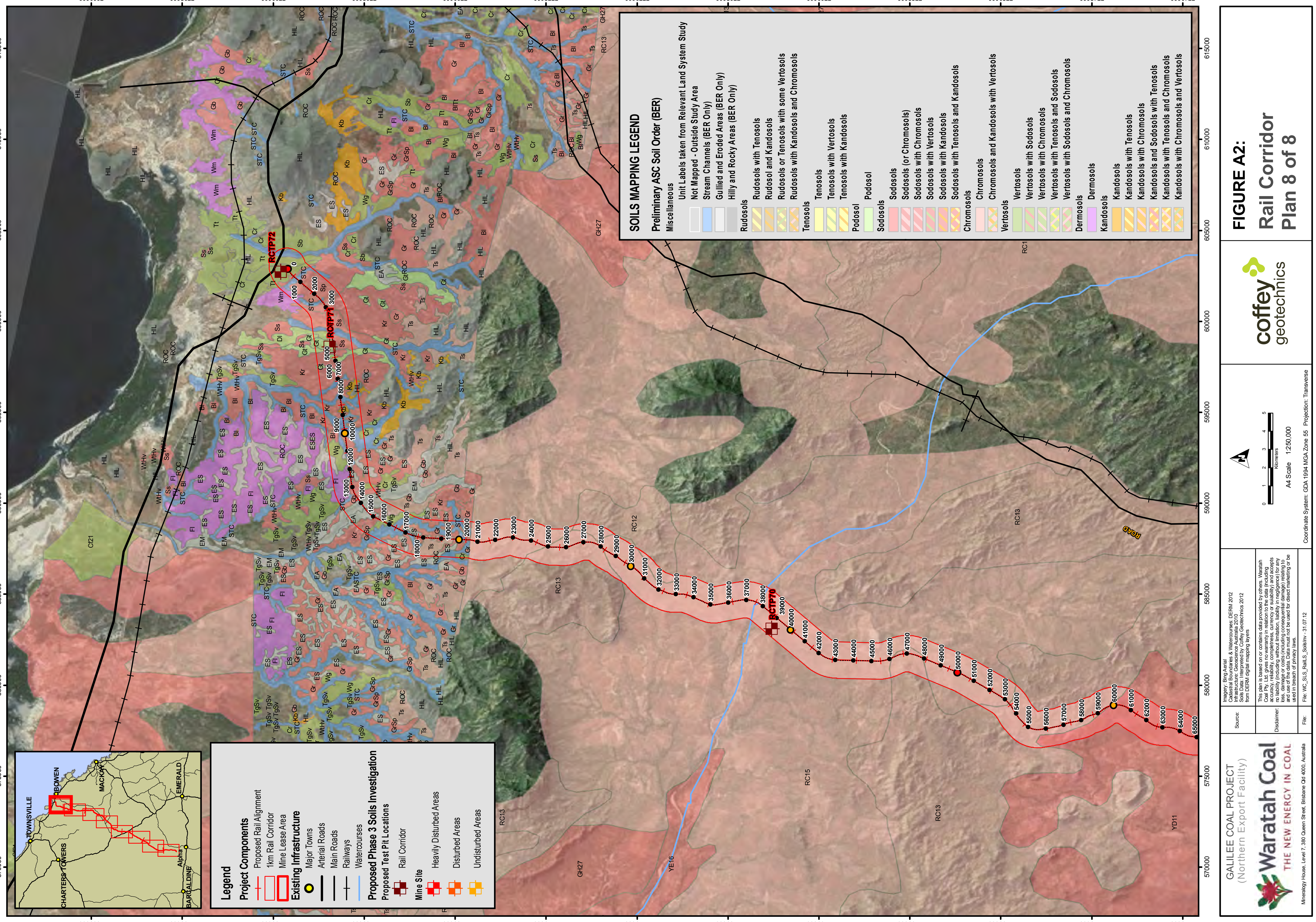

FIGURE A2:
Rail Corridor
Plan 8 of 8
coffey geotechnics
GALILEE COAL PROJECT
(Northern Export Facility)
Waratah Coal
THE NEW ENERGY IN COAL
SOILS MAPPING LEGEND
Preliminary ASC Soil Order (BER)
Miscellaneous
Unit Labels taken from Relevant Land System Study
Not Mapped - Outside Study Area
Stream Channels (BER Only)
Gullied and Eroded Areas (BER Only)
Hilly and Rocky Areas (BER Only)
Rudosols
Rudosols with Tenosols
Rudosol and Kandosols
Rudosols or Tenosols with some Vertosols
Rudosols with Kandosols and Chromosols
Tenosols
Tenosols
Tenosols with Vertosols
Tenosols with Kandosols
Podosol
Podosol
Sodosols
Sodosols
Sodosols (or Chromosols)
Sodosols with Chromosols
Sodosols with Vertosols
Sodosols with Kandosols
Sodosols with Tenosols and Kandosols
Chromosols
Chromosols
Chromosols and Kandosols with Vertosols
Vertosols
Vertosols
Vertosols with Sodosols
Vertosols with Chromosols
Vertosols with Tenosols and Sodosols
Vertosols with Sodosols and Chromosols
Dermosols
Dermosols
Kandosols
Kandosols
Kandosols with Tenosols
Kandosols with Chromosols
Kandosols and Sodosols with Tenosols
Kandosols with Tenosols and Chromosols
Kandosols with Chromosols and Vertosols
Legend
Project Components
Proposed Rail Alignment
1km Rail Corridor
Mine Lease Area
Existing Infrastructure
Major Towns
Arterial Roads
Main Roads
Railways
Watercourses
Proposed Phase 3 Soils Investigation
Proposed Test Pit Locations
Rail Corridor
Mine Site
Heavily Disturbed Areas
Disturbed Areas
Undisturbed Areas
TOWNSVILLE
BOWEN
MACKAY
CHARTERS TOWERS
EMERALD
Alpha
BARCALDINE
RCTP72
RCTP71
RCTP70
ROAD
A4 Scale 1:250,000
Kilometres
Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse

