Central Queensland Coal Project

Chapter 5 – Land

Supplementary Environmental Impact Statement

CDM Smith

listen. think. deliver.

Central Queensland Coal Project
Chapter 5 – Land

20 December 2018

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5 Land

This chapter outlines the environmental values (EVs) of the Central Queensland Coal Mine Project (the Project), haul road corridor and train loadout facility (TLF) in the context of topography, geology, mineral reserves, soil types, land use suitability and visual amenity. The potential impacts of the proposed mining activities on the existing EVs of the area are identified, as are the measures proposed to mitigate any potential impacts.

Matters raised in submission to the Environmental Impact Statement (EIS) relating to Chapter 5 – Land were predominately focused on:

- Erosion and sediment control management;
- Potential to encounter acid sulphate soils (ASS) and management if encountered; and
- Impacts to off-lease Strategic Cropping Land (SCL).

The updated chapter provides additional information in response to the submissions relating to EIS Chapter 5 – Land and the original Supplementary EIS (SEIS).

This chapter should also be read in conjunction with Chapter 7 – Waste Management, Chapter 8 – Waste Rock and Rejects and Chapter 11 – Rehabilitation and Decommissioning which provide further technical details of impacts on land EVs and the management of those impacts.

5.1 Project Overview

Central Queensland Coal Proprietary Limited (Central Queensland Coal) and Fairway Coal Proprietary Limited (Fairway Coal) (the joint Proponents), propose to develop the Central Queensland Coal Mine Project (the Project). As Central Queensland Coal is the senior proponent, Central Queensland Coal is referred to throughout this Supplementary Environmental Impact Statement (SEIS). The Project comprises the Central Queensland Coal Mine where coal mining and processing activities will occur along with a TLF.

The Project is located 130 km northwest of Rockhampton in the Styx Coal Basin in Central Queensland. The Project is located within the Livingstone Shire Council Local Government Area. The Project is generally located on the "Mamelon" property, described as real property Lot 11 on MC23, Lot 10 on MC493 and Lot 9 on MC496. The TLF is located on the "Strathmuir" property, described as real property Lot 9 on MC230. A small section of the haul road to the TLF is located on the "Brussels" property described as real property Lot 85 on SP164785.

The Project will involve mining a maximum combined tonnage of up to 10 million tonnes per annum (Mtpa) of semi-soft coking coal (SSCC) and high grade thermal coal (HGTC). The Project will be located within Mining Lease (ML) 80187 and ML 700022, which are adjacent to Mineral Development Licence 468 and Exploration Permit for Coal (EPC) 1029, both of which are held by the Proponent. It is intended that all aspects of the Project will be authorised by a site specific environmental authority (EA).

Development of the Project is expected to commence in 2019 with initial early construction works and extend operationally for approximately 19 years until the depletion of the current reserve, and rehabilitation and mine closure activities are successfully completed.

The Project consists of two open cut operations that will be mined using a truck and shovel methodology. The run-of-mine (ROM) coal will ramp up to approximately 2 Mtpa during Stage 1 (2019 - 2022), where coal will be crushed, screened and washed to SSCC grade with an estimate 80% yield. Stage 2 of the Project (2023 - 2038) will include further processing of up to an additional 4 Mtpa ROM coal within another coal handling and preparation plant (CHPP) to SSCC and up to 4 Mtpa of HGTC with an estimated 95% yield. At full production two CHPPs, one servicing Open Cut 1 and the other servicing Open Cut 2, will be in operation. Rehabilitation works will occur progressively through mine operation, with final rehabilitation and mine closure activities occurring between 2036 and 2038.

A new TLF will be developed to connect into the existing Queensland Rail North Coast Rail Line. This connection will allow the product coal to be transported to the established coal loading infrastructure at the Dalrymple Bay Coal Terminal (DBCT).

Access to the Project will be via the Bruce Highway. The Project will employ a peak workforce of approximately 275 people during construction and between 100 (2019) to 500 (2030) during operation, with the workforce reducing to approximately 20 during decommissioning. Central Queensland Coal will manage the Project construction and ongoing operations with the assistance of contractors.

This SEIS supports the EIS by responding to the submissions that were made during the public notification period regarding the original EIS and identifies the material changes to the Project.

5.2 Relevant Legislation, Guidelines and Criteria

5.2.1 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) is the primary legislation for environmental management and protection in Queensland. It plays an important role in the protection and management of Queensland's environment, particularly in relation to the regulating activities which have potential to release contaminants into the environment (defined as Environmentally Relevant Activities (ERAs)).

The EP Act also governs the management, investigations and remediation of any contaminated land. If land becomes contaminated there is a duty to notify the Department of Environment and Science (DES).

5.2.2 Biosecurity Act 2014

The *Biosecurity Act 2014* (Biosecurity Act) has replaced several separate pieces of legislation that were used to manage biosecurity, including the superseded *Land Protection (Pest and Stock Route Management) Act 2002*. The Biosecurity Act deals with pests (such as wild dogs and weeds), diseases (such as foot-and-mouth disease) and contaminants (such as lead on grazing land).

Under the Act, individuals and organisations whose activities pose potential risks to biosecurity will have greater legal responsibility for managing them. This means Central Queensland Coal will have an obligation to undertake all reasonable steps to ensure no spread of pest, disease or contaminant. There are seven categories of restricted matter listed under the Act. Each category places restrictions on the biosecurity matter or requires actions to be taken to minimise the spread and adverse impact of the matter.

5.2.3 Stock Route Management Act 2002

The purpose of the *Stock Route Management Act 2002* is to provide management for the stock route network. The *Stock Route Management Act 2002* establishes principles for managing the stock route network and activities. The stock route network provides unique interconnectedness and geographical extent to allow for the movement of wildlife.

There are no stock routes near the Project area.

5.2.4 Regional Planning Interests Act 2014

The *Regional Planning Interests Act 2014* (RPI Act) replaced the *Strategic Cropping Land Act 2011* on the 13 June 2014. The RPI Act seeks to manage the impacts from resource activities, and other regulated activities through protecting:

- Living areas in regional communities;
- High-quality agricultural areas from dislocations;
- SCL; and
- Regionally important EVs.

Under the RPI Act, an approval is required when a resource activity or regulated activity is proposed in an area of regional interest. Areas of regional interest are identified as:

- Priority living areas (PLAs);
- Priority agricultural areas (PAAs);
- Strategic cropping areas (SCAs); and
- Strategic environmental areas (SEAs).

The Project activities are not located within any mapped Area of Regional Interest; however, a small portion of SCA is mapped in the north-eastern portion of the ML.

5.2.5 Guideline Mining – Model Mining Conditions

The purpose of the Model Mining Conditions is to provide a set of model conditions to form general environmental protection commitments for the mining activities and the Environmental Authority (EA) conditions pursuant to the EP Act. The guideline states that the '*model conditions should be applied to all new mining project applications lodged after the guideline is approved*', therefore the Project is subject to the criteria outlined in this guideline. Schedule H of the Model Mining Conditions prescribes conditions for land and rehabilitation management.

5.3 Environmental Objectives and Performance Outcomes

5.3.1 Environmental Objectives

The environmental objective relevant to land is provided in the EP Regulation. In accordance with the EP Regulation, the Project's objectives for land are to operate in a way that protects the EVs of land including soils, subsoils, landforms and associated flora and fauna.

5.3.2 Performance Outcomes

The land performance criteria are:

- There is no actual or potential disturbance or adverse effect to the EVs of land as part of carrying out the activity; and
- All of the following:
  - Activities that disturb land, soils, landforms and the land use, flora and fauna associated with the land will be managed in a way that prevents or minimises adverse effects on the EVs of land;
  - Areas disturbed will be rehabilitated or restored to achieve sites that are:
    - Safe to humans and wildlife;
    - Non-polluting;
    - Stable; and
    - Able to sustain an appropriate land use after rehabilitation or restoration.
  - The activity will be managed to prevent or minimise adverse effects on the EVs of land due to unplanned releases or discharges, including spills and leaks of contaminants; and
  - The application of water or waste to the land is sustainable and is managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.

5.4 Assessment Method

To adequately assess the potential impacts that the Project may have on land and the current land use within the Project area, the following detailed assessments have been undertaken:

- Desktop assessment, including review of publicly available literature, maps and resources relevant to the geology, soils and landforms in the Project area; and
- Field surveys and laboratory analyses undertaken focusing on characterisation of soils for land use suitability, agricultural value and potential rehabilitation (as required) as part of the EIS process to improve understanding of soils within the Project area. A detailed field soil survey of the mine area was conducted in April 2017.

5.4.1 Topography

The topography and landscape were reviewed with reference to:

- LiDAR data captured for EPC 1029;
- Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australian Soil Resource Information System (ASRIS) datasets and information obtained from the Department of Natural Resources, Mines and Energy (DNRME);
- Resource and tenure maps and records from DES;
- Local government mapping; and
- Cadastral data.

Specific topographic maps used for the assessment include:

- DES 10 m contour data; and
- Queensland Globe (DNRME 2018a) feature of Google Earth.

Landforms were mapped using landscape units that provide a basis for the description of the physical environment. The information reflects the distribution of geological structures, landforms and associated soil types. Landscape units are a combination of several map units including:

- Broad landform (topography, slope and relief), geology and lithology;
- Dominant soil orders;
- Local climate, drainage networks and related soil profile classes;
- Regolith materials; and
- Similar geomorphological systems.

5.4.2 Geology

Various publicly available data sources were consulted to determine the geomorphology and geology underlying the Project are:

- Surface geological mapping from the Geological Survey of Queensland (1:250,000 Series) (Geoscience Australia 2008);
- Queensland Globe (DNRME 2018a) feature of Google Earth;
- Mines Online Maps (DNRME 2018b); and
- Geological information provided by Central Queensland Coal. This information was focused primarily on the economic geology for the area.

Published DNRME landform data was also consulted as part of the desktop assessment.

Existing mapping of the Project area indicates a number of geological units exist throughout the mine area, the haul road corridor and the TLF.

5.4.3 Soils

5.4.3.1 Desktop Assessment

A preliminary desktop soils and landform assessment was undertaken to inform the fieldwork component of the assessment. All information pertaining to topography and landform was derived from relevant publicly available soils and geology databases and available mapping. Existing published soils and landform information for the region was derived from the following sources:

- ASRIS 2011: This is a National soils mapping dataset made available by CSIRO which provides a general description of soils classified in accordance to the Australian Soil Classification (Isbell 2002);
- ‘Atlas of Australian Soils’ by CSIRO (Isbell et al. 1967): This provides general background information on landscape features and general soil families and soil types expected to occur in the region;
- Queensland Globe’s ASS distribution map (scale 1:100,000): This mapping provides an indication of the likelihood of Acid Sulphate Soils (ASS) or potential ASS (PASS) being present across the Project site; and
- Review of site-specific soil sample records in the locality to further define local soil physical attributes and confirm application of land resource area descriptions.

5.4.3.2 Field Assessment

Field assessment methodologies were designed, developed and undertaken in accordance with the following:

- Technical Guidelines for Environmental Management of Exploration and Mining in Queensland ((DME 1995) (including the collection of soil samples in line with the Land Suitability Assessment Techniques (LSAT Guidelines) within DME 1995);
- The Australian Soil Classification (Isbell 2002);
- SPP – state interest guideline - Agriculture;
- Planning Guideline: The Identification of Good Quality Agricultural Land. Department of Primary Industries (DPI) and Department of Housing and Local Government Planning (DHLGP), (DPI/DHLGP 1993);
- Guidelines for Surveying Soil and Land Resources (McKenzie et al. 2008);
- Australian Soil and Land Survey Field Handbook (NCST 2009); and
- Australian Soil and Land Survey Handbook – Guidelines for Conducting Surveys (Gunn et al. 1988).

Density and Scale of the Soil and Landscape Surveys

For the purposes of producing an EIS, the most suitable soil mapping scale for strategic planning of the Project was identified as 1:50,000 based on the *Guidelines for Surveying Soil and Land Resources* (McKenzie et al. 2008). The guidelines nominate a medium intensity or semi-detailed investigation with a minimum soil sampling density of one sample per 100 hectares (ha). Of this, a minimum of 12 percent (%) of samples should be detailed soil profiles and descriptions and a maximum of 88% of sample sites should consist of a visual assessment of the soil and landscape characteristics in the immediate vicinity (herein termed 'observations').

The soil survey included 11 soil auger sites (where detailed soil profile descriptions were made and samples were taken), 16 observation locations, and laboratory analysis. The soil sampling density was equivalent to one profile or observation being taken every 43ha compared to a total disturbance area of 1,124.8 ha. This density of sampling meets the requirements outlined in the nominated guidelines described above. The sampling density used in the investigation was determined based on existing and publicly available soil unit mapping. The sampling locations of boreholes constructed for detailed analysis and those sites nominated as observations in the haul road corridor and TLF are shown in Figure 5-1.

Detailed Sites

Detailed soil profile descriptions were made at 11 sites in the Project area (shown as the subsoil sample locations in Figure 5-1). The detailed sites were augered to a depth of 1.5 m or until refusal was reached. Soil sampling of profiles was conducted as per the Guidelines for Surveying Soil and Land Resources (Gunn et al. 1988).

All soil samples were issued for laboratory analysis. These were selected for analysis based on the 'representativeness' of the sample to the surrounding soils area and the soil unit map being proposed. Sample results are presented in Section 5.5.4.3.

Several samples were taken from down the soil profile to allow for suitable information to be gathered from the A horizons 'topsoils' and B horizons 'subsoils'. Texture was assessed in-field where changes in the profile were evident.

Information recorded at each detailed sample location included the following:

- Location (GDA94);
- Major vegetation types and land use of immediate surrounding area;
- Landform type, position on the site and slope gradient;
- Published geology and land resource management unit for the location;
- Surface condition (including any presence of cracks, surface crusts, rock stones and cobbles, erosion status and micro relief);
- Types and vertical extent of soil horizons;
- Colour of the soil matched to the Munsell Soil Colour Charts (Munsell) and mottling of each horizon (Munsell 2000);
- Field texture (based on the behaviour of a moist bolus);

- Field pH (CSIRO pH Kit);
- Structure (presence and abundance of segregations, coarse fragments, structure, consistency, pedality and moisture content), noting that some disturbance of structure occurs during auguring;
- Boundary, including depth of horizons and the nature of the boundary (clear, distinct or diffuse between layers); and
- Photographs of the soil profile (from auger samples) and the surrounding landscape.