# Appendix B

## Soil and Land Management Unit Characteristics

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | BR1 | 12 | Backplains | Brown and grey uniform cracking clay soils with thin self-mulching topsoils and sodic subsoils | Vertosols | Sodic, dispersive subsoils, but water erosion not reported to be problematic | M | Cohesive clay soils | L | C1 | * Heavy clay soils with low available moisture for plant growth, but wide cracks allow rainwater to rapidly infiltrate soils during rainstorms. * Waterlogging (especially associated with gilgai depressions) causing trafficability and stock movement problems during wet periods. *Reactive soils/gilgai microrelief, sufficient to cause damage to structures and plants. * Sodic, saline subsoils. *Supports unique flora/fauna communities. * Production limited by lack of moisture rather than fertility (with a short growing season. * Overgrazing changes pasture composition to annuals, severely reducing productivity. | Improved pasture | 3 |
| DUSLARA | BR2 | 10 | Alluvial terraces | Very deep red gradational soils with sandy loam topsoils and light clay subsoils | Kandosols | Surface soils susceptible to sheet erosion | M | Sandy loam topsoils | M | D | * Very low nutrients. * Supports riparian habitat that provides important corridors for wildlife. * Provides crucial stabilisation for creek banks, traps nutrients and maintains water quality. * Susceptible to weed infestation. * Narrow ribbons of land are difficult to manage differently to surrounding areas. | Unsuitable for agricultural use due to catchment values | 2 |
| DUSLARA | BR4 | 10 | Streambed and levees | Young sandy deposits with little or no profile development | Rudosols or Tenosols with some Vertosols in low lying areas | Loose, unstable sandy soils which are well-drained and prone to cattle podding erosion. Vertosols are less erodible | M/ H | Loose sandy soils. Vertosols are less erodible | L/ H | D | * Well-drained soils, which can be mobilised during frequent flooding. * Very low nutrients. * Supports riparian habitat that provides important corridors for wildlife. * Provides crucial stabilisation for creek banks, traps nutrients and maintains water quality. * Susceptible to weed infestation. * Narrow ribbons of land are difficult to manage differently to surrounding areas. | Unsuitable for agricultural use due to catchment values | 2 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | CC2 | 8 | Plain | Very deep, red, gradational soils with some uniform sandy and texture contrast soils | Kandosols with some Tenosols and Chromosols | Topsoils susceptible to sheet erosion and livestock podding. Sandy soils well drained but loose. | M | Hardsetting or clay topsoils, some loose sandy soils | L/H | C2 | * Well-drained but susceptible to water erosion. * Topsoils susceptible to sheet erosion. * Changes to vegetation cover can cause devegetation and soil degradation unless pastures are intensively managed. * Introduction of pasture species unsustainable due to low soil nutrients. * Livestock podding erosion can damage vegetation. * Revegetation of areas where topsoil has been eroded is difficult and slow. | Low intensity grazing on native pasture | 4 |
| DUSLARA | CE2 | 1 | Scarp with steep slopes and cliffs of massive ironstone | Shallow, rocky reddish-brown gradational soils | Kandosols | Sheet/gully erosion of shallow soils above bedrock | M | Soil texture not susceptible to wind erosion | L | C2 | * Shallow, gravelly soils. * Low to very low water storage capacity. * Topsoils susceptible to compaction and sheet erosion. * Areas of run-off affected by sheet and gully erosion. * Low nutrients and phosphorous deficiency. * Rooting depth constrained by bedrock within 1m of surface. * Poor plant growth conditions, maintains sparse coverage; low pasture yield. | Low intensity grazing on native pasture | 4 |
| DUSLARA | CE3 | 1 | Steep slopes | Shallow gradational soils with exposed sandstone bedrock | Kandosols | Sheet/gully erosion of shallow soils above bedrock | M | Soil texture not susceptible to wind erosion | L | C2 | * Shallow, gravelly soils. * Low to very low water storage capacity. * Topsoils susceptible to compaction and sheet erosion. * Areas of run-off affected by sheet and gully erosion. * Low nutrients and phosphorous deficiency. * Rooting depth constrained by bedrock within 1m of surface. * Poor plant growth conditions, maintains sparse coverage; low pasture yield. | Low intensity grazing on native pasture | 4 |
| DUSLARA | CE4 | 9 | Lower slopes | Deep reddish-brown gradational and texture-contrast profiles, with some uniform clay soils | Chromosols (Sodosols) and Kandosols (Dermosols), with Vertosols | Variable soil types | M | Clay and sandy loam topsoils | L/M | C2 | * Hardpans limit rooting depth and deep water movement, but reduce water percolation below root zone. * Low nutrients. * Ground cover of 30% - 40% required for sufficient infiltration and to reduce runoff and erosion. Overgrazing causes weeds to take over - frequent livestock paddock rotation is required. | Low intensity grazing on native pasture | 3 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | CE5 6 | | Drainage depressions and alluvial terraces | Fine sandy and silty loam textures in deep uniform and gradational soil profiles | Tenosols in drainage depressions and Kandosols on upper slopes | Surface soils susceptible to sheet erosion | M | Fine sandy topsoils | H | C 2 | * Well-drained soils - important habitat for native fauna. * Sheet erosion, especially where vegetation has been removed; or where the vegetation coverage has been changed. * Prone to seasonal flooding and gully erosion (exacurbated by excavation). * Overgrazing can allow introduced species and weeds to take over. | Low intensity grazing on native pasture | 4 |
| DUSLARA | CO2 1 | | Scarp | Shallow, reddish-brown gradational soils, often with ferricrete or pallid zone | Kandosols | Sheet/gully erosion of shallow soils above hardpan | M | Soil texture not susceptible to wind erosion | L | C2 | * Shallow, gravelly soils. * Low to very low water storage capacity. * Topsoils susceptible to compaction and sheet erosion. * Areas of run-off affected by sheet and gully erosion. * Low nutrients and phosphorous deficiency. * Rooting depth constrained by hardpan (ferricrete) within 1m of surface. * Poor plant growth conditions, maintains sparse coverage; low pasture yield. | Low intensity grazing on native pasture | 4 |
| DUSLARA | CO3 9 | | Footslopes | Deep red-brown texture contrast soils with sodic clay subsoils | Sodosol | Sodic, dispersive subsoils | H | Probably sandy loam topsoils | M | C2 | * Hardpans limit rooting depth and deep water movement, but reduce water percolation below root zone. * Low nutrients. * Ground cover of 30% - 40% required for sufficient infiltration and to reduce runoff and erosion. Overgrazing causes weeds to take over - frequent livestock paddock rotation is required. | Low intensity grazing on native pasture | 3 |
| DUSLARA | CO4 8 | | Alluvial fans | Very deep uniform sandy soils with weak horizon development | Tenosols | Loose sandy soils which are well-drained | M | Loose sandy soils | H | C 2 | * Well-drained with very low water holding capacity. * Changes to vegetation cover can cause devegetation and soil degradation unless pastures are intensively managed. * Introduction of pasture species unsustainable due to low soil nutrients. * Livestock podding erosion can damage vegetation. * Revegetation of areas where topsoil has been eroded is difficult and slow. | Low intensity grazing on native pasture | 4 |

B3

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | CO5 | 10 | Drainage depressions | Variable soils with deep uniform sands dominant | Tenosols | Loose, unstable sandy soils which are prone to cattle podding erosion | H | Loose sandy soils | H | D | * Well-drained soils, which can be mobilised during frequent flooding. * Very low nutrients. * Supports riparian habitat that provides important corridors for wildlife. * Provides crucial stabilisation for creek banks, traps nutrients and maintains water quality. * Susceptible to weed infestation. * Narrow ribbons of land are difficult to manage differently to surrounding areas. | Unsuitable for agricultural use due to catchment values | 2 |
| DUSLARA | DA1 | 8 | Upper slopes of alluvial fans | Moderately deep texture contrast soils with sandy loam topsoils over reddish brown sandy clay subsoils. Hardpan usually present below 0.5m | Chromosols | Topsoils susceptible to sheet erosion and livestock podding | M | Hardsetting sandy loam topsoils | L | C2 | * Well-drained but susceptible to water erosion. * Topsoils susceptible to sheet erosion. * Changes to vegetation cover can cause devegetation and soil degradation unless pastures are intensively managed. * Introduction of pasture species unsustainable due to low soil nutrients. * Livestock podding erosion can damage vegetation. * Revegetation of areas where topsoil has been eroded is difficult and slow. | Low intensity grazing on native pasture | 4 |
| DUSLARA | DA2 | 8 | Lower slopes of alluvial fans | Moderately deep texture contrasts soils overlying hardpan at about 1.5m deep | Sodosols | Dispersive, sodic subsoils. Topsoils susceptible to sheet erosion and livestock podding. | H | Hardsetting sandy loam topsoils | L | C2 | * Topsoils susceptible to compaction and hardsetting (leading to high runoff) and sheet erosion. * Native vegetation has adapted to sodic soils: changes to vegetation cover can cause devegetation and soil degradation unless pastures are intensively managed. * Introduction of pasture species unsustainable due to low soil nutrients. * Livestock podding erosion can damage vegetation. * Revegetation of areas where topsoil has been eroded is difficult and slow. | Low intensity grazing on native pasture | 4 |

B4

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | DA3 6 | | Drainage depressions | Variable soils with very deep reddish-brown gradational profiles most common | Variable with dominant Kandosols | Surface soils susceptible to sheet erosion. | M | Variable soil textures | L | C2 | * Better moisture supply and longer growing season than most other units - important habitat for native fauna. * Prone to high volume surface water flows. * Sheet erosion, especially where vegetation has been removed; or where the vegetation coverage has been changed. * Prone to seasonal flooding and gully erosion (exacurbated by excavation). * Overgrazing can allow introduced species and weeds to take over. | Low intensity grazing on native pasture | 4 |
| DUSLARA | GT1 3 | | Plain | Very deep, red, sandy uniform and gradational soils | Kandosols (possibly Dermosols) | Loose sandy topsoils prone to erosion; increased runoff causes subsequent subsoil erosion | M | Loose sandy topsoils | H | C 2 | * Low nutrients, well-drained and leached. * Hard crusting of subsoils if topsoils eroded, reducing infiltration and increasing runoff. *Low potential for increased productivity, requiring additional water and nutrients. * Introduced pasture species can result in long-term disturbance and land degradation, as native plants have adapted to low nutrients. * Low lying areas can have slightly better nutrients and moisture holding capacity, and are thus prone to overgrazing. * Natural regeneration takes considerable time | Low intensity grazing on native pasture | 4 |
| DUSLARA | JJ1 3 | | Upper slopes | Deep, red, loamy sand gradational soils | Kandosols | Topsoils moderately likely to erode; increased runoff causes subsequent subsoil erosion | L | Loose sandy topsoils | H | C 2 | * Low nutrients, well-drained and leached. * Hard crusting of subsoils if topsoils eroded, reducing infiltration and increasing runoff. *Low potential for increased productivity, requiring additional water and nutrients. * Introduced pasture species can result in long-term disturbance and land degradation, as native plants have adapted to low nutrients. * Low lying areas can have slightly better nutrients and moisture holding capacity, and are thus prone to overgrazing. * Natural regeneration takes considerable time | Low intensity grazing on native pasture | 4 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | JJ2 1 | | Crests and upper slopes | Shallow red to yellowish brown texture contrast soils with sandy loam topsoils and ironstone hardpan within 0.5m of surface | Chromosols | Sheet/gully erosion of shallow soils | M | Soil texture not susceptible to wind erosion | L | C2 | * Shallow, gravelly soils. * Low to very low water storage capacity. * Topsoils susceptible to compaction and sheet erosion. * Areas of run-off affected by sheet and gully erosion. * Low nutrients and phosphorous deficiency. * Rooting depth constrained by hardpan (ironstone) within 0.5m of surface. * Poor plant growth conditions, maintains sparse coverage; low pasture yield. | Low intensity grazing on native pasture | 4 |
| DUSLARA | JJ3 1 | | Scarps | Shallow, stony, red-brown gradational soils, often with ironstone hardpan exposed | Kandosols | Sheet/gully erosion of shallow soils above hardpan | M | Soil texture not susceptible to wind erosion | L | C2 | * Shallow, gravelly soils. * Low to very low water storage capacity. * Topsoils susceptible to compaction and sheet erosion. * Areas of run-off affected by sheet and gully erosion. * Low nutrients and phosphorous deficiency. * Rooting depth constrained by hardpan (ironstone, silcrete, calcrete) within 1m of surface. * Poor plant growth conditions, maintains sparse coverage; low pasture yield. | Low intensity grazing on native pasture | 4 |
| DUSLARA | JJ4 9 | | Lower slopes | Deep texture contrast profiles with sandy loam topsoils and yellowish-brown clayey subsoils | Chromosols | Deep, clayey subsoils | M | Sandy loam topsoils | M | C2 | * Hardpans limit rooting depth and deep water movement, but reduce water percolation below root zone. * Low nutrients. * Ground cover of 30% - 40% required for sufficient infiltration and to reduce runoff and erosion. Overgrazing causes weeds to take over - frequent livestock paddock rotation is required. | Low intensity grazing on native pasture | 3 |
| DUSLARA | JJ5 6 | | Drainage depressions | Texture contrast profiles with sodic, mottled clay subsoils. A sandy wash layer may be present | Sodosols with Vertosols in closed drainage depressions | Surface soils susceptible to sheet erosion. Dispersive, sodic subsoils susceptible to gully erosion. | H | Loose sandy topsoils | H | C 2 | * Better moisture supply and longer growing season than most other units - important habitat for native fauna. * Prone to high volume surface water flows. * Sheet erosion and salinity scalding, especially where vegetation has been removed; or where the vegetation coverage has been changed. * Sodic, low permeability clay subsoils. * Prone to seasonal flooding and gully erosion (exacurbated by excavation). * Overgrazing can allow introduced species and weeds to take over. | Low intensity grazing on native pasture | 4 |

B6

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | JJ6 8 | | Alluvial fans | Very deep, reddish-brown, uniform sandy loams [wash?] overlying buried clay soil | Chromosol/Sodosol | Topsoils susceptible to sheet erosion and livestock podding. Subsoils can be sodic and dispersive | M/ H | Hardsetting sandy loam topsoils | L | C2 | * Topsoils susceptible to compaction and hardsetting (leading to high runoff) and sheet erosion; subsoils can be sodic and dispersive. * Changes to vegetation cover can cause devegetation and soil degradation unless pastures are intensively managed. * Introduction of pasture species unsustainable due to low soil nutrients. * Livestock podding erosion can damage vegetation. * Revegetation of areas where topsoil has been eroded is difficult and slow. | Low intensity grazing on native pasture | 4 |
| DUSLARA | LC1 8 | | Alluvial plains | Reddish-brown gradational soils with minor occurrences of texture contrast and uniform clay profiles | Kandosols with Chromosols and Vertosols | Topsoils susceptible to sheet erosion and livestock podding. | M | Hardsetting or clay topsoils | L | C2 | * Changes to vegetation cover can cause devegetation and soil degradation unless pastures are intensively managed. * Introduction of pasture species unsustainable due to low soil nutrients. * Livestock podding erosion of topsoils can damage vegetation. * Revegetation of areas where topsoil has been eroded is difficult and slow. | Low intensity grazing on native pasture | 4 |
| DUSLARA | LC2 1 | 4 | Backplains | Brown, uniform cracking clay soils with pronounced gilgai | Vertosols | Dense clay soils | L | Dense clay soils | L | C1 | * Critical habitat/wetlands supporting unique flora and fauna * Prone to inundation for extended periods and soils can remain saturated after flooding * Improved pasture crops limited to annuals, as most species cannot cope with inundation * Saline subsoils *Gilgai microrelief | Improved pasture | 3 |
| DUSLARA | LC3 1 | 0 | Drainage depressions | Variable soils with uniform sandy loam profiles most common | Tenosols | Loose, unstable sandy soils which are well-drained and prone to cattle podding erosion | H | Loose sandy soils | H | D | * Well-drained soils, which can be mobilised during frequent flooding. * Very low nutrients. * Supports riparian habitat that provides important corridors for wildlife. * Provides crucial stabilisation for creek banks, traps nutrients and maintains water quality. * Susceptible to weed infestation. * Narrow ribbons of land are difficult to manage differently to surrounding areas. | Unsuitable for agricultural use due to catchment values | 2 |