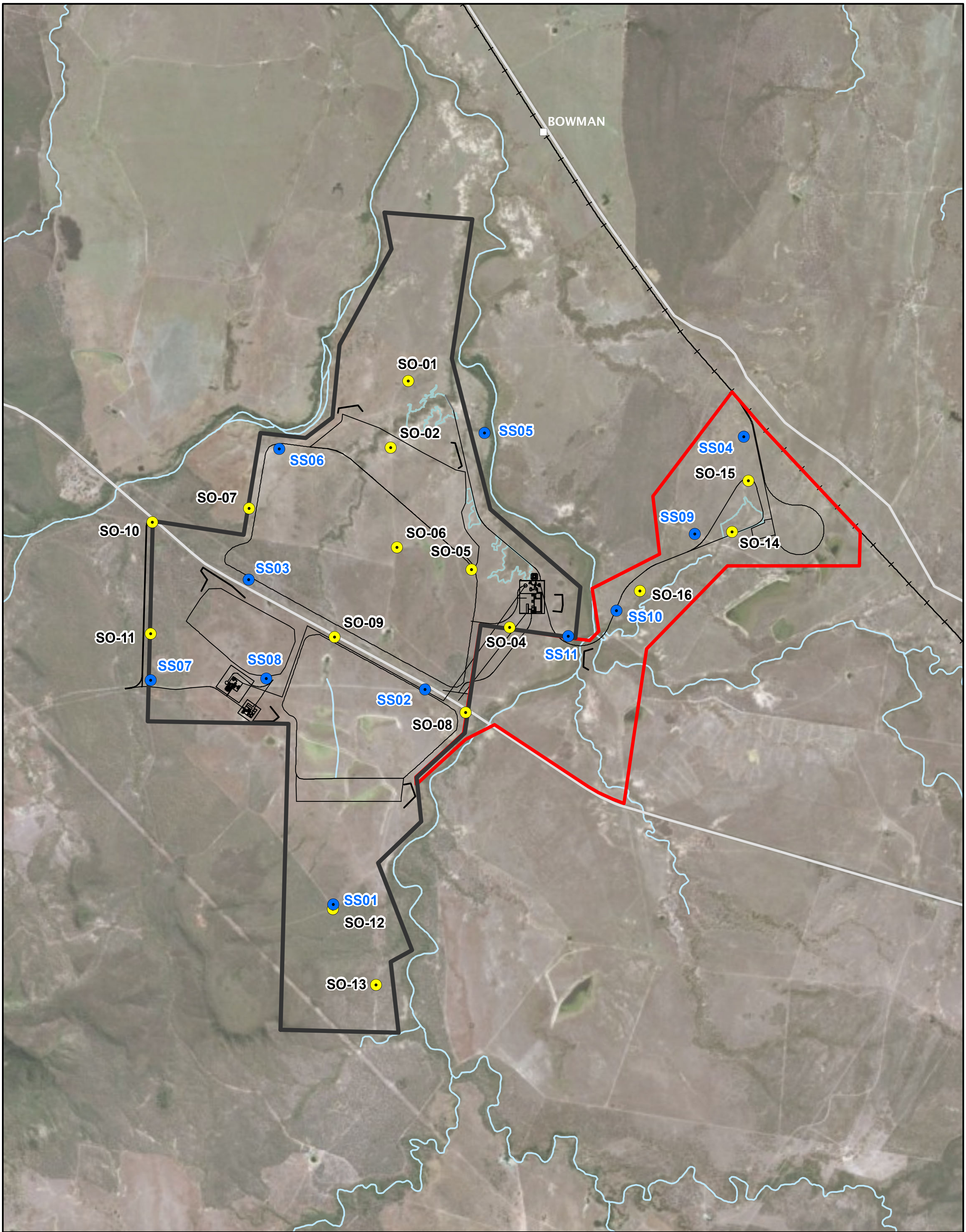
Observation Sites

In addition to the full soil profile samples, 16 observations were conducted in the Project area. The observations consisted of a visual assessment of soil conditions and the surrounding environment considering the general terrain of the area, and landform and vegetative characteristics across the site.

Information collected at each observation site included:

- General landform, vegetation, land use and slope;
- Actual geology or land resource area reference as described by relevant published data;
- Visible and inferred soil types present; and
- Any management issues of significance (including potential dispersive, acid sulphate, or highly erodible soils).

Observations were used to support the soils information gathered during the detailed site investigation and laboratory analysis and provided information on landform mapping boundaries.



N

0 0.5 1 km

Scale @ A4 1:60,000
Date: 19/10/18
Drawn: Gayle B.

Legend

Soil Sample Location

- Observation Soil
- Subsoil Sample
- ML 80187
- ML 700022
- Mine infrastructure
- Main Road
- North Coast Rail Line
- Watercourse
- Dam

Figure 5-1

Project soil sample locations

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018
Esri Basemaps, 2017

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BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 R1 mine soil sample locations_5-1.mxd 10/19/2018

5.4.3.3 Laboratory Analysis

Those samples collected from detailed sites that were considered most representative of the mapped soil units were submitted to a National Association of Testing Authorities (NATA) accredited laboratory for soil testing, providing information that directly informed the overall soils characterisation and determination of agricultural suitability of the soils. Laboratory analysis was also used in determining soil suitability for future rehabilitation based on physical and chemical parameters and potential future amelioration techniques. The parameters analysed for the surface (A horizon) and subsoil (B horizon) is presented in Table 5-1. Full laboratory results are presented in Appendix A3 – Soil Survey Results.

Table 5-1 Surface (A horizon) and subsoil (B horizon) parameters analysed

Parameters	Surface (A horizon) Parameters	Subsoil (B horizon) Parameters
pH	✓	✓
Moisture	✓	×
Chloride	✓	✓
Electrical conductivity	✓	✓
Organic matter (including % organic carbon)	✓	×
Total nitrogen and total kieldahl nitrogen	✓	×
Bicarbonate extractable phosphorus	✓	×
Particle size distribution by hydrometer	✓	✓
Dispersibility	✓	✓
Trace metals – copper, iron, manganese and zinc	✓	×
Extractable boron	✓	×
Full cation suite (Na, K, Ca, Mg, Fe, Al, Cl, S, CEC, SAR, ESP and exchangeable Ca:Mg)	✓	✓

5.4.4 Agricultural Land Suitability

5.4.4.1 Land Use Suitability

Classifying land suitability in Queensland is based on classifications provided in the LSAT Guidelines within the Technical Guidelines for Environmental Management of Exploration and Mining in Queensland (DME 1995). The class ratings and definitions, as described in Table 5-2, will be applied to mapped soil units to inform rehabilitation programmes for post-mining land use.

Table 5-2 Land suitability classes

Land suitability classes	Definition
Class 1	Suitable land with negligible limitations that is highly productive and requires only simple management to maintain economic production.
Class 2	Suitable land with minor limitations which either reduce production or require more than the simple management practices of Class 1 to maintain economic production.
Class 3	Suitable land with moderate limitations which either further lower production or require more than those management practices of Class 2 to maintain economic production.
Class 4	Currently unsuitable land with severe limitations which make it doubtful whether benefits of the activity will outweigh the inputs/costs required to achieve and maintain production in the long term under current environmental and economic conditions. A change in future conditions may induce a change to Class 3.
Class 5	Unsuitable land with extreme limitations that preclude its use.

Adopted from the LSAT Guidelines (DME 1995).

The LSAT Guidelines provide general criteria and threshold values for assessment of a range of soil limitations to rain fed cropping and beef cattle grazing land use. A combination of field and laboratory data has been used to assess whether any limitations exist across the Project site and, if so, the severity of those, as well as determining the land suitability class of each soil unit against the LSAT Guidelines.

Grazing suitability classifications evaluate the potential for grazing across the site and consider limiting factors including plant available water capacity, nutrient deficiency, soil physical factors, salinity, rockiness, micro relief, susceptibility to water erosion, topography and flooding.

5.4.4.2 Good Quality Agricultural Land

Good quality agricultural land (GQAL) is assessed using the Agricultural Land Classes (ALC) nominated in the Planning Guideline: The Identification of Good Quality Agricultural Land (1993). The relationship between GQAL and ALCs is shown in Table 5-3.

Table 5-3 Relationship between GQAL and ALCs

Agricultural land class	Land suitability (cropping)	Land suitability (grazing)	Description
A	1-3	1-3	**Crop land** – Land that is suitable for current and potential crops with limitations that range from none to moderate levels.
B	4	1-3	**Limited crop land** – Land that is marginal for current and potential crops due to severe limitations and suitable pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping.
C	Sub categories are as follows:		**Pasture land** – Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.
C1	5	1-2	**Land suitable for improved pastures**. In some circumstances may be considered as good quality agricultural land.
C2	5	3	**Land suitable for native pastures**.
C3	5	4	**Land suitable for limited grazing of native pastures**.
D	5	5	**Non-agricultural land** – Land not suitable for agricultural uses due to extreme limitations. This may be land which is unsuitable because of very steep slopes, shallow soils, rock outcrops or poor drainage.

5.4.5 Contaminated Land

A site history of the Project area was compiled and used to identify past and present potentially contaminating activities. This was undertaken in accordance with the Guidelines for contaminated land professionals (EHP 2012) and included:

- A review of the DES Contaminated Land Register (CLR) and Environmental Management Register (EMR); and
- A review of historic aerial photography to identify any potentially contaminating land uses.

5.4.6 Infrastructure

Existing infrastructure associated with the agricultural land use was identified through desktop research and various field surveys. The mining area is located entirely within a single property boundary (Mamelon). A road reserve corridor (Mt Bison Road) crosses Mamelon on the western side of the Bruce Highway and will require realignment as the reserve will be impacted by Open Cut 1. The land within the TLF and most of the haul road is within Strathmuir property, whilst a small section of the haul road crosses the Brussels property. Both properties are owned by private landholders.

The land within the Project disturbance area does not support any homesteads, gas or water pipelines, or communications. The existing Powerlink 275 kilovolt Stanwell to Nebo transmission alignment is located in the south of the ML 80187; however, the easement is situated well outside the proposed disturbance areas. Several stockyards are located within the disturbance area and will no longer be in use during mining operations.

The existing infrastructure that may be affected by the Project are:

Mine Area

- Unformed farm access tracks;
- Two windmills and dams;
- Two vacant homesteads and farming infrastructure; and
- Fence lines around paddocks.

Haul Road Corridor and Train Loadout Facility

- Fence lines around paddocks.

5.4.7 Environmentally Sensitive Areas

Environmentally sensitive area (ESA) mapping identified a Category B ESA within the ML (Figure 5-2). This Category B ESA is associated with remnant vegetation listed as Endangered under the *Vegetation Management Act 1999*. Several Category A, B and C ESAs are located within the wider locality (within 50 km of the Project area), including various protected areas and nature refuges (Table 5-4).

Tooloombah Creek Conservation Park (Category A) is located less than 1 km west of the ML boundary. The Great Barrier Reef World Heritage Area (GBRWHA) and Great Barrier Reef Marine Park boundaries and Broad Sound Fish Habitat Area overlap (all Category B) and are located 8 km north of the Project. Waters associated with the Styx River are also designated as a 'coastal management district' which is also a Category C ESA.

Further details and locations of ESAs are presented in Chapter 14 – Terrestrial Ecology.

Table 5-4 Environmental sensitive areas within 50 km of the Project area

Environmentally Sensitive Area	Category	Approximate distance to Project area (km)
		Mine area
Tooloombah Creek Conservation Park	Category A	0.8
Great Barrier Reef World Heritage Area	Category B	8.0
Bukkulla Conservation Park	Category A	16.9
Marlborough State Forest	Category C	16.5
Eugene State Forest	Category C	19.0
Mt Buffalo State Forest	Category C	25.0
Develin Nature Refuge	Category C	19.0
Burwood Nature Refuge	Category C	19.3
Great Barrier Reef Marine Park – general use area	Category B	8.0
Fish Habitat Area – Broad Sound	Category B	8.0
Endangered remnant vegetation	Category B	Within entire 25 km radius
Marine Plants	Category B	7.5 (north – associated with Styx River estuarine plain)
Coastal Management District	Category C	2.0 (north – associated with Styx River)

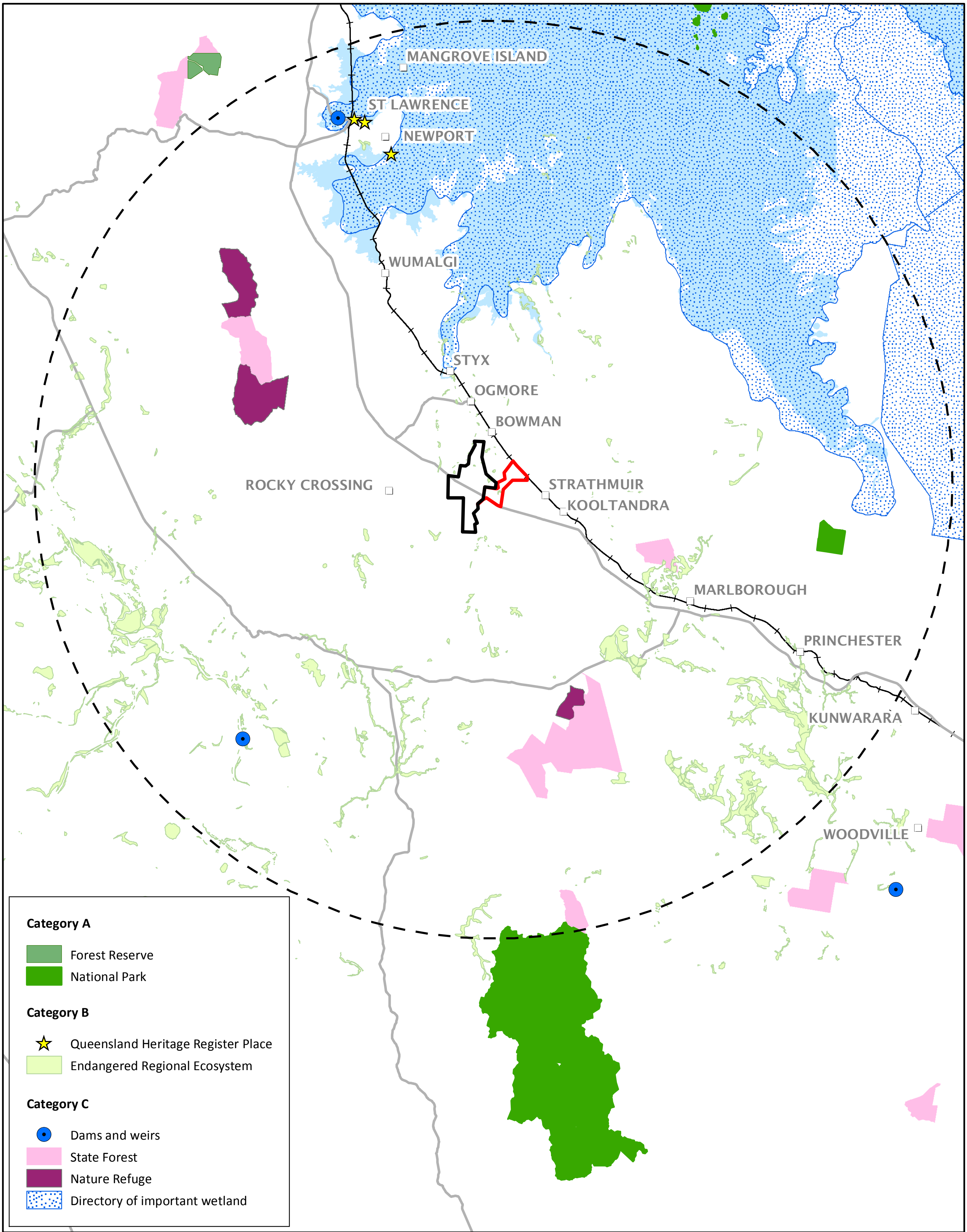

Figure 5-2
Location of Environmentally Sensitive Areas within 50 km of the Project Area

N

0 5 10 km

Scale @ A4 1:540,000
Date: 27/11/18
Drawn: Gayle B.

Legend

- ML 80187
- ML 700022
- Project Area 50 km buffer
- North Coast Rail Line
- Main road
- Estuary

DATA SOURCE
QLD Department of Environment and Heritage Protection, 2016
QLD Open Source Data, 2018

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5.4.8 Landscape Character and Visual Amenity

5.4.8.1 Visual Impact Assessment Method

The purpose of undertaking a Visual Impact Assessment (VIA) is to examine the extent of visual change to the landscape because of the Project and assess how the change will impact on the area's scenic amenity.

Specifically, the study:

- Assesses the existing landscape character of the Project area providing comment on the changes already made to the natural landscape since European settlement;
- Describes existing landscape features, panoramas and views that have or are expected to have value to the community;
- Identifies the potential sensitive receptors within the immediate landscape where visual amenity may be impacted; and
- Determines the significance of potential impacts from sensitive receptors. Consideration includes:
  - Value of existing vegetation as a visual screen
  - Identification of the ability of the landscape to absorb change without significant detriment to the existing visual quality and landscape character
  - Ability to mitigate impacts through design considerations.

GIS modelling was utilised to determine potential visibility of the mining operation from a variety of sensitive receptors. This GIS information has been combined with available field data to quantify the landscape change.

The study area for the EIS was defined by the visual catchment of the Project, or the area from which the Project could reasonably be seen. The visual catchment was determined through the review of aerial photographs, topographic maps and landform.

The VIA assessment relied on the following data sources:

- Aerial photography;
- 1 Second SRTM v1.0 Digital Elevation Models (Geoscience Australia 2011);
- Derived hill shade from 1 Second SRTM v1.0 Digital Elevation Models;
- Homestead locations (DNRME 2018a); and
- Queensland Globe (DNRME 2018a) feature of Google Earth.

5.4.8.2 Desktop Assessment

When undertaking a VIA, it is generally recognised that there is a limit to the human field of vision. The key factors in determining visual impact are based on:

- The human perception of views and parameters of vision;
- The natural topography and topographical change; and
- The natural vegetation that has the potential to screen views.

Scientific studies undertaken by Costella (1995) and Ball et al. (2005) identify the relationship between the potential landscape change and the proportion of area the development occupies (i.e. how much can be seen) within the horizontal and vertical line of sight.

The duration in which people view the landscape is a crucial factor in analysing the sensitivity to change. Variations in the landscape are more noticeable from lookouts and permanent viewing points compared to a view while travelling along a road. As such, the relative duration spent at each viewing location has a significant influence on the sensitivity of change to the landscape.

5.4.8.3 Landscape Character

The landscape character assessment included mapping and describing broad landscape character types and any discrete landscape character areas within each character type. The potential impact on landscape character is measured by the responses felt by sensitive receptors towards the combined effects of the new development. Determining the landscape character areas includes consideration of:

- Landform;
- Vegetation;
- Intensity; and
- Character of land.

5.4.8.4 Identification of Sensitive Receptors

Potential sensitive visual receptors were identified with the aid of mapping data sources (including GIS) and the soil surveys. They are nominated at locations where the Project may be visible to residents, or areas where visitors spend extended amounts of time. Sensitive receptors include homesteads as well as areas from which transient views are possible, such as roads, service stations and rail lines.

5.4.8.5 Calculation of Zone of Theoretical Visibility

A zone of theoretical visibility (ZTV) is the theoretic assessment of visibility to or from a designated point in the landscape. It uses elevation data to calculate the extent of visibility from that point to anywhere in the study area. The mapping does not consider buildings or vegetation screening and hence reflects a 'bare-earth landscape', which represents the "worst case scenario". The ZTV generated for this assessment is based on 1s Shuttle Radar Topography Mission (SRTM) v1.0 Digital Elevation Model (DEM) (Geoscience Australia 2011) and an observer eye height of 1.8 m. A ZTV was generated for each of the relevant homesteads identified for the preliminary investigation area.

5.4.8.6 Visual Sensitivity

Visual sensitivity refers to receptors and their sensitivity to their visual environment. Visual impacts relate to the change that arise in composition of available views as a result of changes to the existing landscape, people's responses to these changes, and the overall impacts with respect to visual amenity.

For this assessment, key visual receptors include any nearby residents, users of transport routes (road and rail) as well as users of public recreation whom all have differing sensitivities to their visual environment. Generally, sensitivity is derived from a combination of factors including:

- The receptors interest in the visual environment i.e. high, medium or low interest in their everyday visual environment, and the duration of the effect;
- The receptors duration of viewing opportunity, i.e. prolonged, regular viewing opportunities;
- Number of viewers and their distance / angle of view from the source of the effect, extent of screening/filtering of the view, where relevant;
- Magnitude of change in the view (i.e. loss / addition of features that change the view's composition) and integration of changes within the existing view (form, mass, height, colour and texture); and
- Effectiveness of proposed mitigation.

The terminology set out in Table 5-5 has been used to describe visual sensitivity.

Table 5-5 Visual sensitivity definitions

Sensitivity	Definition
High	Occupiers of residential properties with long viewing periods, within proximity to the proposed development. Communities that place value upon the landscape and enjoyment of views of the landscape setting.
Medium	Outdoor workers who may also have intermittent views of the Project area. Viewers at outdoor recreation areas located within proximity but where viewing periods are limited. Occupiers of residential properties with long viewing periods, at a distance from or screened / filtered views of the Project area.
Low	Road users in motor vehicles, trains or on transport routes that are passing though or adjacent to the study area and have short term / transient views.
Neutral	Viewers from locations where there is screening by vegetation or structures where only occasional views are available and viewing times are short.
Nil	No view of the Project area is possible.

5.4.8.7 Limitations

Key viewing locations were selected as the most sensitive viewing locations or where the Project is likely to be viewed by the greatest number of people via a desktop assessment. Despite this limitation, the most important sensitive receptors, in terms of number of people being affected, have been captured as part of this assessment.

5.5 Description of Environmental Values

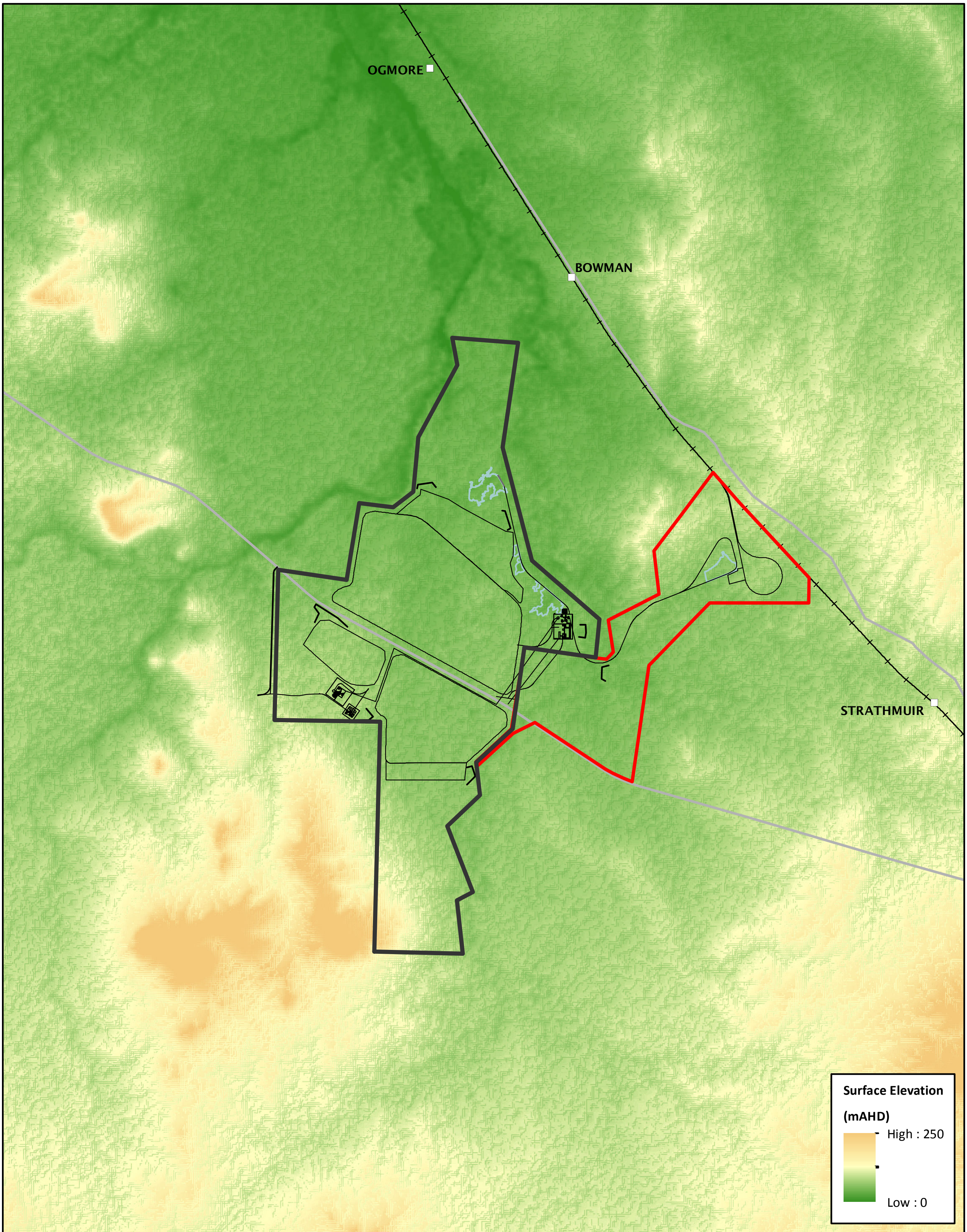
5.5.1 Topography

Elevations across the Styx catchment range from 0 to 540 m above sea level. The area predominantly comprises flat or undulating lands, draining via several smaller creeks and tributaries to the Styx River and estuary, and into the Coral Sea (see Figure 5-3). The land within the Project area can be described as gently undulating (see Plate 5-1 to Plate 5-11).

A LiDAR survey was conducted of the EPC 1029 area. Based on this data, elevations within the EPC vary between 4.5 and 155 m Australian Height Datum (AHD), with the ML located between 11.4 and 43.8 m AHD.

Based on the Capricornia Coastal Lands program (DPI, 1995), the ML area contains the following geomorphological land units:

- Broad, level to gently undulating alluvial plains and fans on alluvium, including some areas of gilgai microrelief (melonhole);
- Level to gently undulating plains and rises on sedimentary rocks and unconsolidated sediments, including some minor to severe melonhole;
- Undulating rises and low hills on deeply weathered sedimentary and metamorphic rocks;
- Dissected low plateaus on gently dipping sedimentary rocks; and
- Rolling low hills and rises on hard sedimentary rocks.



0 1 2 km

Scale @ A4 1:80,000
Date: 19/10/18
Drawn: Gayle B.

Legend

- ML 80187
- ML 700022
- Mine infrastructure
- Main Road
- North Coast Rail Line
- Dam

Figure 5-3
Site topography

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018
1 Second SRTM v1.0 DEM
Geoscience Australia, 2011

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 R1 Topography_5-3.mxd 10/19/2018

Plate 5-1: Terrain at the south of Open Cut 1 - Waste Rock Stockpile 1b (SS01 location)

Plate 5-2: Terrain looking south across Open Cut 1 (SS02 location)

Plate 5-3: Terrain looking east across Open Cut 2 (SS03 location)

Plate 5-4: Terrain at the TLF (SS04 location)

Plate 5-5: Terrain next to Deep Creek looking south towards Open Cut 2 (SS05 location)

Plate 5-6: Terrain looking south over Open Cut 2 adjacent to Tooloombah Creek (SS06 location)

Plate 5-7: Terrain looking east towards Open Cut 1 (SS07 location)

Plate 5-8: Terrain looking east towards Open Cut 1 (SS08 location)

Plate 5-9: Terrain looking east towards Open Cut 1 (SS09 location)

Plate 5-10: Terrain looking east towards Open Cut 1 (SS10 location)

Plate 5-11: Terrain looking east towards Open Cut 1 (SS11 location)

5.5.2 Land Use

The Project is wholly contained within the Styx Drainage Basin, comprising of Styx River, Deep, Tooloombah, Barrack, Waverley and St Lawrence Creeks. The Styx Basin discharges to the GBRMP. The Project is bordered by two watercourses as defined under the Water Act, namely Tooloombah Creek and Deep Creek. These creeks meet at a confluence downstream of the Project area to form the Styx River. The coastal zone, commencing downstream of the North Coast Rail Line, is located approximately 10 km downstream of the ML area. The GBRMP is located approximately 40 km downstream of the ML area.

Cattle grazing is the principal agricultural industry in the Project area (see Figure 5-4). Based on historical studies carried out as part of the EIS (see Chapter 18 - Cultural Heritage) the first pastoral runs within the Project area were issued licenses in the early 1860s. Since then, cattle grazing has continued across the broader Project area. This was confirmed through a review of information pertaining to land use derived from review of previous land use assessments, aerial photo interpretation and informal discussions with the existing landholders.

Cattle grazing, for both fattening and breeding of stock, has relied on stock dams, fencing and associated access tracks constructed within the Project area.

The Mamelon property is generally considered suitable for beef cattle grazing on pastures. Whilst some areas within Mamelon and the adjoining Brussels Strathmuir properties are theoretically suitable for cropping, this type of agriculture enterprise has not occurred at these properties.

Central Queensland Coal will manage its operations and conduct decommissioning and rehabilitation activities to ensure that the land disturbed is returned to land suitable for the natural regeneration of land undisturbed by mining activities or revegetated to meet conservation objectives where appropriate. To achieve the commitment to return the land to a stable landform, Central Queensland Coal has committed to destocking the majority of the Mamelon property once mining activities commence. A small section of the Mamelon property, located at the southern extent of the ML boundary, will continue to be set aside for ongoing grazing. The destocking of the majority of the Mamelon Property will enable the undisturbed land, including the riparian corridors and associated buffer zones, and the areas under rehabilitation, to regenerate without competing grazing pressures.

This approach to destock the property is consistent with the Reef 2050 Plan which recognises the extent to which grazing contributes annually to the sediment load reporting to the Great Barrier Reef (GBR). This is discussed further in Section 5.6 of this Chapter. The approach to rehabilitation is discussed in SEIS Chapter 11 – Rehabilitation.

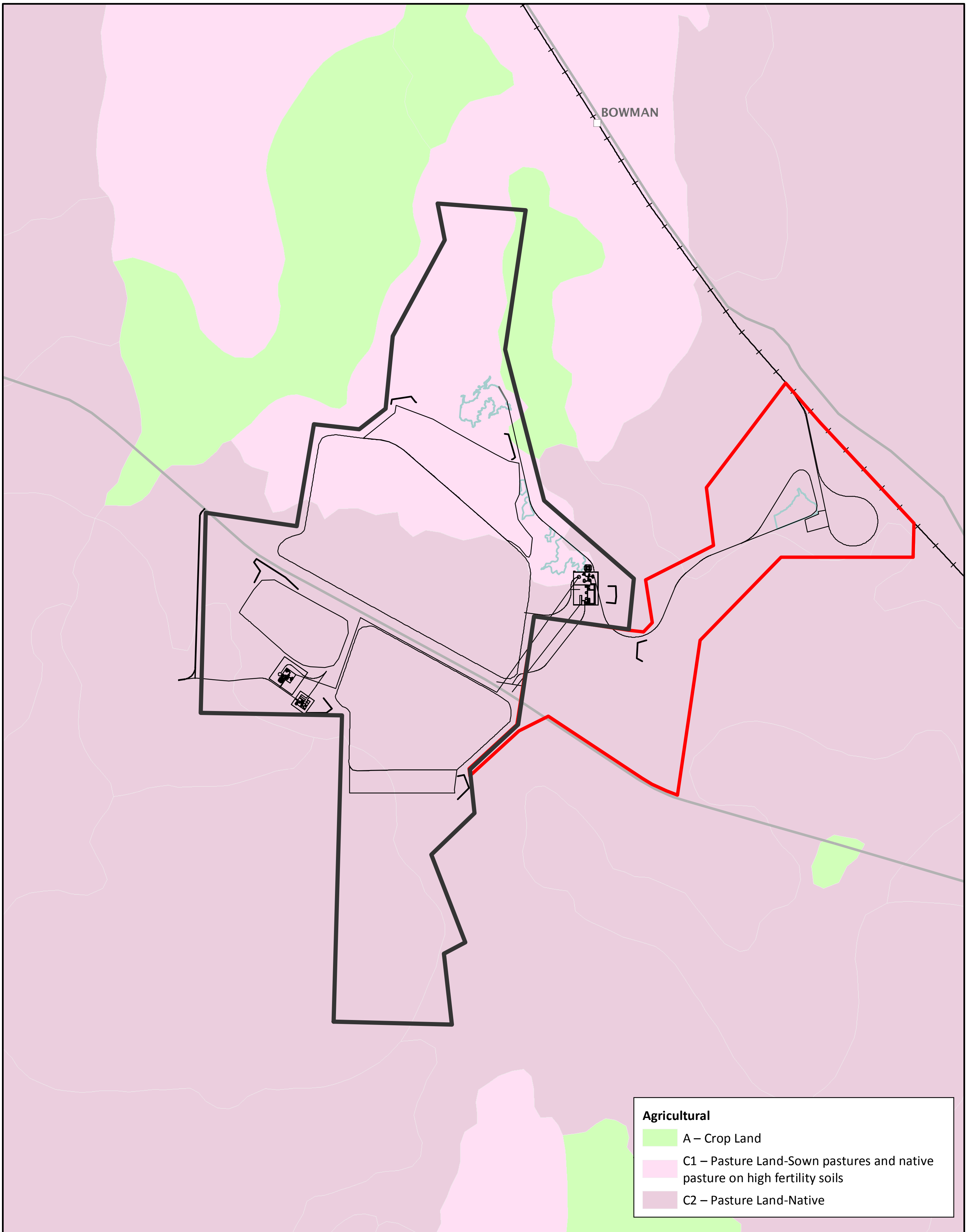


Figure 5-4
Existing land use in the Project area

N

0 0.5 1 km

Scale @ A4 1:60,000
Date: 19/10/18
Drawn: Stuart

Legend

- ML 80187
- ML 700022
- Mine infrastructure
- Main Road
- North Coast Rail Line
- Dam