B7

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | LM1 8 | | Upper slopes of alluvial fans | Deep, texture contrast soils with thick loamy sand topsoils over reddish-yellow sodic clay loams, with hardpan at about 1.2m | Sodosols with Kandosols on upper slopes | Topsoils susceptible to sheet erosion and livestock podding. Sodic, dispersive subsoils. | M/ H | Hardsetting sandy loam topsoils | L | C2 | * Well-drained but susceptible to water erosion. * Topsoils susceptible to sheet erosion, with dispersive subsoils. * Changes to vegetation cover can cause devegetation and soil degradation unless pastures are intensively managed. * Introduction of pasture species unsustainable due to low soil nutrients. * Livestock podding erosion can damage vegetation. * Revegetation of areas where topsoil has been eroded is difficult and slow. | Low intensity grazing on native pasture | 4 |
| DUSLARA | LM2 6 | | Lower slopes of alluvial fans | Very deep texture contrast soils with thick sandy loam topsoils and mottled sodic sandy clay subsoils | Sodosols with some Kandosols on upper slopes | Surface soils susceptible to sheet erosion. Dispersive, sodic subsoils susceptible to gully erosion. | H | Loose sandy topsoils | H | C 2 | * Better moisture supply and longer growing season than most other units - important habitat for native fauna.* Prone to high volume surface water flows. * Sheet erosion and salinity scalding, especially where vegetation has been removed; or where the vegetation coverage has been changed. * Sodic, low permeability clay subsoils. * Prone to seasonal flooding and gully erosion (exacurbated by excavation). * Overgrazing can allow introduced species and weeds to take over. | Low intensity grazing on native pasture | 4 |
| DUSLARA | LM3 6 | | Drainage depressions | Deep texture contrast profiles and uniform sandy loam profiles | Sodosol with some Tenosols/Kandosol s | Surface soils susceptible to sheet erosion. Dispersive, sodic subsoils susceptible to gully erosion. | H | Loose sandy topsoils | H | C 2 | * Better moisture supply and longer growing season than most other units - important habitat for native fauna.* Prone to high volume surface water flows. * Sheet erosion and salinity scalding, especially where vegetation has been removed; or where the vegetation coverage has been changed. * Sodic, low permeability clay subsoils. * Prone to seasonal flooding and gully erosion (exacurbated by excavation). * Overgrazing can allow introduced species and weeds to take over. | Low intensity grazing on native pasture | 4 |