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018
QLD Natural Resources & Mines, 2018

CDM Smith

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5.5.3 Geology

5.5.3.1 Regional Geology

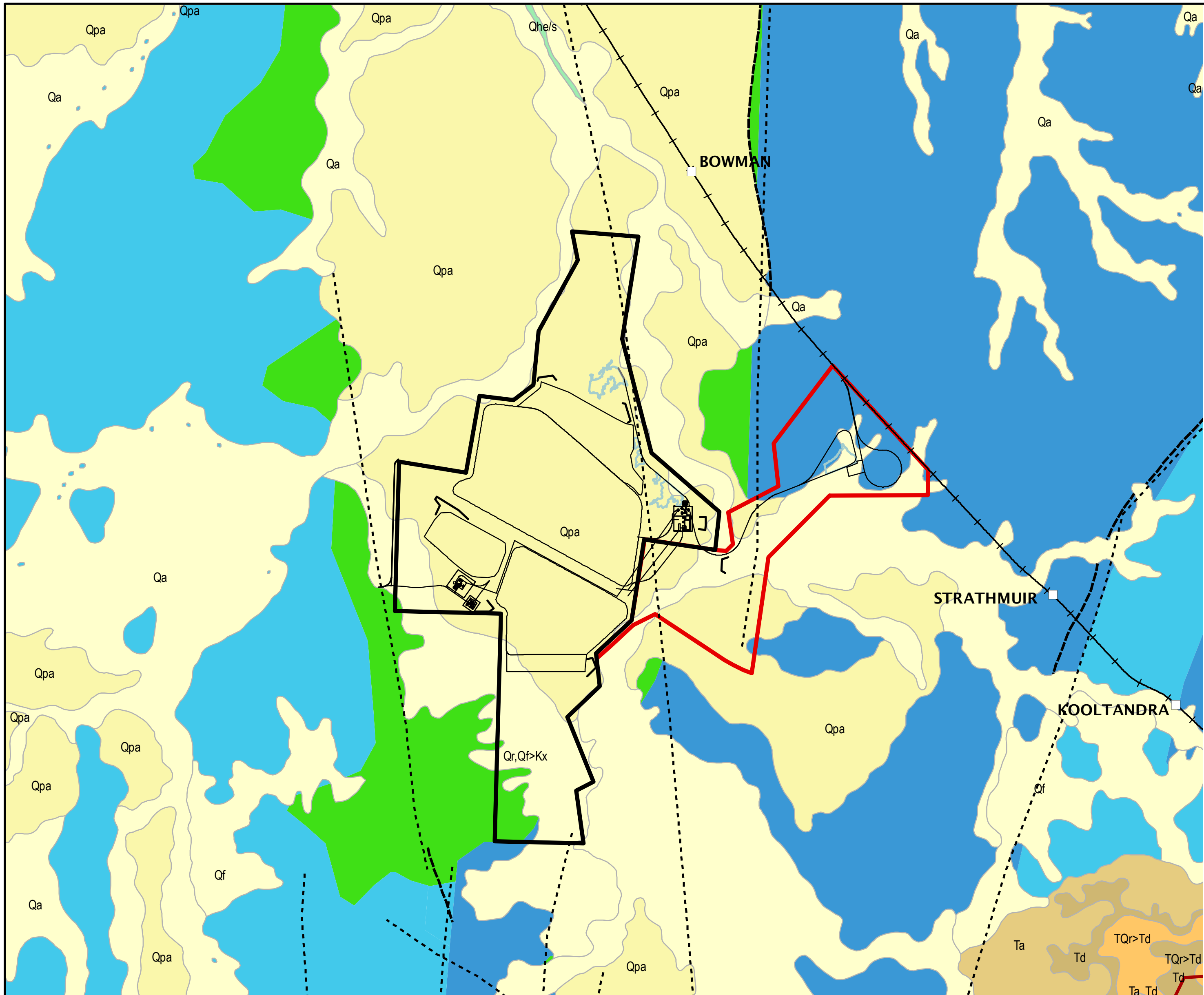
The Styx Coal reserves lie in the Styx Basin, a small, Early Cretaceous, intracratonic sag basin that covers an area of approximately 300 km^2 onshore and 500 km^2 offshore. The known coal bearing strata of the basin are referred to as the Styx Coal Measures and consist of quartzose, calcareous, lithic and pebbly sandstones, pebbly conglomerate, siltstone, carbonaceous shale and coal. The environment of deposition was freshwater, deltaic to paludal with occasional marine incursions (Taubert 2002). The regional geology of the Styx Basin is shown at Figure 5-5 and described in Table 5-6.

Table 5-6 Geological units underlying the Styx Basin

Period	Group	Sub-group/formation	Dominant lithology
Quaternary	Surficial	Quaternary Alluvial	Alluvium, coastal swamp deposits
Cainozoic	Surficial	Undifferentiated sediment	Sand, soil, alluvium, lateritic gravel
Lower Cretaceous	-	Styx Coal Measures	Quartz sandstone, conglomerate, siltstone, carbonaceous shale, coal
Upper Permian	Back Creek Group	Boomer Formation	Volcanolithic sandstone, claystone, siltstone, pebble conglomerate
Permian	Back Creek Group	Back Creek Group	Undifferentiated: fossiliferous volcanolithic sandstone, siltstone, limestone

The Styx Coal Measures are preserved as basin infill in a half graben geometry which has an overall plunge to the north. Earlier attempts to understand coal-seam geometry are thought to have been incorrect, in assuming that the deposit was basically flat lying rather than incorporating the north and east dipping components.

The Styx Basin is relatively undeveloped, except for two small scale, government owned mines that were in operation from 1919 to 1963. The Ogmore and Bowman collieries, located close to the north and northeast of ML 80187 respectively, produced small qualities of low quality coal, for use in steam trains and other boiler requirements (see Chapter 18 - Cultural Heritage).



FAULTS

- Fault Approximate
- Fault Concealed
- Fault Inferred
- Trend Line
- Trend Line Showing Dip 5 to 15 Degrees

CENOZOIC SURFACE GEOLOGY

HOLOCENE

- Estuarine deposits

PLEISTOCENE

- Alluvium

QUATERNARY

- Alluvium

LATE TERTIARY-QUATERNARY

- Colluvium

TERTIARY

- Poorly consolidated sediments
- Ferricrete

BOWEN ROCK UNIT SOLID

CARBONIFEROUS-LATE PERMIAN

- Back Creek Group
- Boomer Formation
- Styx Coal Measures

N

0 1 2 km

Scale @ A4 1:100,000
Date: 08/11/18
Drawn: Gayle B.

Legend

- ML 80187
- ML 700022
- Mine infrastructure
- North Coast Rail Line
- Dam

Figure 5-5

Regional geology

DATA SOURCE
QLD Open Source Data, 2018;
Waratah Coal, 2018

CDM Smith

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5.5.3.2 Geology of the Project Area

The stratigraphy of the Project area is shown at Figure 5-6. The coal seams are relatively shallow, and the average cumulative thickness of the full sequence of coal (Grey to V_L2 seams) is approximately 6 m, contained within a sequence of approximately 120 m of coal bearing strata.

The coal seams dip generally to the east in the area west of the Bruce Highway, with the Violet seam, the lowest coal seam in the sequence subcropping in the western part of ML 80187. The deposit structure is currently interpreted to be a syncline structure, the axis of which runs northwest / southeast through the mine area. This structural interpretation follows the deposit structure originally described by Morten (1955).

No faults have been interpreted, and the apparent undulation seen in the floor contours of the coal seams is interpreted to be small scale folding associated with the syncline in the area.

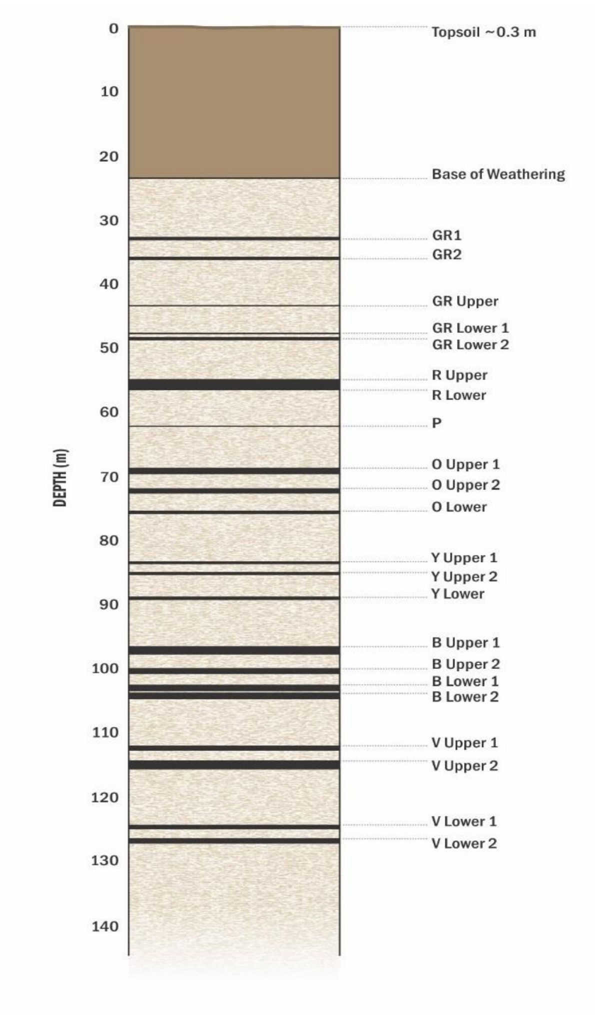

Figure 5-6 Schematic stratigraphic section

The economic Cretaceous coal measures targeted for mining are the Styx Coal Measures, contained within the Styx Basin. The Styx basin is located on the central Queensland coast, north of Marlborough. It is a Lower Cretaceous sedimentary basin which unconformably overlies Permian sedimentary rocks of the Back Creek Group that have been compressed into a broad regional syncline, the Strathmuir Syncline. The basin extends beneath the sea bed into the Broad Sound near the Port of St Lawrence. Its portion on land is approximately 20 km wide (east-west) and 70 km long (north-south).

The majority of the Styx Coal Measures are concealed beneath Tertiary sediment. Queensland Geological Survey mapping shows the eastern margin of the Styx Basin extends to the eastern edge of the terrestrial Cainozoic sediments that conceal it. The Styx Coal Measures outcrop in the western margin of the Styx Basin as low forested hills. These outcrops form a series of detached hills, orientated north-south, that continue for about 60 kilometres (km) northward to the coastline near the Port of St Lawrence. The outcrops generally form small hills and hillocks, but at their greatest height, are 100 metres above the low-lying sediment flats to the east. The hills are probably the coal-barren basal section of the Styx Coal Measures sequence, which consists of thick beds of quartz-dominant sandstones.

The strata of the Styx Basin dip gently to the east, at around three degrees. Tertiary-aged, lateritised sedimentary rocks outcrop to the east of the southern part of the basin. Styx Basin sediments lap onto Permian strata in the west but appear to be faulted against them in the east. The southern part of the basin is bounded to the east by a post-depositional high-angle reverse fault. Adjacent to this fault, the Cretaceous sediments are folded and faulted.

The Styx Basin sediments were laid down on a coastal plain which developed on the Palaeozoic Strathmuir Syncline during the Early Cretaceous. The Styx Basin probably developed by subsidence of the Strathmuir Synclinorium, an older feature containing Permian Bowen Basin strata. A schematic geological section (east-west) across the Styx Basin is shown in Figure 5-7.

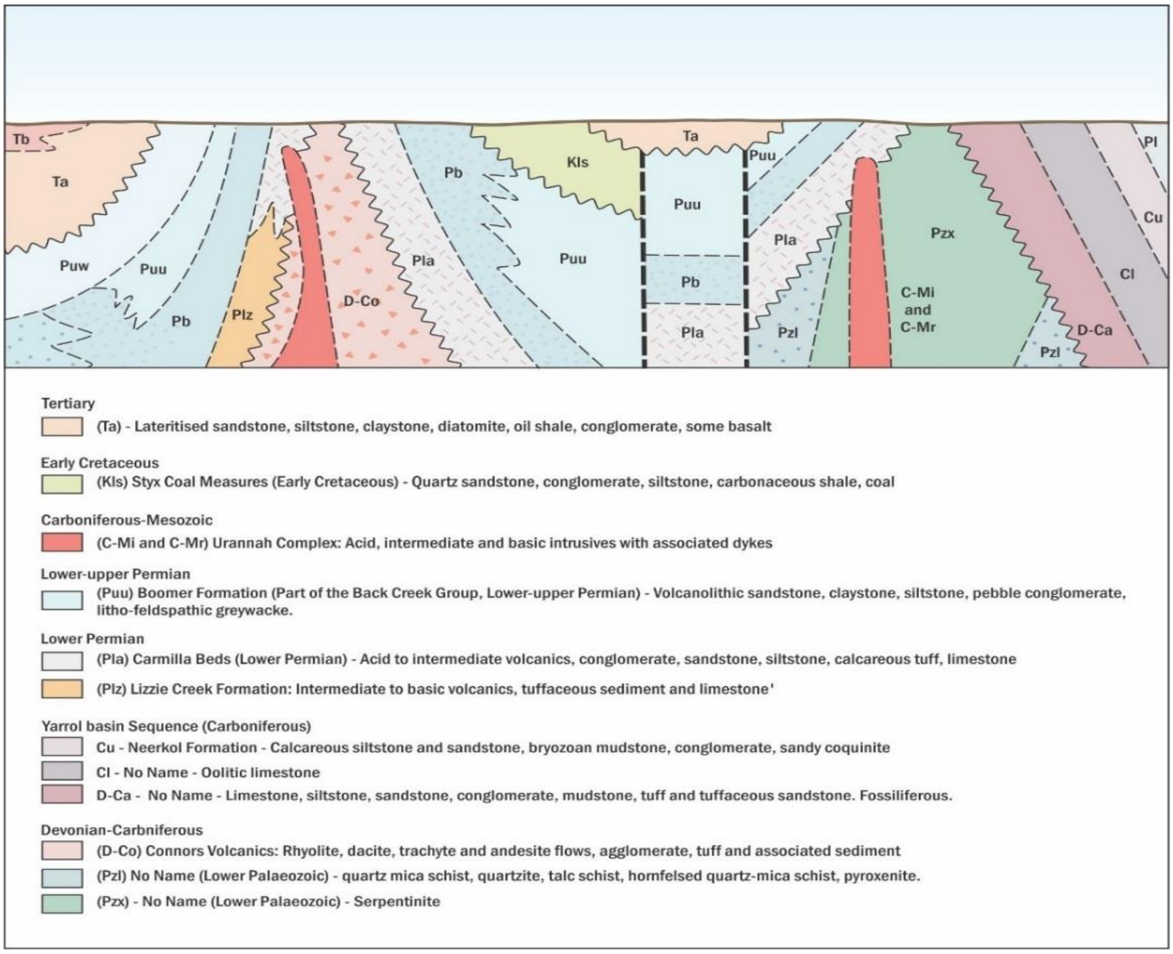

Figure 5-7 Schematic west to east geological cross section (see Australia 1:250 000 Geological Series)

Cretaceous Coal Seam Characteristics – Styx Coal Measures

The coal seams that comprise the Styx Coal Measures are generally thin, commonly less than two metres in thickness. Seam splitting is common and seam thicknesses vary considerably. All seams are potentially economically exploitable, despite their relatively small thicknesses. Coal quality throughout the deposit is generally consistent and all seams demonstrate coking properties.