B8

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | SP1 | 1 | Crests and upper slopes | Shallow uniform sands and sandy loams with a ferricrete hardpan at less than 0.5m depth | Rudosols (and Tenosols) | Sheet/gully erosion of shallow soils above hardpan | M | Soil texture not susceptible to wind erosion | L | C2 | * Shallow, gravelly soils. * Low to very low water storage capacity. * Topsoils susceptible to compaction and sheet erosion. * Areas of run-off affected by sheet and gully erosion. * Low nutrients and phosphorous deficiency. * Rooting depth constrained by hardpan (ferricrete) within 0.5m of surface. * Poor plant growth conditions, maintains sparse coverage; low pasture yield. | Low intensity grazing on native pasture | 4 |
| DUSLARA | SP2 | 9 | Plains | Very deep texture contrast soils with thick sandy loam topsoils over red to reddish brown clays | Sodosols (or Chromosols) | Sodic, dispersive subsoils | H | Sandy loam topsoils | M | C2 | * Hardpans limit rooting depth and deep water movement, but reduce water percolation below root zone. * Low nutrients. * Ground cover of 30% - 40% required for sufficient infiltration and to reduce runoff and erosion. Overgrazing causes weeds to take over - frequent livestock paddock rotation is required. | Low intensity grazing on native pasture | 3 |
| DUSLARA | SP3 | 6 | Drainage depressions and low lying areas | Young sandy soils of variable depth and deep, uniform cracking clay soils in closed depressions | Tenosols on floodplains with Vertosols in closed drainage depressions | Loose alluvial soils susceptible to sheet erosion. Dispersive, sodic clay soils susceptible to gully erosion. | H | Loose sandy Tenosols are prone to wind erosion (M), clay Vertosols are not suscepible to wind erosion (L) | L/ M | C2 | * Vertosols have better moisture supply and longer growing season than most other units. * Vertosols prone to high volume surface water flows. * Sheet erosion (Tenosols) and salinity scalding (Vertosols), especially where vegetation has been removed; or where the vegetation coverage has been changed. * Sodic, low permeability clay Vertosols. * Prone to seasonal flooding and gully erosion (exacurbated by excavation). * Overgrazing can allow introduced species and weeds to take over. | Low intensity grazing on native pasture | 4 |
| DUSLARA | TS1 | 8 | Alluvial fans, upper and middle slopes | Deep, texture-contrast soils with sandy loam topsoils and yellowish brown, mottled sandy clay subsoils. | Sodosols with Chromosols on upper slopes | Topsoils susceptible to sheet erosion and livestock podding. Subsoils can be sodic and dispersive | M/ H | Hardsetting sandy loam topsoils | L | C2 | * Well-drained but susceptible to water erosion. * Topsoils susceptible to sheet erosion, with dispersive subsoils. * Changes to vegetation cover can cause devegetation and soil degradation unless pastures are intensively managed. * Introduction of pasture species unsustainable due to low soil nutrients. * Livestock podding erosion can damage vegetation. * Revegetation of areas where topsoil has been eroded is difficult and slow. | Low intensity grazing on native pasture | 4 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUSLARA | TS3 6 | | Drainage depressions | Deep, variable soils. Hardpans exposed in creek beds | Sodosol in drainage depressions | Surface soils susceptible to sheet erosion. Dispersive, sodic subsoils susceptible to gully erosion. | H | Loose sandy topsoils | H | C 2 | * Better moisture supply and longer growing season than most other units - important habitat for native fauna.* Prone to high volume surface water flows. * Sheet erosion and salinity scalding, especially where vegetation has been removed; or where the vegetation coverage has been changed. * Sodic, low permeability clay subsoils. * Prone to seasonal flooding and gully erosion (exacurbated by excavation). * Overgrazing can allow introduced species and weeds to take over. | Low intensity grazing on native pasture | 4 |
| ZCQ | Al | Alpha | Higher alluvial plains and terraces | Deep red and yellow earths (Wilpeena) and texture contrast soils (Luxor and Taurus), on plains and terraces, minor alluvial soils (Davy and Warrinilla). | Kandosols and Sodosols, with some alluvial Tenosols/ Kandosols | Surface erosion of texture contrast soils; gradational/uniform soils moderately erodible, some sodic subsoils | M/H | Sandy and loamy topsoils susceptible to wind erosion | M | C2 | * Low nutrients. * Moderate to severe restriction to plant growth due to hardpan/surface crusting. * Some areas of dispersive, sodic subsoils | Limited improved pasture | 3 |
| ZCQ | Av | Avon | Clay plains and gently undulating lowlands. Very shallow open valleys and poorly drained clay plains | Cracking clay soils (Logan). | Vertosols | Cohesive clay soils, but erodible when disturbed | M | Cohesive clay soils | L | B | * Strongly alkaline at surface, becoming slightly to strongly acidic at depth. * Moderate to large quantities of gypsum (moderately saline). * Moderate restriction to workability. *Poorly drained and frequently waterlogged. * Plant growth limited by lack of rainfall, rather than poor nutrients | Limited cropland requiring considerable improvement | 4 |
| ZCQ | Bl | Blackwater | Plains, lowlands, level to gently undulating | Cracking clay soils (Rolleston) and texture contrast (Retro) on rises/upper slopes. | Vertosols (Sodic subsoils) on plains/ Chromosols on upper slopes | Sheet erosion of thin surface soils; cohesive clay subsoils, but erodible when disturbed | M | Clay or sandy clay loam topsoils prone to surface crusting | L | C2 | * Moderate restriction to plant growth due to hardpan/surface crusting. * Moderately saline subsoils, which tend to be either sodic and strongly acid (Vertosols) or strongly alkaline (Chromosols). * Vertosols have moderate fertility | Limited improved pasture | 4 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZCQ | Bo | Borilla | Rocky hills, strike ridges. | Shallow soils (Shotover) with minor shallow uniform coarse textured soils (Petrona). | Rudosols with Tenosols on lower slopes | Erodible soils, but only on steeper slopes than encountered | L | Shallow, gravelly soils | L | D | * Shallow, acidic soils. * Stony ground makes machine use impractical | Forestry or wildlife conservation areas | 2 |
| ZCQ | By | Banchory | Alluvial clay plains and narrow silty levees | Cracking clay soils (Vermont) uniform medium to heavy clays and some texture-contrast (Wyseby and Retro). | Vertosols on alluvial plains, Chromosols and Sodosols on levees and higher alluvial plains | Cohesive clay soils, but erodible when disturbed | M | Cohesive clay soils | L | B | * Pasture cropping limited by short growing season, rather than other limitations. * Vertosols have moderate fertility. * Moderate restriction to plant growth due to hardpan/surface crusting. * Moderately saline soils | Limited cropland requiring considerable improvement | 3 |
| ZCQ | Ct | Comet | Alluvial clay plains with some weathered clays | Cracking clay soils (Vermont), texture contrast soils (Taurus and Retro) with thin sandy/loamy surface soils and strongly alkaline subsoils. | Vertosols and Sodosols on lower slopes, Chromosols on upper slopes | Cohesive, but sodic, dispersive clay subsoils: erodible when disturbed. Sheet wash of surface soils | H | Thin sandy to sandy loam topsoils | M | C1 | * Pasture cropping limited by short growing season, rather than other limitations. * Vertosols have moderate fertility. * Frequent waterlogging. * Moderate restriction to plant growth due to hardpan/surface crusting. | Improved pasture/ native pasture | 4 / 2 |
| ZCQ | D | Disney | Small lateritic mesas surrounded by gently undulating slopes | Red and yellow earths (Dunrobin and Struan) minor sandy earths (Annandale and Forrester) on upper slopes. Uniform coarse textured soils (Petrona and Highmount) on aprons. | Mainly loamy Kandosols, with sandy Kandosols on rises and mesas and Tenosols on aprons of slopes | Surface soils prone to sheet erosion | M | Sandy loam and sandy clay loam topsoils | M | C2 | * Well-drained soils with moderate water storage capacity but low to very low nutrients. * Prone to sheet erosion | Limited improved pasture | 3 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZCQ | Hu | Humboldt | Lowland plains with no hills | Cracking clay soils (Rolleston) (possibly with some texture contrast soils with thin topsoils and gravelly subsoils (Retro, Springwood, Taurus and Wyseby) | Vertosols with some Sodosols | Cohesive, but sodic, dispersive clay subsoils: erodible when disturbed. Sheet wash of surface soils | H | Cohesive clay soils, some thin sandy soils | L | C1 | * Pasture cropping limited by short growing season, rather than other limitations. * Vertosols have moderate fertility. * Moderately saline with sodic subsoils. * Prone to compaction | Improved pasture | 3 |
| ZCQ | I | Islay | Plains with gilgaied clay soils; lowlands and depressions | Deep, gilgaied clay soils (Pegunny) and texture contrast (Retro) with deep cracking clays (Rolleston) on footslopes | Vertosols with Sodosols on footslopes | Cohesive, but sodic, dispersive clay subsoils: erodible when disturbed. Sheet erosion of surface soils | H | Cohesive clay soils, some thin sandy soils | L | C1 | * Gilgai microrelief. * Clay soils prone to compaction. * Erosion on shallow slopes. * Sodic, saline subsoils. * Surface crusting can cause plant growth restriction | Improved pasture | 3 |
| ZCQ | L | Loudon | Low hills: breakaways, rocky hills, steep strike ridges and undulating lowlands | Mainly shallow rocky soils (Rugby and Shotover) with minor red and yellow earths (Dunrobin and Struan). Texture contrast soil (Southernwood, Luxor and Broadmeadow) on undulating lowlands | Rudosols with Kandosols and Chromosols/ Sodosols on undulating lowlands | Sheet erosion and gullying | H | Shallow, gravelly soils but some deeper soils with sandy topsoils | M | C3 | * Stoniness makes use of machinery impracticable. * Shallow, stony (often sodic) soils, moderately affected by salinity. | Low intensity grazing on native pasture | 3 / 4 |
| ZCQ | Le | Lennox | Level to gently undulating plains | Loamy yellow earths (Struan), loamy red earths (Dunbrobin), sandy red and yellow earths (Annandale and Forrester). | Kandosols | Prone to sheet erosion and some gullying | M | Sandy and loamy topsoils susceptible to wind erosion | H | C 2 | * Low nutrients and low available water capacity. * Often require clearance of woodlands. * Prone to sheet erosion and occasional gullying (latter associated with steep slopes) | Low intensity grazing on native pasture | 3 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZCQ | Mo | Monteagle | Level to undulating plains with some gullying, minor sandy fans and old alluvial terraces | Deep texture contrast soils with variable texture and depth topsoils. Shallow texture-contrast soils with alkaline subsoils in the north (Medway). | Sodosols on lower slopes with some Chromosols on upper slopes | Sodic, dispersive soils prone to gullying | H | Sandy and loamy topsoils susceptible to wind erosion | H C | 2 | * Surface crusting of sodic soils likely to restrict plant growth. * Slightly to moderatly affected by salinity. * Erosion on shallow slopes. | Low intensity grazing on native pasture | 3 |
| ZCQ | My | Moray | Clay plains and gently undulating lowlands with patches of sand and gravel | Deep cracking, self-mulching clay soils (Natal), some gypseous clay soils (Logan) - mottled subsoils. | Vertosols | Cohesive clay soils, but erodible when disturbed | M | Cohesive clay soils | L B | | * Clay soils are prone to compaction. * Moderately saline soils. * Strongly alkaline and sodic at depth | Limited cropland requiring considerable improvement | 3 |
| ZCQ | Ru | Rutland | Lowlands and low hills | Shallow to moderately deep texture contrast soils (Medway, Taurus, Retro) with alkaline subsoils. Some deep cracking clay soils (Teviot) | Sodosols with some Vertosols | Sodic, dispersive soils prone to gullying. Sheet erosion of surface soils. | H | Sandy and loamy topsoils susceptible to wind erosion | H C | 1 | * Tillage restricted by gravelly soils. * Surface crusting restricts plant growth. | Improved pasture | 4 |
| ZCQ | So | Somerby | Plains, weathered clay | Cracking clay soils (Pegunny and Rolleston), with some texture contrast soils (Retro) | Vertosols and some Sodosols | Cohesive, but sodic clay subsoils: erodible when disturbed. | M | Cohesive clay soils and thin sandy soils | L C | 1 | * Gilgai microrelief, with some large melonhole gilgai. * Moderately to seriously affected by salinity. * Clay soils prone to compaction. | Improved pasture | 2 |
| ZCQ | Ti | Tichbourne | Plains, undulations, level to low hills. Some sandy colluvial fans | Loamy red and yellow earths (Dunrobin and Struan) some sandy yellow earths (Forrester) and texture contrast soils (Luxor and Taurus) on fans | Kandosols with Chromosols on fans | Prone to sheet erosion and some gullying | M | Sandy and loamy topsoils susceptible to wind erosion | H C | 2 | * Low nutrients and low available water capacity. *Plant growth limited by low rainfall. * Often require clearance of woodlands. * Prone to sheet erosion and occasional gullying (latter associated with steep slopes) | Low intensity grazing on native pasture | 3 |

B13

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZEB | Cc8 | | Alluvial floodplains associated with major streams, often dissected by numerous channels. Subject to irregular flooding | Deep grey clays with lesser dark or brown deep clays | Grey (and Brown) Vertosols | Susceptible to gully erosion | H | Associated duplex soils susceptible to wind erosion of topsoils | M | C1 | * Although suitable for cultivation, low/variable rainfall, high evaporation and unavailability of irrigation water is a serious limitation. * Irregular flooding. * Moderate gilgai microrelief. * Clay soils prone to compaction. | Improved pasture | 3 |
| ZEB | Cd12 | | Level plains with slight to moderate gilgai (1-2'), occasionally stronger. Some areas subject to flooding | Very deep grey clays, less commonly brown clays | Grey (and Brown) Vertosols | | | | | | | | |
| ZEB | Cf17 | | Undulating lands with gently sloping plains and moderate to high stony ridges and low stony basalt hills | Medium to deep dark clays on plains and lower ridge slopes, with some linear gilgai | Black Vertosols | Cohesive clay soils, but erodible if disturbed | M | Cohesive clay soils | L | C1 | * Often stony with low phosphorous levels. * Gilgai microrelief. * Clay soils prone to compaction. * Irregular flooding | Improved pasture | 2 |
| ZEB | Cf21 | | Level plains | Deep dark cracking clays with lesser grey clays, often with slight gilgai | Black Vertosols | Cohesive clay soils, but erodible if disturbed | M | Cohesive clay soils | L | C1 | * Often stony with low phosphorous levels. * Minor gilgai microrelief. * Clay soils prone to compaction. * Irregular flooding | Improved pasture | 2 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZEB | GA34 | | Undulating lands with many low sandstone mesas, lateritic scarps and their dissected remnants | Shallow/moderately deep pale mottled yellow/grey clay subsoils on higher elevation, sloping sites | Kurosols (or Sodosols) | Sodic, dispersive subsoils and sandy topsoils | H | Sandy, but stony, topsoils | M | C3 | * Waterlogging due to dense clay subsoils. * Shallow, stony soils. * Topographic constraints. * Low nutrient status. | Low intensity grazing on native pasture or Forestry | 2 |
| ZEB | GG6 | | Moderately undulating lands with broad valleys | Shallow/moderately deep sandy or loamy-surfaced alkaline bleached duplex soils | Sodosols | Sodic, dispersive subsoils and sandy topsoils | H | Sandy and loamy topsoils | H | C1 | * Dense clay subsoils which cause waterlogging and impede root penetration. * Can be shallow and stony. * Very low nutrient status, but suitable for improvement through clearance and fertilisation. | Improved pasture | 3 |
| ZEB | GG9 | | Moderately to strongly undulating lands with occasional high strike ridges and sandstone outcrops | Shallow/moderately deep loamy surfaced alkaline bleached duplex soils | Sodosols | Sodic, dispersive subsoils and sandy topsoils | H | Loamy topsoils | H | C2 | * Dense clay subsoils which cause waterlogging and impede root penetration. * Can be shallow and stony. * Very low nutrient status, but can be suitable for improvement through clearance and fertilisation. | Low intensity grazing on native pasture | 3 |
| ZEB | GH27 | | Undulating or gently undulating lands | Deep sandy or loamy bleached duplex soils, often gritty surfaced | Sodosols | Sodic, dispersive subsoils and sandy topsoils | H | Sandy and loamy, but gritty topsoils | M | C2 | * Dense clay subsoils which cause waterlogging and impede root penetration. * Often with a gritty surface * Very low nutrient status, but can be suitable for improvement through clearance and fertilisation. | Low intensity grazing on native pasture | 3 |
| ZEB | mb20 | | Undulating lands with occasional lateritic scarps and low mesas. | Moderately deep, slightly acid red massive soils, often with ironstone nodules at depth | (Ferrous) Red Kandosols | Friable when moist | M | Friable when moist | M | C2 | * Highly friable when moist. * Low fertility with low to very low nutrients. * Low water holding capacity, but permeable and penetratable by plant roots. * Ironstone nodules at depth | Low intensity grazing on native pasture | 3 |