The seams were divided into seam groups and named using a colour scheme. From the base of the Measures to the top, they are tagged as: Violet, Blue, Yellow, Orange, Pink, Red, Green and Grey.

The coal plies may coalesce to form substantially thick seams in parts of the deposit (e.g. Violet and Blue) but in other seams (Orange, Green, Grey) coalescence is not evident in the ML 80187 area. It is common for the coal plies to lense out over moderate distances. The Orange, Green and Grey Seams are characteristically coal ply groups that may coalesce elsewhere in the Styx Basin, but do not coalesce within the proposed mining area. The Red, Yellow and Pink Seams split into two plies in isolated areas. The Red Seam is the most consistent in thickness and quality throughout the ML 80187 area and occurs in the middle of the coal-bearing part of the stratigraphic sequence. The Red Seam commonly exceeds two metres in thickness.

All plies and coalesced seams demonstrate coal quality and seam thickness characteristics that are attractive mining targets. Coal quality analysis and reconciliation with geophysical data show that the majority of ROM coal will require wash-plant treatment to remove partings. Sulphur content is low, even in the raw sample analysis. Pyrite has not been noted in any geological logging or results of quality analysis. Float-sink, drop-shatter, sizing and associated analyses indicate wash-plant yields are likely to be around 80% of ROM coal. Basic seam thickness information is provided in Table 5-7.

Table 5-7 Cretaceous coal measures coal seam characteristics

Seam	Ply	Seam thickness (m)		
		Min	Max	Average
Grey	GR1	0.11	1.09	0.42
	GR2	0.10	0.77	0.37
Green	GR Upper	0.10	0.85	0.34
	GR Lower1	0.10	0.79	0.37
	GR Lower2	0.10	0.29	0.19
Red	R Upper	0.10	2.24	0.81
	R Lower	0.10	1.32	0.71
Pink	P	0.10	0.25	0.16
Orange	O Upper1	0.10	0.60	0.33
	O Upper2	0.10	0.39	0.26
	O Lower	0.10	0.71	0.36
Yellow	Y Upper1	0.10	2.74	0.64
	Y Upper2	0.10	1.03	0.30
	Y Lower	0.10	0.78	0.37
Blue	B Upper1	0.10	1.76	0.56
	B Upper2	0.10	1.71	0.71
	B Lower1	0.10	2.23	0.53
	B Lower2	0.11	0.88	0.37
Violet	VI Upper1	0.10	1.35	0.36
	VI Upper2	0.10	0.30	0.18
	VI Lower1	0.10	1.19	0.43
	VI Lower2	0.10	0.74	0.34
	VI Lower2	0.10	0.71	0.39

5.5.3.3 Fossils

A review of the Queensland Museum palaeontology database (May 2017) records indicate no significant fossils have previously been identified within the Project area and are considered unlikely to occur. If fossils with the potential to be of paleontological significance are discovered, the immediate site of the fossil find will be isolated and the Queensland Museum will be notified.

5.5.4 Soils

5.5.4.1 Desktop Assessment

An assessment of publicly available soil and landform mapping data provided an initial indication of relevant soil types across and surrounding the Project area. Results from the desktop assessment as they relate to soils and landforms are described below.

Mapped landscape units identified four broad scale units that occur within the Project area – CC32, Mw26, Ub89 and Vd3 (Figure 5-8). The landscape unit descriptions provided by ASRIS are summarised below:

- CC32: Gently undulating or level plains - This landform comprises gently undulating or level plains, often with slight to moderate gilgai microrelief and is characterised by deep grey clays with lesser deep brown clays. Closely associated are extensive areas of loamy duplex soils and friable brown clays;
- Mw26: Strongly undulating lands with some high narrow ridges - This landform comprises strongly undulating lands with some high narrow ridges, low dissected mesas and steep-scarped low cuestas and is characterised by deep sandy red earths that are occasionally gravelly. On higher more dissected landscape sites are shallow stony loams, and lower flatter slopes mostly have deep sandy-surface duplex soils;
- Ub89: Moderate to strongly undulating lands with occasional low hilly areas - This landform comprises moderate to strongly undulating lands with occasional low hilly areas and is characterised by shallow loamy duplex soils. A prominent stony layer is often present at the base of the A horizons. Higher ridges and low hilly areas have very shallow stony similar duplex soils; and
- Vd3: Gently undulating slightly elevated plains - This landform comprises gently undulating slightly elevated plains with a slight gilgai microrelief and is characterised by soils with deep loamy A horizons. Duplex soils occur on level sites, in most puffs (the small mounds in gilgai settings), and in all depressions. In the latter, A horizons are deep. Grey clays occur occasionally on some better-defined puffs.

Queensland soil maps indicate sodosols, vertosols and kandosols are the predominant soil orders within the Project area (Figure 5-9). ASRIS indicated the same dominant soil orders across the mine, haul road corridor and TLF. The vertosols correspond to the flatter landscape (CC32) in the north of the Project site. The sodosols are the most widespread soil order in the Project surrounds and correspond to the more elevated plains (Vd3) which run east-west through the central axis of the Project site. The Kandosols correspond to the undulating land (Mw26) to the south west of the Project site.

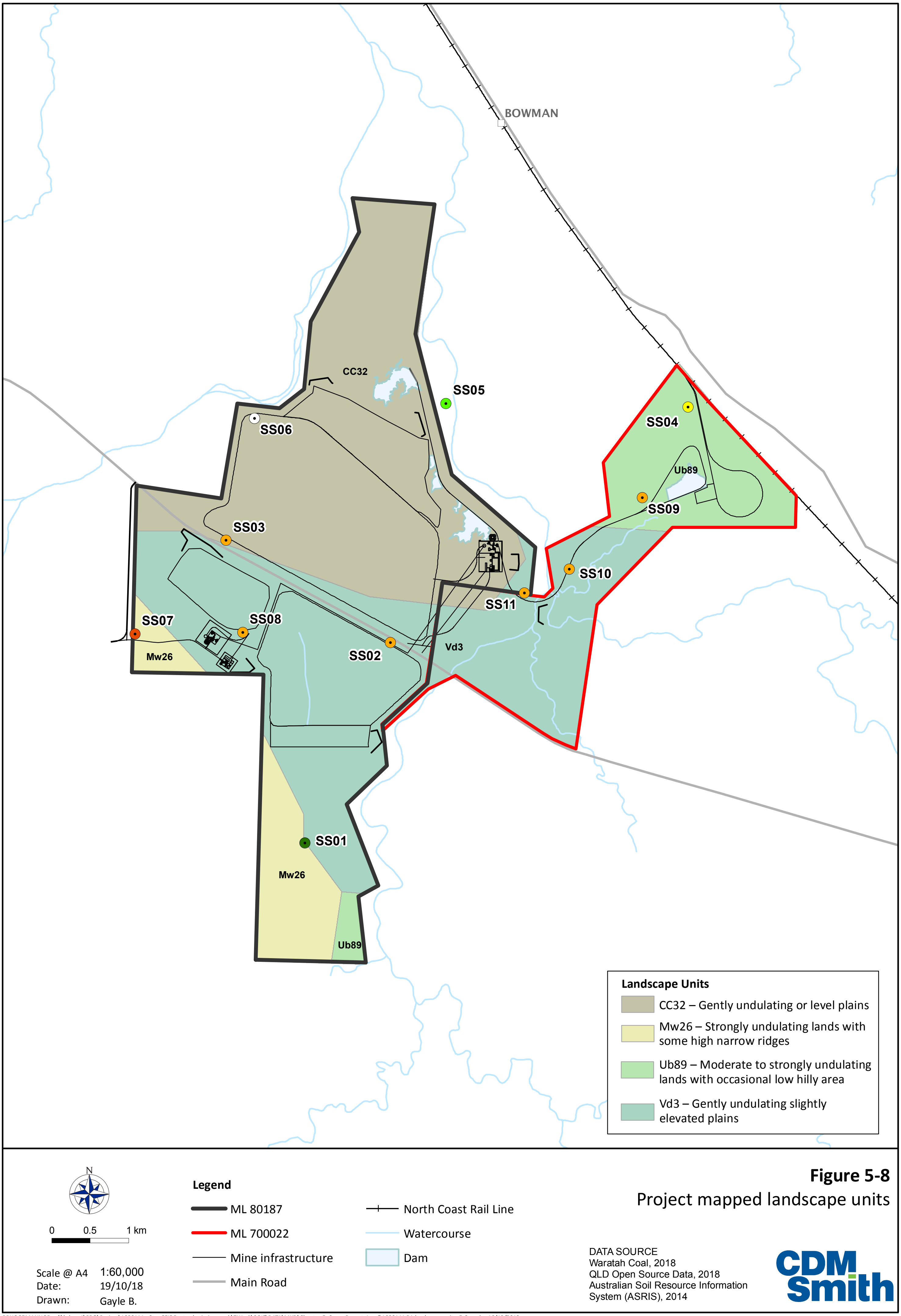

Figure 5-8
Project mapped landscape units

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018
Australian Soil Resource Information System (ASRIS), 2014

CDM Smith

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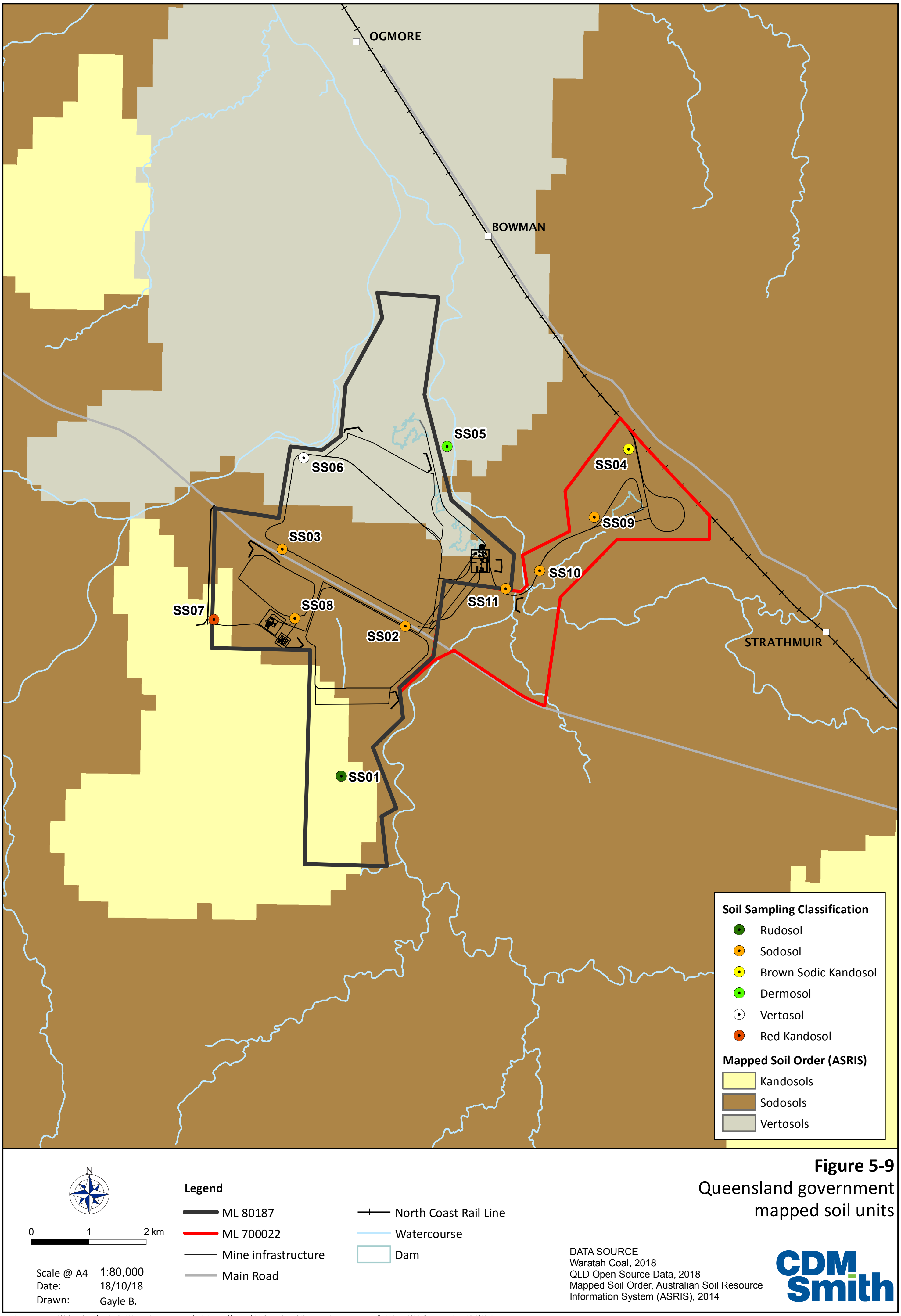


Figure 5-9
Queensland government mapped soil units

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018
Mapped Soil Order, Australian Soil Resource Information System (ASRIS), 2014

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 Qld Soil__5-9.mxd 10/18/2018

5.5.4.2 Field Assessment

During the field assessment 11 full soil samples were collected (SS01 – SS11) and 16 soil observations undertaken (SO-01 to SO-13). The description of each of the full soils samples are provided at Table 5-8 to Table 5-18.

There was reasonable alignment between the soil orders mapped by desktop analyses and the soil classifications made by field investigations. The exceptions were: SS01 (mapped as a Kandosol but classed as a Rudosol due to negligible pedological organisation but sharing many of the characteristics of a Kandosol); SS04 (mapped as a Sodosol but as classed as a Kandosol due to a lack of a strong texture-contrast between A and B horizons despite being sodic); and SS05 (mapped as a Vertosol but classed as a Dermosol due to soil texture not being sufficiently heavy to meet the criteria for Vertosols).

The two sites classed as Kandosols (SS04 and SS07) are distinctly different soils despite being grouped within the same soil order. This is reflected in their classification with SS04 being classed as a brown sodic Kandosol and SS07 being classed as a Red Kandosol.