B15

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZEB | md4 | | Gently undulating extensive plateau with low scarped margins | Moderately deep, slightly acid yellow gradational soils, often with a prominent ironstone nodule horizon | (Ferrous) Yellow Kandosols | Friable when moist | M | Friable when moist | M | C2 | * Highly friable when moist. * Low fertility with low to very low nutrients. * Low water holding capacity, but permeable and penetratable by plant roots. * Ironstone and laterites common | Low intensity grazing on native pasture | 3 |
| ZEB | md6 | | Undulating plains interrupted by low mesas or their dissected remnants | Moderately deep, neutral or acid (with A2 horizon), strongly nodular at depth | (Ferrous) Yellow Kandosols | Friable when moist | M | Friable when moist | M | C2 | * Highly friable when moist. * Low fertility with low to very low nutrients. * Low water holding capacity, but permeable and penetratable by plant roots. * Strongly nodular at depth | Low intensity grazing on native pasture | 3 |
| ZEB | RC12 | | Hilly lands with some strongly undulating maginal slopes; hillcrests are often rounded, rock outcrops are common | Shallow neutral red duplex soils. Often stony. | Red Chromosols | Cohesive clay soils, but prone to severe gully and sheetwash if cleared | H | Hardsetting topsoils | L | C2 | * Shallow, often stony soils, with frequent rock outcrops. * Hardsetting loamy topsoils * Low nutrient status, but suitable for pasture development in low-relief areas | Grazing on native pastures with potential for some improvement | 2 |
| ZEB | RC13 | | High hills with some mountainous areas, rock outcrops common | Shallow neutral red duplex soils. Often stony. | Red Chromosols | Cohesive clay soils, but prone to severe gully and sheetwash if cleared | H | Hardsetting topsoils | L | C3 | * Shallow, often stony soils, with frequent rock outcrops. * Hardsetting loamy topsoils * Low nutrient status, but suitable for pasture development in low-relief areas | Low intensity grazing on native pasture | 3 |
| ZEB | RC15 | | Moderate to strongly undulating lands with occasional isolated hills, some rock outcrops | Shallow to moderate neutral red duplex soils, occasionally stony | Red Chromosols | Cohesive clay soils, but prone to severe gully and sheetwash if cleared | H | Hardsetting topsoils | L | C2 | * Soils can be shallow and stony with rock outcrops. * Hardsetting loamy topsoils * Low nutrient status, but suitable for pasture development in low-relief areas | Grazing on native pastures with potential for some improvement | 2 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZEB | RD2 | | Gently undulating alluvial floodplains with marked terraces and shallow drainage depressions. | Deep neutral red duplex soils with a deep sandy surface and an A2 horizon - located on older terraces and levees | Red Chromosols | Cohesive clay soils, but prone to severe gully and sheetwash if cleared | H | Deep sandy surface and associated friable loams | M/ H | B | * Hardsetting loamy topsoils. * Low nutrient status, but suitable for cultivation with suitable management | Limited cropland requiring considerable improvement | 3 |
| ZEB | Sc4 | | Strongly undulating lands with some low cuesta-like hills. Massive sandstone outcrops | Sand or sandy loam, often gravelly. | (Leached) Tenosols/ Rudosols | Loose, granular soils | H | Sandy and sandy loam topsoils | H | C3 | * Shallow and often stony with frequent rock outcrops. * Very low nutrients and low water storage capacity | Low intensity grazing on native pasture | 3 |
| ZEB | Se8 | | Low hilly to strongly undulating elevated lands with some steeper high hilly areas. Volcanic rock outcrop very common | Very shallow sands and sandy loams. Almost always stony | (Leached) Tenosols/ Rudosols | Loose, granular soils | H | Sandy and sandy loam topsoils | H | C3 | * Shallow and often stony with frequent rock outcrops. * Very low nutrients and low water storage capacity | Low intensity grazing on native pasture | 3 |
| ZEB | Se9 | | High steep-sided sandstone hills and strike ridges with narrow intervening valleys. Frequent rock outcrops | Sands on higher elevation sites with frequent rock outcrops | (Leached) Tenosols/ Rudosols | Loose, granular soils | H | Sandy and sandy loam topsoils | H | C3 | * Shallow and often stony with frequent rock outcrops. * Very low nutrients and low water storage capacity | Low intensity grazing on native pasture | 3 |

B17

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZEB | YD11 | | Undulating lands with occasional low hills. | Shallow, often stony yellow/grey-brown duplex soils | Sodosols | Sodic, dispersive subsoils and sandy topsoils | H | Hardsetting, loamy topsoils | L | C2 | * Shallow, gravelly soils with dense clay subsoils and hardsetting topsoils. * Very low nutrients | Low intensity grazing on native pasture | 2 |
| ZEB | YD14 | | Strongly undulating lands with occasional low hills and common rock outcrops | Shallow yellow/grey-brown duplex soils , with a gravel-strewn surface | Sodosols | Sodic, dispersive subsoils and sandy topsoils | H | Hardsetting, loamy topsoils | L | C3 | * Shallow, gravelly soils with dense clay subsoils and hardsetting topsoils. * Rock outcrops common. * Very low nutrients | Low intensity grazing on native pasture | 3 |
| BER | Bl | Buckley | Undulating plains on acid intrusive rocks | 250-350mm dark sand with conspicuously beached A2 horizon over alkaline brown mottled medium clay B horizon | Sodosol | Sodic, dispersive subsoils and sandy topsoils | H | Loose sandy topsoils, but prone to hardsetting | M | C2 | * Poor drainage. * Low available water capacity. * Erodible on low slopes. * Sodic, alkaline and prone to salinity. * Hardsetting topsoils limit plant growth | Low intensity grazing on native pasture | 3 |
| BER | Cr | Carew | Stagnant alluvial plains | Self-mulching dark medium-heavy clay over neutral to alkaline very dark grey heavy clay over dark yellowish brown heavy clay. Some carbonate. Normal gilgai | Black Vertosol | Sodic, dispersive subsoils | H | Cohesive clay topsoils | L | A | * Gilgai microrelief * Internal and surface drainage impeded. * Hardsetting and crusting of surface soils limits plant growth. * Sodic lower subsoils. * High chance of salinity. | Rice and grain crops | 3 |
| BER | Dl | Dillon | Poorly drained gentle slopes, plains and prior streams | 300-450mm dark greyish brown coarse sand to clayey sand with mainly unbleached A2 over neutral yellowish brown mottled clayey coarse sand to sandy clay loam B horizon. Some ferruginous nodules | Podosol | Low clay content, sodicity and dispersivity | M | Variable texture topsoils | M | C2 | * Poor drainage. * Low available water capacity. * Erodible on low slopes. * Alkaline and prone to sodicity and salinity. * Hardsetting surface soils can limit plant growth | Low intensity grazing on native pasture | 3 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BER | EA | | Gullied and Eroded Areas in Alluvial Terraces | | | Gullying and erosion | H | Cohesive older alluvial soils | L | C2 | | Low intensity grazing on native pasture | 4 |
| BER | EM | | Gullied and Eroded Banks of Major Streams | | | Gullying and erosion | H | Loose alluvial soils | M | C2 | | Low intensity grazing on native pasture | 4 |
| BER | ES | | Gullied and eroded areas in sedentary soils - Hills & Mountains | | | Gullying and erosion | H | Cohesive residual soils | L | C2 | | Low intensity grazing on native pasture | 4 |
| BER | Gb | Goodbye | Stagnant alluvial plains | 150-250mm dark greyish brown sandy clay loam to light clay with sporadically bleached A2 over alkaline dark greyish mottled heavy clay B horizon. Some carbonate | Sodosol | Sodic, dispersive subsoils | H | sandy clay loam to clay topsoils | L | C1 | * Poor drainage. * Low available water capacity. * Sodic and prone to salinity. * Hardsetting topsoils limit plant growth. * Gilgai microrelief. * Typically found with associated soils of different characteristics, requiring different management techniques | Sugar cane, rice, grain cropping possible, but better suited to improved pasture | 2 |
| BER | Gr | Glenroc | Dissected undulating rises on intermediate instrusive rocks | 250-450mm dark greyish or brownish sand to light sandy clay loam with bleached A2 over neutral to alkaline yellowish-brown mottled medium clay B horizon. Some carbonate | Sodosol | Sodic, dispersive subsoils | H | sand to sandy clay loam topsoils | M/ H | B | * Poor drainage. * Hardsetting surface soils and dense subsoils can limit plant growth. * Soil characteristics can be variable. *Soils can be gravelly with rock outcrops. | Majority of locally grown crops, except rice | 2 |

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BER | GrSp | Glenroc Stony Phase | | As Gr, but 10% surface and profile stone | Sodosol | | | | | | | | |
| BER | Gt | Greentop | Level alluvial plains on cemented fine gravel | 600-900mm pale greyish or yellowish coarse sand with conspicuously beached A2 over neutral yellowish clayey coarse sand colour B horizon. Minor ortstein | Podosol (?) | Deep sandy topsoils over clayey (possibly sodic) sand subsoils | M | Loose, coarse sand, but may be hardsetting | M | C1 | * Very deep, sandy topsoils result in low available water capacity | Improved pasture | 2 |
| BER | HIL | Hills and Mountains | Hills & Mountains | | | | | | | | | | |
| BER | Kb | Knobbies | Colluvial deposits on pediments | 100mm dark brown sand clay loam over alkaline reddish light clay B horizon. Some carbonate | Kandosol | Shallow soils that are prone to erosion | M | Sandy clay loam topsoils | L | B | * Shallow, gravelly, erodible soils | Sugar cane, grain and small crops | 4 |
| BER | Kr | Kangaroo | Level alluvial plains on cemented fine gravel | 300-450mm greyish or yellowish loamy coarse sand to sandy clay loam with bleached A2 over neutral to alkaline brownish mottled coarse sandy clay to medium clay B horizon. | Sodosol | Sodic, dispersive subsoils and sandy topsoils | H | Loamy coarse sand | L | C2 | * Poor drainage. * Low available water capacity. * Erodible on low slopes. * Sodic, alkaline and prone to salinity. * Hardsetting topsoils limit plant growth | Low intensity grazing on native pasture | 3 |

B20

Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BER | Sb | Salisbury | Colluvial/ alluvial pediplains | Self-mulching black medium or heavy clay over neutral to alkaline black heavy clay B horizon over greyish clay. Some carbonate. Linear and normal gilgai. | Black Vertosol | Slightly sodic, moderately erodible clay soils | M | Cohesive clay topsoils | L | A | * Clay surface soils prone to compaction. * Erodible slopes requiring contour ploughing. * Minor sodicity and salinity of subsoils. * Shallow gilgai microrelief. | Sugar cane, grain, small crops and mangos | 2 |
| BER | Sp | Splitters | Stagnant alluvial plains | 100-250mm dark brownish loamy sand or sandy clay loam with sporadically bleached A2 over neutral to alkaline brown heavy sandy clay or light medium clay B horizon | Sodosol | Slightly sodic, moderately erodible clay soils | M | Loamy sand to sandy clay loam topsoils, prone to hardsetting | L | A | * Moderately poorly drained. * Erodible on low slopes. * Dense, sodic lower subsoils, possibly saline. * Hardsetting topsoils and dense subsoils can limit plant growth | Majority of locally grown crops | 3 |
| BER | Ss | Seven Sisters | Poorly drained gentle slopes, plains and prior streams | 200-450mm dark greyish loamy sand to sandy clay loam with conspicuously beached A2 over yellowish brown mottled medium clay or heavy sandy clay B horizon. Some carbonate. | Sodosol | Sodic, dispersive subsoils and sandy topsoils | H | Loamy sand to sandy clay loam topsoils, prone to hardsetting | L | C2 | * Poor drainage. * Low available water capacity. * Erodible on low slopes. * Sodic, alkaline and prone to salinity. * Hardsetting topsoils limit plant growth | Low intensity grazing on native pasture | 3 |
| BER | STC | Creek Flats and Stream Channels | | | | Transport of creek channel material | H | Loose alluvial soils | M | N/A | | N/A | N/A |

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Appendix B

| Study | Map Unit | LMU / Unit Name | Landform | Soil Description | Coffey ASC | Water Erosion Susceptibility | Rank | Wind Erosion Susceptibility | Rank | GQAL | Land Suitability Limitations | Intended Land Use | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BER | TgSv | Tolgai (strongly Gilgaied) | Stagnant alluvial plains | Thinly self-mulching greyish heavy clay over neutral to alkaline grey dense heavy clay. Few carbonate nodules. Strong cracking and gilgai | Grey Vertosol | | | | | | * Poor drainage. * Low available water capacity. * Erodible on low slopes. * Sodic, alkaline and prone to salinity. * Hardsetting topsoils limit plant growth | | |
| BER | Ts | Thurso | Intensely dissected undulating rises on instrusive rocks | 250-350mm brownish loamy sand with unbleached A over neutral yellowish-brown sandy clay loam B horizon. Rock fragments throughout and increasing below. Shallow soils. | Yellow Chromosol | Sodic, dispersive subsoils and sandy topsoils | H | Loose sandy topsoils | M | C2 | * Poor drainage. * Low available water capacity. * Erodible on low slopes. * Shallow, gravelly soils | Low intensity grazing on native pasture | 3 |
| BER | Tt | Tabletop | Floodplains of minor streams | Self-mulching black medium-heavy clay over neutral to alkaline black heavy clay, over dark brown heavy clay. Some carbonate. Normal gilgai. | Black Vertosol | Sodic, dispersive subsoils | H | Cohesive clay topsoils | L | A | * Clay surface soils prone to compaction. * Dense clay subsoils can limit rooting depth. * Periodic flooding. * Poorly drained. * Sodic and saline subsoils, with salinisation hazard if groundwater levels rise. | Majority of locally grown crops | 3 |
| BER | Wg | Wygong | Dissected undulating rises on intermediate instrusive rocks | Self-mulching black medium-heavy clay over neutral to alkaline black heavy clay, over weathering rock. Weak normal and linear gilgai | Black Vertosol | Slightly sodic, moderately erodible clay soils | M | Cohesive clay topsoils | L | A | * Clay surface soils prone to compaction. * Erodible slopes requiring contour ploughing. * Minor sodicity and salinity of subsoils. * Shallow gilgai microrelief. | Sugar cane, grain and small crops | 3 |

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# Appendix C

**Important Information about your Coffey Report**

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# Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

## Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

## Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

## Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

## Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

## Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

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# Important information about your **Coffey** Report

## Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

## Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

## Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

## Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

## Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

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