Table 5-8 SS01 description

Site ID: SS01	**Date 6/05/17**	
Location: Lot 11 on MC23	**Easting: 772837**	**Northing: 7483395**
Geology: Qr-QLD, Qf-QLD>Styx Coal Measures (Qr,Qf>Kx)	Mapped Soil Type: Kandosol	
Micro-relief: Nil	Field Based Soil Type: Rudosol	
Landuse: Grazing (not cleared)	Land Disturbance: High area is full of weeds with minimal native vegetation	
Landscape Unit: Mw26 – Strongly undulating lands with some high narrow ridges	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: Low and scattered regrowth of Narrow-leaf Ironbark (*E. crebra*) and *Melaleuca* species	
Slope: Very gently inclined (1%)	Drainage: Imperfectly drained	
Surface Condition: Soft	Erosion Potential: Low	

Figure 1: SS01 Landscape

Figure 2: SS01 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A	0 – 1.2	Dark brown (10 YR 3/3); fine sandy (single grain)
Terminate		

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	5.3	5.4	5.5	5.5	5.6	5.6
Electrical Conductivity (us/cm)	20	10	7	7	16	34
Moisture Content (%)	9.6	7.9	8.8	9.6	12.2	10.3

Colour (Munsell)	Very Dark Gray	----	----	Light Brownish Gray	----	Light Brownish Gray
Texture	Loamy Sand	----	----	Sand	----	Loamy Sand
Emerson Class Number	3	----	----	8	----	3
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.37	2.5	2.4	2.58	2.5	2.4
Exchange Acidity (meq/100g)	0.6	0.6	0.3	0.5	0.4	0.3
Exchangeable Aluminium (meq/100g)	0.4	0.3	0.2	0.3	0.2	0.2
Exchangeable Calcium (meq/100g)	0.8	0.7	0.3	0.1	<0.1	<0.1
Exchangeable Magnesium (meq/100g)	0.5	0.5	0.4	0.3	1.1	1.3
Exchangeable Potassium (meq/100g)	0.4	0.2	0.2	0.2	0.2	<0.1
Exchangeable Sodium (meq/100g)	<0.1	<0.1	<0.1	<0.1	<0.1	0.4
Cation Exchange Capacity (meq/100g)	2.3	2	1.2	1.1	1.7	2
Exchangeable Sodium Percent (%)	2.2	1.5	1.9	1.8	6.6	21.1
Calcium / Magnesium Ratio	1.6	1.4	0.8	0.3	<0.1	<0.1
Magnesium / Potassium Ratio	1.3	1.8	2.5	2.1	7.2	----
Sulphur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	40
Boron (mg/kg)	0.3	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	197	----	----	----	----	----
Manganese (mg/kg)	5.64	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	1.8	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	730	----	----	----	----	----
Total Nitrogen as N (mg/kg)	730	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	2	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	11	11	8	11	14	18
Silt (2-20 µm) (%)	8	5	9	3	3	4
Fine Sand (0.02-0.2 mm) (%)	12	10	10	10	10	9
Coarse Sand (0.2-2.0 mm) (%)	19	21	19	16	14	17
Gravel (>2mm) (%)	50	53	54	60	59	52

Table 5-9 SS02 description

Site ID: SS02	**Date 6/05/2017**	
Location: Lot 1 on MC813349	**Easting: 773943**	**Northing: 7485595**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: Vd3 - Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: Cleared area with scattered immature trees including Beefwood (*Grevillea striata*), Brigalow (*Acacia harpophylla*) and Poplar Box (*E. populnea*). Beside fence line of larger trees – Poplar Box	
Slope: Level (0.6 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Low	

Figure 1: SS02 Landscape

Figure 2: SS02 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.15	Dull yellow orange (10 YR 7/2), loamy sand, diffuse (>100 m)
A2	0.15 – 0.35	Greyish yellow brown (10 YR 6/2), clayey sand, gradual 50 – 100 mm)
A3	0.35 – 0.45	Dull yellow orange (10 (YR 6/3), clayey sand, clear (20 – 50 mm)
B1	0.45 – 0.84	Yellowish brown (10 YR5/6), clayey sand, gradual 50 – 100 mm)
B2	0.84 – 1.2	Brown (10 YR 4/6), clayey sand
Terminate		

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	6.2	6	6.1	7.6	8	8
Electrical Conductivity (us/cm)	10	38	192	581	554	517
Moisture Content (%)	3.3	8.2	9.6	13.6	10	10
Colour (Munsell)	Brown	----	----	Pale Brown	----	Brown
Texture	Loamy Sand	----	----	Clay Loam	----	Clay Loam
Emerson Class Number	3	----	----	2	----	2
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.36	2.56	2.5	2.48	2.33	2.35
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	2.4	4.1	5.1	2.1	2.1	1.8

Exchangeable Magnesium (meq/100g)	1.9	5.7	7.9	4	3.6	3.1
Exchangeable Potassium (meq/100g)	0.2	0.2	0.3	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	0.2	1.1	2	1.3	1.5	1.3
Cation Exchange Capacity (meq/100g)	4.7	11.4	15.5	7.4	7.2	6.1
Exchangeable Sodium Percent (%)	3.9	9.6	13.1	17	20.9	21.3
Calcium / Magnesium Ratio	1.3	0.7	0.6	0.5	0.6	0.6
Magnesium / Potassium Ratio	10.6	21.9	28.3	----	----	----
Sulphur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	990	----	820
Boron (mg/kg)	0.2	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	62.5	----	----	----	----	----
Manganese (mg/kg)	62.7	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	<0.1	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	550	----	----	----	----	----
Total Nitrogen as N (mg/kg)	550	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	1.3	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	18	22	51	42	35	36
Silt (2-20 µm) (%)	42	60	32	33	31	29
Fine Sand (0.02-0.2 mm) (%)	24	13	15	23	29	30
Coarse Sand (0.2-2.0 mm) (%)	2	<1	1	<1	4	4
Gravel (>2mm) (%)	14	4	1	1	1	1

Table 5-10 SS03 description

Site ID: SS03	Date 5/05/2017	
Location: Lot 10 on MC493	**Easting: 771804**	**Northing: 7487330**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: Vd3 - Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: RE 11.4.2 - Poplar Box and Narrow-leaf Ironbark dominated woodland with sparse understorey	
Slope: Level (0.6 %)	Drainage: Poorly drained	
Surface Condition: Firm	Erosion Potential: Moderate	

Figure 1: SS03 Landscape

Figure 2: SS03 Soil Profile, Depth to 1.2 m

Horizon	Depth (m)	Description
A1	0.0 – 0.23	Bright Brown (10 YR 6/6), loamy sand, diffuse (>100 mm)
A2	0.23 – 0.33	Dull yellowish brown (10 YR 5/4), clayey sand, diffuse (>100 mm)
A3	0.33 – 0.5	Yellowish brown (10 YR 5/6), light clay, clear (20 – 50 mm)
B	0.5 – 1.2	Brown (10 YR 4/6), light medium clay
Terminate		

Laboratory Results

Analysis	Depth Tested (m)					
	0.0 – 0.1	0.1 – 0.2	0.2 – 0.3	0.5 – 0.6	0.8 – 0.9	1.1 – 1.2
pH Value (pH unit)	6.3	6.5	7	8.3	9.1	9.1
Electrical Conductivity (us/cm)	7	13	51	215	492	412
Moisture Content (%)	2.8	3.2	6.4	8.4	8.4	7.5
Colour (Munsell)	Brown	----	----	Yellowish Brown	----	Yellowish Brown
Texture	Clay Loam	----	----	Clay Loam	----	Clay Loam
Emerson Class Number	3	----	----	1	----	1
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.38	2.37	2.32	2.32	2.46	2.43
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	1.6	1.3	1.8	0.8	0.7	0.8
Exchangeable Magnesium (meq/100g)	2.5	2.6	4.6	3.3	3.2	3.5

Exchangeable Potassium (meq/100g)	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	0.3	0.6	1.4	1.7	2.1	2.6
Cation Exchange Capacity (meq/100g)	4.8	4.6	7.9	5.8	6	6.9
Exchangeable Sodium Percent (%)	7	12.4	18.1	29	35.2	37.7
Calcium / Magnesium Ratio	0.6	0.5	0.4	0.2	0.2	0.2
Magnesium / Potassium Ratio	----	----	----	----	----	----
Sulphur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	190	----	430
Boron (mg/kg)	0.3	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	40.5	----	----	----	----	----
Manganese (mg/kg)	36.9	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	<0.1	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	440	----	----	----	----	----
Total Nitrogen as N (mg/kg)	440	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	1.1	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	23	26	45	38	34	32
Silt (2-20 µm) (%)	15	17	14	17	14	16
Fine Sand (0.02-0.2 mm) (%)	20	19	12	20	23	24
Coarse Sand (0.2-2.0 mm) (%)	12	11	8	8	11	11
Gravel (>2mm) (%)	30	27	21	17	18	17

Table 5-11 SS04 description

Site ID: SS04	Date 5/05/2017	
Location: Lot 9 on MC230	**Easting: 777863**	**Northing: 7489007**
Geology: Back Creek Group-Pb (Pb)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Kandosol (Brown sodic Kandosol)	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: Ub89 – Moderate to strongly undulating lands with occasional low hilly areas	Landform Element: Upper slope	
Landform Pattern: Rises	Vegetation: Cleared pasture	
Slope: Gently inclined (6 %)	Drainage: Very poorly drained	
Surface Condition: Surface crust	Erosion Potential: Moderate	

Figure 1: SS04 Landscape

Figure 2: SS04 Soil Profile, Depth to 0.5 m

Horizon	Depth (m)	Description
A1	0.0 – 0.23	(10 YR 6/2), clayey sand, diffuse (>100 mm)
A2	0.23 – 0.45	Dull yellowish brown (10 YR 5/3), loamy sand, clear (20 – 50 mm)
B	0.45 – 0.5	(10 YR 5/4), loamy sand, abrupt (5 – 20 mm)
Terminate		Ceased hole – hit rock

Laboratory Results

Analysis	Depth Tested (m)					
	0.0 – 0.1	0.1 – 0.2	0.2 – 0.3	0.45 – 0.5		
pH Value (pH unit)	7	7.6	8.2	9.5		
Electrical Conductivity (us/cm)	45	71	160	339		
Moisture Content (%)	7.3	8.3	9	7.5		
Colour (Munsell)	Dark Greyish Brown	----	----	Brown		
Texture	Clay Loam	----	----	Sandy Clay Loam		
Emerson Class Number	2	----	----	2		
Soil Particle Density (Clay / Silt / Sand) (g/cm3)	2.45	2.47	2.37	2.47		
Exchange Acidity (meq/100g)	----	----	----	----		
Exchangeable Aluminium (meq/100g)	----	----	----	----		
Exchangeable Calcium (meq/100g)	2.8	1.1	0.9	1.2		
Exchangeable Magnesium (meq/100g)	7.4	3.7	3	3.1		
Exchangeable Potassium (meq/100g)	0.3	<0.2	<0.2	<0.2		

Exchangeable Sodium (meq/100g)	1.8	1	0.9	1.1		
Cation Exchange Capacity (meq/100g)	12.5	5.7	4.8	5.4		
Exchangeable Sodium Percent (%)	15	17.2	19.3	19.7		
Calcium / Magnesium Ratio	0.4	0.3	0.3	0.4		
Magnesium / Potassium Ratio	22.4	----	----	----		
Sulphur (%)	<0.01	----	----	----		
Chloride (mg/kg)	30	----	----	130		
Boron (mg/kg)	0.5	----	----	----		
Copper (mg/kg)	<1.00	----	----	----		
Iron (mg/kg)	64.6	----	----	----		
Manganese (mg/kg)	2.03	----	----	----		
Zinc (mg/kg)	<1.00	----	----	----		
Nitrite + Nitrate as N (mg/kg)	0.2	----	----	----		
Total Kjeldahl Nitrogen as N (mg/kg)	1000	----	----	----		
Total Nitrogen as N (mg/kg)	1000	----	----	----		
Bicarbonate Ext. P (mg/kg)	<5	----	----	----		
Organic Matter (%)	1.6	----	----	----		
Particle size distribution						
Clay (<2 µm) (%)	35	40	32	19		
Silt (2-20 µm) (%)	14	13	13	13		
Fine Sand (0.02-0.2 mm) (%)	12	12	14	13		
Coarse Sand (0.2-2.0 mm) (%)	10	13	11	18		
Gravel (>2mm) (%)	29	22	30	37		

Table 5-12 SS05 description

Site ID: SS05	**Date 5/05/2017**	
Location: Lot 10 on MC493	**Easting: 774667**	**Northing: 7489109**
Geology: Qa-QLD (Qa)	Mapped Soil Type: Vertosol	
Micro-relief: Nil	Field Based Soil Type: Dermosol	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: CC32 – Gently undulating or level plain	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: Cleared area beside RE 11.3.4 – mixed eucalypt open forest on alluvial soils. Weedy understorey dominated by Lantana (*Lantana camara*)	
Slope: Gently inclined (6 %)	Drainage: Imperfectly drained	
Surface Condition: Loose	Erosion Potential: Moderate	

Figure 1: SS05 Landscape

Figure 2: SS05 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.2	Greyish yellow brown (10 YR 6/2), sandy loam, diffuse (>100 mm)
A2	0.2 – 0.35	Dull yellowish brown (10 YR 5/3), sandy loam, abrupt (5-25 mm)
B	0.35 – 1.2	Brown (10 YR 3/4), sandy loam
Terminate		

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	6.8	6.7	6.6	6.6	6.7	6.7
Electrical Conductivity (us/cm)	16	12	9	6	6	5
Moisture Content (%)	6.2	6.2	7.2	10.9	12.4	11.7
Colour (Munsell)	Very Dark Greyish Brown	----	----	Brown	----	Yellowish Brown
Texture	Loam	----	----	Loam	----	Loamy Sand
Emerson Class Number	3	----	----	3	----	3
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.33	2.55	2.49	2.65	2.26	2.45
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	1.6	5.8	5.1	6.2	5	3.7
Exchangeable Magnesium (meq/100g)	2.5	2	1.8	2.3	2.6	2.4

Site ID: SS05			**Date 5/05/2017**			
Exchangeable Potassium (meq/100g)	<0.1	0.9	0.6	0.4	0.2	0.2
Exchangeable Sodium (meq/100g)	0.3	<0.1	<0.1	<0.1	<0.1	0.1
Cation Exchange Capacity (meq/100g)	4.8	8.7	7.6	9	7.9	6.4
Exchangeable Sodium Percent (%)	7	0.6	0.6	0.6	0.8	2
Calcium / Magnesium Ratio	0.6	2.9	2.8	2.7	1.9	1.5
Magnesium / Potassium Ratio	----	2.3	2.8	5.4	10.9	12.9
Sulphur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	<10
Boron (mg/kg)	0.3	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	75.5	----	----	----	----	----
Manganese (mg/kg)	19.1	----	----	----	----	----
Zinc (mg/kg)	1.19	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	0.2	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	990	----	----	----	----	----
Total Nitrogen as N (mg/kg)	990	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	28	----	----	----	----	----
Organic Matter (%)	2.4	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	20	23	20	22	20	21
Silt (2-20 µm) (%)	16	13	11	15	10	11
Fine Sand (0.02-0.2 mm) (%)	22	18	24	23	23	20
Coarse Sand (0.2-2.0 mm) (%)	28	30	30	30	33	34
Gravel (>2mm) (%)	14	16	15	10	14	13

Table 5-13 SS06 description

Site ID: SS06	**Date 5/05/2017**	
Location: Lot 10 on MC493	**Easting: 772179**	**Northing: 7488909**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Vertosol	
Micro-relief: Melonhole gilgai in proximity	Field Based Soil Type: Vertosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: CC32 – Gently undulating or level plain	Landform Element: Upper slope	
Landform Pattern: Plateau	Vegetation: Cleared pasture	
Slope: Very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Cracking	Erosion Potential: Moderate	

Figure 1: SS06 Landscape

Figure 2: SS06 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.18	Dull yellow orange (10 YR 6/3), loamy sand, gradual (50 – 100 mm)
A2	0.18 – 0.34	Dull yellowish brown (10 YR 5/4), loamy sand, clear (20 – 50 mm)
B	0.34 – 1.2	Dull yellowish brown (10 YR 4/3), clay loam
Terminate		

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	7.5	7.9	9	9.3	9.1	9.2
Electrical Conductivity (us/cm)	26	64	189	396	1160	1190
Moisture Content (%)	9.2	9	11.2	12.3	14.8	11.5
Colour (Munsell)	Dark Greyish Brown	----	----	Dark Greyish Brown	----	Brown
Texture	Sandy Clay	----	----	Sandy Clay	----	Sandy Clay
Emerson Class Number	3	----	----	1	----	2
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.33	2.55	2.49	2.65	2.26	2.45
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	2.9	2.9	4.9	5.5	2.8	3.5
Exchangeable Magnesium (meq/100g)	2	2	3.9	6.8	4.3	5.4
Exchangeable Potassium (meq/100g)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	0.2	0.2	0.9	4.3	3.4	4
Cation Exchange Capacity (meq/100g)	5.3	5.3	9.9	16.7	10.6	12.8

Site ID: SS06			Date 5/05/2017			
Exchangeable Sodium Percent (%)	4.2	4.7	9.3	26	32.4	30.8
Calcium / Magnesium Ratio	1.4	1.4	1.2	0.8	0.7	0.6
Magnesium / Potassium Ratio	----	----	----	----	----	----
Sulphur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	<10
Boron (mg/kg)	1.2	----	----	----	----	----
Copper (mg/kg)	2.65	----	----	----	----	----
Iron (mg/kg)	112	----	----	----	----	----
Manganese (mg/kg)	23.5	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	0.6	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	1590	----	----	----	----	----
Total Nitrogen as N (mg/kg)	1590	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	47	----	----	----	----	----
Organic Matter (%)	2.3	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	34	38	44	40	48	49
Silt (2-20 µm) (%)	30	30	29	26	26	26
Fine Sand (0.02-0.2 mm) (%)	24	22	18	18	15	13
Coarse Sand (0.2-2.0 mm) (%)	5	4	3	3	4	3
Gravel (>2mm) (%)	7	6	6	13	7	9

Table 5-14 SS07 description

Site ID: SS07	**Date 6/05/2017**	
Location: Lot 1 on MC813349	**Easting: 770623**	**Northing: 7486115**
Geology: Qr-QLD, Qf-QLD>Styx Coal Measures (Qr, Qf>Kx)	Mapped Soil Type: Kandosol	
Micro-relief: Nil	Field Based Soil Type: Red Kandosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: Mw26 – Strongly undulating lands with some high narrow ridges	Landform Element: Upper slope	
Landform Pattern: Lower slope	Vegetation: Edge of disturbed regrowth habitat located within RE 11.5.8a – Mixed eucalypt woodland including Poplar Gum (*E. platyphylla*) Ghost Gum (*E. dallachiana*) and Pink Bloodwood (*Corymbia intermedia*). Mid-dense lower tree and shrub layer	
Slope: Very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Loose	Erosion Potential: Moderate	
Figure 1: SS07 Landscape 	**Figure 2: SS07 Soil Profile, Depth to 1.2 m** 	

Horizon	**Depth (m)**	**Description**
A1	0 – 0.1	(2 YR 6/5), fine sandy, diffuse (>100 mm)
A2	0.1 – 0.2	(2 YR 5/6), loamy sand, diffuse (>100 mm)
B	0.2 – 1.2	(2 YR 4/6), loamy sand
Terminate		

Laboratory Results

Analysis	**Depth Tested**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	5.6	5.7	5.6	5.6	5.6	6.6
Electrical Conductivity (us/cm)	7	9	9	9	8	7
Moisture Content (%)	6	6.9	10	10.5	9.6	9.1
Colour (Munsell)	Dark Red	----	----	Dark Red	----	Dark Red
Texture	Silty Clay Loam	----	----	Silty Clay Loam	----	Clay Loam
Emerson Class Number	4	----	----	4	----	4
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.51	2.42	2.53	2.66	2.63	2.6
Exchange Acidity (meq/100g)	0.2	0.2	0.2	0.2	<0.1	----
Exchangeable Aluminium (meq/100g)	0.2	0.2	0.1	<0.1	<0.1	----
Exchangeable Calcium (meq/100g)	0.6	0.6	0.5	<0.1	<0.1	<0.1

Exchangeable Magnesium (meq/100g)	1.8	2.1	2.5	2.7	2.6	2.4
Exchangeable Potassium (meq/100g)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Exchangeable Sodium (meq/100g)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cation Exchange Capacity (meq/100g)	2.7	2.9	3.2	2.9	2.6	2.6
Exchangeable Sodium Percent (%)	2	2.3	2.8	3.3	3.6	2.8
Calcium / Magnesium Ratio	0.3	0.3	0.2	<0.1	<0.1	<0.1
Magnesium / Potassium Ratio	17.9	----	----	----	----	----
Sulphur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	<10
Boron (mg/kg)	0.2	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	15.9	----	----	----	----	----
Manganese (mg/kg)	1.36	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	----	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	----	----	----	----	----	----
Total Nitrogen as N (mg/kg)	----	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	0.8	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	35	42	50	44	37	38
Silt (2-20 µm) (%)	5	5	3	4	4	6
Fine Sand (0.02-0.2 mm) (%)	10	9	7	12	13	10
Coarse Sand (0.2-2.0 mm) (%)	14	12	13	12	14	14
Gravel (>2mm) (%)	36	32	27	29	32	32

Table 5-15 SS08 description

Site ID: SS08	**Date 6/05/2017**	
Location: Lot 1 on MC813349	**Easting: 772020**	**Northing: 7486135**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: Vd3 – Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: Cleared pasture	
Slope: very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Low	

Figure 1: SS08 Landscape

Figure 2: SS08 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.13	(10 YR 6/2), loamy sand, gradual (50 – 100 mm)
A2	0.13 – 0.2	(10 YR 6/6), clayey sand, gradual (50 – 100 mm)
B	0.2 – 1.2	(10 YR 5/2), light clay
Terminate		

Laboratory Results

Analysis	**Depth Tested**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	6.3	7.2	7.3	7.4	8.4	8.5
Electrical Conductivity (us/cm)	15	16	26	85	592	636
Moisture Content (%)	3.8	5.7	8.9	5.8	8.6	10
Colour (Munsell)	Brown	----	----	Yellowish Brown	----	Dark Yellowish Brown
Texture	Clay Loam	----	----	Sandy Clay Loam	----	Sandy Clay
Emerson Class Number	3	----	----	1	----	1
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.44	2.48	2.54	2.55	2.43	2.5
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	5	4.3	4.4	0.4	0.7	1
Exchangeable Magnesium (meq/100g)	3.9	5	6.2	1.5	3.7	4.9

Exchangeable Potassium (meq/100g)	0.1	0.1	0.1	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	0.3	0.7	1	0.6	1.8	2.5
Cation Exchange Capacity (meq/100g)	9.3	10.2	11.7	2.5	6.2	8.5
Exchangeable Sodium Percent (%)	3.3	7.2	8.8	24	29.2	29.9
Calcium / Magnesium Ratio	1.3	0.9	0.7	0.3	<0.2	0.2
Magnesium / Potassium Ratio	34.9	46.7	50.1	----	----	----
Sulphur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	<10
Boron (mg/kg)	0.3	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	69.5	----	----	----	----	----
Manganese (mg/kg)	62.8	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	<0.1	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	910	----	----	----	----	----
Total Nitrogen as N (mg/kg)	910	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	1.9	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	21	47	49	35	38	38
Silt (2-20 µm) (%)	17	14	10	15	15	16
Fine Sand (0.02-0.2 mm) (%)	18	12	14	15	12	20
Coarse Sand (0.2-2.0 mm) (%)	11	8	7	11	10	11
Gravel (>2mm) (%)	33	19	20	24	25	15

Table 5-16 SS09 description

Site ID: SS09	**Date 14/06/2017**	
Location: Lot 9 on MC230	**Easting: 775681**	**Northing: 7486642**
Geology: Qa-QLD	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: Ub89 – Moderate to strongly undulating lands with occasional low hilly areas	Landform Element: Upper slope	
Landform Pattern: Low hills	Vegetation: Cleared pasture	
Slope: very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Low	

Figure 1: SS09 Landscape

Figure 2: SS09 Soil Profile, Depth to 0.8 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.15	(10 YR 6/2), clayey sand, gradual (50 – 100 mm)
A2	0.15 – 0.2	(10 YR 5/3), silty clay loam, gradual (50 – 100 mm)
B	0.2 – 0.8	(10 YR 5/4), silty clay loam
Terminate		

Laboratory Results

Analysis	**Depth Tested**			
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**
pH Value (pH unit)	6.4	7.3	8	8.9
Electrical Conductivity (us/cm)	48	365	588	750
Moisture Content (%)	5.3	----	----	9.3
Colour (Munsell)	Brown	----	----	Brown
Texture	Sandy Clay	----	----	Sandy Clay
Emerson Class Number	1	----	----	2
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.73	2.67	2.75	2.72
Exchange Acidity (meq/100g)	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----
Exchangeable Calcium (meq/100g)	----	0.7	0.8	0.8
Exchangeable Magnesium (meq/100g)	----	3.4	4.6	3.8
Exchangeable Potassium (meq/100g)	----	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	----	1.3	2	2.1

Cation Exchange Capacity (meq/100g)	----	5.3	7.5	6.7
Exchangeable Sodium Percent (%)	----	24	27.4	32
Calcium / Magnesium Ratio	----	0.2	<0.2	<0.2
Magnesium / Potassium Ratio	16.1	----	----	----
Sulphur (%)	<0.01	----	----	----
Chloride (mg/kg)	40	----	----	1190
Boron (mg/kg)	<0.2	----	----	----
Copper (mg/kg)	13	----	----	----
Iron (mg/kg)	76300	----	----	----
Manganese (mg/kg)	178	----	----	----
Zinc (mg/kg)	20	----	----	----
Nitrite + Nitrate as N (mg/kg)	0.2	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	470	----	----	----
Total Nitrogen as N (mg/kg)	470	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----
Organic Matter (%)	1.4	----	----	----
Particle size distribution				
Clay (<2 µm) (%)	26	47	45	41
Silt (2-20 µm) (%)	11	12	13	12
Fine Sand (0.02-0.2 mm) (%)	33	23	21	20
Coarse Sand (0.2-2.0 mm) (%)	16	11	10	18
Gravel (>2mm) (%)	14	7	11	9

Table 5-17 SS10 description

Site ID: SS10	Date 14/06/2017	
Location: Lot 9 on MC230	**Easting: 776267**	**Northing: 7486953**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: Vd3 – Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Low hills	Vegetation: Cleared pasture	
Slope: very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Moderate	

Figure 1: SS10 Landscape

Figure 2: SS10 Soil Profile, Depth to 0.8 m

Horizon	Depth (m)	Description
A1	0.0 – 0.2	(10 YR 6/2), clayey sand, gradual (50 – 100 mm)
A2	0.2 – 0.35	(10 YR 5/3), loamy sand, gradual (50 – 100 mm)
B	0.35 – 0.8	(10 YR 5/4), loamy sand
Terminate		

Laboratory Results

Analysis	Depth Tested				
	0.0 – 0.1	0.1 – 0.2	0.2 – 0.3	0.5 – 0.6	0.8 – 0.9
pH Value (pH unit)	6.6	7.4	7.7	8.7	9.4
Electrical Conductivity (us/cm)	49	220	310	680	792
Moisture Content (%)	5.3	----	----	9	----
Colour (Munsell)	Brown	----	----	Brown	----
Texture	Loam	----	----	Clay Loam	----
Emerson Class Number	2	----	----	1	----
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	----	----	----	----	----
Exchange Acidity (meq/100g)	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----
Exchangeable Calcium (meq/100g)	----	0.3	0.9	0.6	1.5
Exchangeable Magnesium (meq/100g)	----	1	3.1	3.1	3.8
Exchangeable Potassium (meq/100g)	----	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	----	0.6	1.8	2.3	2.6

Cation Exchange Capacity (meq/100g)	----	2	5.8	6.1	7.9
Exchangeable Sodium Percent (%)	----	31.3	31.4	38.3	33.2
Calcium / Magnesium Ratio	----	0.3	0.3	0.2	0.4
Magnesium / Potassium Ratio	----	----	----	----	----
Sulphur (%)	<0.01	----	----	----	----
Chloride (mg/kg)	50	----	----	920	----
Boron (mg/kg)	<0.2	----	----	----	----
Copper (mg/kg)	<5	----	----	----	----
Iron (mg/kg)	5480	----	----	----	----
Manganese (mg/kg)	35	----	----	----	----
Zinc (mg/kg)	<5	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	<0.1	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	450	----	----	----	----
Total Nitrogen as N (mg/kg)	450	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----
Organic Matter (%)	1	----	----	----	----
Particle size distribution					
Clay (<2 µm) (%)	----	----	----	----	----
Silt (2-20 µm) (%)	----	----	----	----	----
Fine Sand (0.02-0.2 mm) (%)	----	----	----	----	----
Coarse Sand (0.2-2.0 mm) (%)	----	----	----	----	----
Gravel (>2mm) (%)	----	----	----	----	----

Table 5-18 SS11 description

Site ID: SS11	Date 14/06/2017	
Location: Lot 10 on MC493	Easting: 775681	Northing: 7486643
Geology: Qa-QLD	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: Vd3 – Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Low hills	Vegetation: Cleared pasture	
Slope: very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Moderate	

Figure 1: SS11 Landscape

Figure 2: SS11 Soil Profile, Depth to 0.9 m

Horizon	Depth (m)	Description
A1	0.0 – 0.2	(10 YR 6/2), sandy loam, gradual (50 – 100 mm)
A2	0.2 – 0.3	(10 YR 7/2), sandy loam, gradual (50 – 100 mm)
B	0.3 – 0.9	(10 YR 4/6), sandy clay
Terminate		

Laboratory Results

Analysis	Depth Tested				
	0.0 – 0.1	0.1 – 0.2	0.2 – 0.3	0.5 – 0.6	0.8 – 0.9
pH Value (pH unit)	6.1	6.3	6.6	8	8.6
Electrical Conductivity (us/cm)	5	8	42	521	873
Moisture Content (%)	6.7	----	----	9.3	----
Colour (Munsell)	Brown	----	----	Brown	----
Texture	Sandy Loam	----	----	Clay Loam	----
Emerson Class Number	3	----	----	1	----
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.61	2.64	2.63	2.68	2.69
Exchange Acidity (meq/100g)	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----
Exchangeable Calcium (meq/100g)	1.4	1.1	0.8	----	----
Exchangeable Magnesium (meq/100g)	1.5	1.6	1.7	----	----
Exchangeable Potassium (meq/100g)	0.2	<0.1	<0.1	----	----
Exchangeable Sodium (meq/100g)	<0.1	0.2	0.6	----	----

Cation Exchange Capacity (meq/100g)	3.3	3	3.3	----	----
Exchangeable Sodium Percent (%)	3	7.4	19.9	----	----
Calcium / Magnesium Ratio	0.9	0.7	0.5	----	----
Magnesium / Potassium Ratio	8	----	----	----	----
Sulphur (%)	<0.01	----	----	----	----
Chloride (mg/kg)	<10	----	----	810	----
Boron (mg/kg)	<0.2	----	----	----	----
Copper (mg/kg)	5	----	----	----	----
Iron (mg/kg)	14900	----	----	----	----
Manganese (mg/kg)	409	----	----	----	----
Zinc (mg/kg)	12	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	0.2	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	560	----	----	----	----
Total Nitrogen as N (mg/kg)	560	----	----	----	----
Bicarbonate Ext. P (mg/kg)	5	----	----	----	----
Organic Matter (%)	0.9	----	----	----	----
Particle size distribution					
Clay (<2 µm) (%)	16	16	20	33	29
Silt (2-20 µm) (%)	17	18	18	21	19
Fine Sand (0.02-0.2 mm) (%)	61	57	59	43	48
Coarse Sand (0.2-2.0 mm) (%)	6	9	3	2	4
Gravel (>2mm) (%)	<1	<1	<1	1	<1

Soil Order

The five soil orders observed across the Project site are summarised in Table 5-19. The characteristics for each of the soil orders identified within the Project area are described in Table 5-20.

Table 5-19 Soil order summary

Soil Order	Description
Dermosol	Soils which have B2 horizons with structure more developed than weak throughout the major part of the horizon, and do not have clear or abrupt textural B horizons.
Sodosol	Soils which have a clear and strong texture contrast from the A horizon and a sodic B horizon (exchangeable sodium percentage >6%).
Kandosol	Soils which lack strong texture contrast, have massive or only weakly structured B horizons and are not calcareous throughout.
Rudosol	Soil with negligible (rudimentary) pedologic organisation apart from minimal development of an Al horizon or the presence of less than 10% of B horizon material (including pedogenic carbonate) in fissures in the parent rock or saprolite. The soils are apedal or only weakly structured in the A1 horizon and show no pedological colour changes apart from the darkening of an A1 horizon. There is little or no texture or colour change with depth unless stratified or buried soils are present.
Vertosol	Clayey soils (having a field texture of 35% clay or greater throughout the profile) with vertic (shrink-swell) properties.

Table 5-20 Characteristics of soil families identified within the Project area

Soil family	Water availability	Drainage	Aeration	Physical root limitation	Erosion hazard	Nutrient availability	Potential toxicities	Workability
Dermosol	Moderate to high.	Tend to be well drained.	Usually well aerated.	Generally, few restrictions.	Depends on vegetation cover, slope and rainfall.	Moderate to high fertility.	Uncommon.	Generally good.
Sodosol	Limited plant water availability.	Most are poorly drained. Generally low permeability.	Depends on site drainage, often poorly aerated.	Clay sodic B horizon generally will restrict root growth.	Depends on vegetation cover, slope and rainfall. Severe on slopes in high intensity rainfall areas.	Mostly deficient in nitrogen and phosphorus.	Secondary salinity may be a problem.	Surface soil subject to crusting and hard setting.
Kandosol	Moderate to high, less in shallower soils.	Most are well drained. Generally high permeability.	Usually well aerated.	Generally, few restrictions.	Depends on vegetation cover, slope and rainfall. Severe on slopes in high intensity rainfall areas.	Mostly deficient in nitrogen and phosphorus.	Uncommon. Potentially aluminium induced by strong acidity.	Generally good. Surface soil subject to crusting and hard setting.
Rudosol	Low to moderate.	Depends on texture.	Depends on texture.	Not typically restrictive for root growth.	Depends on vegetation cover, slope and rainfall.	Typically, low.	Uncommon.	Dependent on parent material.
Vertosol	Moderate to high.	Poor.	Depends on site drainage.	Cracks provide opportunities for root growth.	Depends on vegetation cover, slope and rainfall.	Moderate to high.	Uncommon.	Difficult due to heavy textures.

5.5.4.3 Summary of Key Soil Properties

The following summary of key soils properties is based on in-field assessment and receipt of laboratory data. Further details of the laboratory analysis for each of the samples is included at Appendix A3 – Soil Survey Results.

Soil Depth

Soil depth generally extended beyond the sampling limit (1.2 m) but would be expected to be variable across the Project area with shallower soils occurring in undulating terrain to the south and deeper soils being present in the flatter terrain to the north. Topsoil thickness is indicated by field classifications of A horizons, which varied by soil type as follows:

- Brown sodic Kandosol, 0.45 m (SS04);
- Dermosol, 0.35 m (SS05);
- Red Kandosol (SS07);
- Rudosol, 1.2 m (SS01);
- Sodosol, 0.2–0.45 m (SS02, SS03, SS08, SS09, SS10, SS11); and
- Vertosol, 0.35 m (SS06).

The median topsoil thickness is 0.35 m.

Emerson Aggregate Test

The Emerson aggregate test measures the dispersion potential of soils and has a direct effect on the erosion susceptibility of a soil, as outlined further below. The Emerson classes as per AS1289.3.8.1 – 2006 are described in Table 5-21.

Table 5-21 Emerson class descriptions

Emerson Class	Definition
Class 1	Air-dried crumbs of soil show a strong dispersing reaction, i.e. a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10 minutes. In extreme cases, all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay.
Class 2	Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognizable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs.
Class 3	The soil remoulded at the plastic limit disperses in water.
Class 4	The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulphate (gypsum) is present.
Class 5	The remoulded soil does not disperse in water and the 1:5 soil / water suspension remains dispersed after five minutes.
Class 6	The remoulded soil does not disperse in water and the 1:5 soil / water suspension begins to flocculate within five minutes.
Class 7	The air-dried crumbs of soil remain coherent (do not disperse) in water and swell.
Class 8	The air-dried crumbs of soil remain coherent (do not disperse) in water and do not swell.

All but one of the soil samples were rated as between Class 1 and Class 4 based on the Emerson aggregate test undertaken at the laboratory. A single result was rated as Class 8 (SS01 at 0.5 – 0.6 tested depth) and is considered an anomaly as the laboratory advised that this sample was pure sand, with no reaction, no dispersion and no ribboning.

Of the samples analysed 14 were rated as Class 1 or Class 2. These sample locations indicate soils that have greater dispersive potential and, when disturbed, are prone to erosion and soil structural decline. Of the remaining samples, 10 were rated as Class 3 and three were rated as Class 4. These samples are considered to only have moderate dispersive tendencies, can be remoulded and will not readily disperse in water.

Sodicity

Exchangeable Sodium Percentage (ESP) measures the sodicity of a soil which, along with the Emerson aggregate test, is directly related to a soils structural stability and erosion potential. The sodicity ratings for soils, following Northcote and Skene (1972), are shown in Table 5-22.

Table 5-22 Soil sodicity / ESP ratings

Sodicity Rating	ESPs proposed for Australian soils (%)
Non-sodic	0 – 6
Sodic	6 – 15
Strongly sodic	> 15

A combination of non-sodic, sodic and strongly sodic soils was identified from the soil samples (see Table 5-23). These results indicate that there are some areas of increased potential for soil structural decline.

Table 5-23 Soil sodicity / ESP results

Sample	Depth	ESP Result (%)	Sodicity Rating
SS01	0.0 – 0.1	2.2	Non-sodic
	0.1 – 0.2	1.5	Non-sodic
	0.2 – 0.3	1.9	Non-sodic
	0.5 – 0.6	1.8	Non-sodic
	0.8 – 0.9	6.6	Sodic
	1.1 – 1.2	21.1	Strongly sodic
SS02	0.0 – 0.1	3.9	Non-sodic
	0.1 – 0.2	9.6	Sodic
	0.2 – 0.3	13.1	Sodic
	0.5 – 0.6	17	Strongly sodic
	0.8 – 0.9	20.9	Strongly sodic
	1.1 – 1.2	21.3	Strongly sodic
SS03	0.0 – 0.1	7.0	Sodic
	0.1 – 0.2	12.4	Sodic
	0.2 – 0.3	18.1	Strongly sodic
	0.5 – 0.6	29	Strongly sodic
	0.8 – 0.9	35.2	Strongly sodic
	1.1 – 1.2	37.7	Strongly sodic
SS04	0.0 – 0.1	15	Sodic / Strongly sodic
	0.1 – 0.2	17.2	Strongly sodic
	0.2 – 0.3	19.3	Strongly sodic
	0.45 – 0.5	19.7	Strongly sodic
SS05	0.0 – 0.1	7	Sodic
	0.1 – 0.2	0.6	Non-sodic

Sample	Depth	ESP Result (%)	Sodicity Rating
	0.2 – 0.3	0.6	Non-sodic
	0.5 – 0.6	0.6	Non-sodic
	0.8 – 0.9	0.8	Non-sodic
	1.1 – 1.2	2	Non-sodic
SS06	0.0 – 0.1	4.2	Non-sodic
	0.1 – 0.2	4.7	Non-sodic
	0.2 – 0.3	9.3	Sodic
	0.5 – 0.6	26	Strongly sodic
	0.8 – 0.9	32.4	Strongly sodic
	1.1 – 1.2	30.8	Strongly sodic
SS07	0.0 – 0.1	2	Non-sodic
	0.1 – 0.2	2.3	Non-sodic
	0.2 – 0.3	2.8	Non-sodic
	0.5 – 0.6	3.3	Non-sodic
	0.8 – 0.9	3.6	Non-sodic
	1.1 – 1.2	2.8	Non-sodic
SS08	0.0 – 0.1	3.3	Non-sodic
	0.1 – 0.2	7.2	Sodic
	0.2 – 0.3	8.8	Strongly sodic
	0.5 – 0.6	24	Strongly sodic
	0.8 – 0.9	29.2	Strongly sodic
	1.1 – 1.2	29.9	Strongly sodic
SS09	0.0 – 0.1	-	-
	0.1 – 0.2	24	Strongly sodic
	0.2 – 0.3	27.4	Strongly sodic
	0.5 – 0.6	32	Strongly sodic
SS10	0.0 – 0.1	-	-
	0.1 – 0.2	31.3	Strongly sodic
	0.2 – 0.3	31.4	Strongly sodic
	0.5 – 0.6	38.3	Strongly sodic
	0.8 – 0.9	33.2	Strongly sodic
SS11	0.0 – 0.1	3	Non-sodic
	0.1 – 0.2	7.4	Sodic
	0.2 – 0.3	19.4	Strongly sodic
	0.5 – 0.6	-	-
	0.8 – 0.9	-	-

The ESP data has been summarised by soil type and soil horizon in Figure 5-10, with the sodicity evident in the Sodosols, Vertosols and the brown sodic Kandosol.

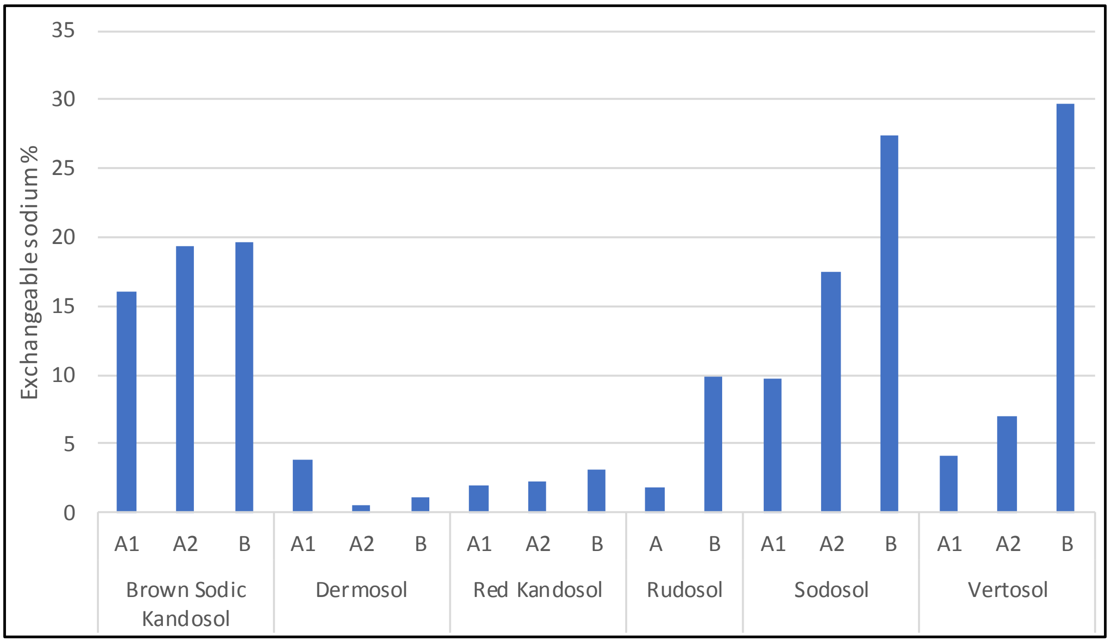


Figure 5-10 Average Exchangeable Sodium Percentage (ESP) by soil type and soil horizon

Soil Erosion Susceptibility

The susceptibility of an area of land to water erosion is a function of the soil type, soil cover, topography and slope, rainfall intensity and land use. An Erosion and Sediment Control Plan (ESCP), prepared by a Certified Professional in Erosion and Sediment Control (CPESC), will be developed for the construction and operation phases of the Project (see Section 5.11). The plan will consider and address the variables in a seasonal context to measure (using the Revised Universal Soil Loss Equation (RUSLE)) and manage the risk of soil erosion from all activities associated with the mine, haul road and TLF. Soil conservation and site rehabilitation shall also be integrated into the detailed ESCP.

The sites erosion hazard and erosion risk is considered important in determining the appropriate erosion and sediment controls (ESC) to be implemented as part of the Project's construction and operation phases. Soil erosion hazard can be described as the susceptibility of a parcel of land to the prevailing agents of erosion / soil erosion risk and the likelihood of environmental harm occurring due to disturbance activities of the Project.

An assessment of soil erosion susceptibility is provided in Table 5-24, which lists influencing factors for each soil type.

Table 5-24 Soil erosion susceptibility

Soil Order	Sodicity	Emerson Class	Texture	Landform	Vegetation cover	Erosion susceptibility
Dermosol	Non-sodic	Class 3	Loam	Undulating plain	Cleared with mixed eucalypt open forest	Low susceptibility due to low relief and non-dispersive soils
Sodosol	Sodic	Class 3 – Class 1	Clay loam – sandy clay	Gently undulating plains	Cleared	Highly susceptible when disturbed
Kandosol	Non-sodic	Class 4	Clay loam	Undulating rises	Variable but mostly cleared	Moderate-High on slopes in high intensity rainfall areas.
Rudosol	Non-sodic	Class 3	Loamy sand	Gently undulating plain	Grazed but not cleared	Low susceptibility due to sandy texture and flat terrain

Soil Order	Sodicity	Emerson Class	Texture	Landform	Vegetation cover	Erosion susceptibility
Vertosol	Sodic	Class 1 and Class 4	Sandy clay	Level to gently undulating plain	Cleared	High for disturbed soil and stockpiles, but erosion hazard limited by flat terrain

As the mine is in a sub-tropical climate, soil erosion management shall be undertaken in a two-season approach - wet season (December to March) and dry season (April to November). The erosion hazard based on average monthly rainfall depth (recorded for nearby Marlborough) referenced from the International Erosion Control Association (IECA) – Best Practice Erosion and Sediment Control Guidelines (2008) is described in Table 5-25.

Table 5-25 Erosion hazard based on average monthly rainfall depth (Marlborough)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	High	High	Moderate	Low	Moderate	Low	V Low	V Low	Low	Moderate	High

Source: IECA 2008 Table 4.4.5

The region's seasonality also makes it prone to wind erosion, particularly during the dry season. Wind erosion is a key contributor to dust-generation which has the potential to impact residents surrounding the site, vegetation communities and the operation of the mine itself if located downwind. The site shall employ various erosion control techniques which, if designed, installed and maintained correctly, will reduce the wind erosion hazard to very low in both the dry and wet seasons.

Electrical Conductivity

Electrical conductivity (EC) relates to the degree of salinity in the soil. The higher the EC value, the more soluble salt is in the soil. High soil salinity can be a limitation for vegetation growth, particularly for salt-sensitive species. The soil salinity rating by clay content following Rayment and Lyons (2011) is described in Table 5-26.

Table 5-26 Soil salinity ratings

Soil Salinity Rating	$EC_{1:5}$ (dSm^{-1})			
	10 – 20% Clay	20 – 40% Clay	40 – 60% Clay	60 – 80% Clay
Very Low	< 0.07	< 0.09	< 0.12	< 0.15
Low	0.07 - 0.15	0.09 - 0.19	0.12 - 0.24	0.15 - 0.3
Medium	0.15 - 0.34	0.19 - 0.45	0.24 - 0.56	0.3 - 0.7
High	0.34 - 0.63	0.45 - 0.76	0.56 -0.96	0.7 - 1.18
Very High	0.63 - 0.93	0.76 - 1.21	0.96 - 1.53	1.18 - 1.87
Extreme	> 0.93	> 1.21	>1.53	> 1.87

The soil salinity results and ratings from samples collected across the Project area are shown in Table 5-27. Samples were generally rated Very Low to Medium across the Project area, indicating soil salinity is generally not a limitation for vegetation growth. The exceptions were samples taken from SS02, SS03, SS06, SS08 and SS11 at depths below 0.5 metres below ground level (mbgl), which rated between High to Very High soil salinity, indicating a build-up of salts in some subsoils. The site SS09, located nearby to the TLF, was the only location presenting high salinity ratings between 0.0 – 0.5 mbgl.

Table 5-27 Soil salinity results and ratings

Sample	Depth	Clay (%)	$EC_{1:5}$ (dSm^{-1})	Soil Salinity Rating
SS01	0.0 – 0.1	11	0.02	Very Low
	0.1 – 0.2	11	0.01	Very Low
	0.2 – 0.3	8	0.007	Very Low
	0.5 – 0.6	11	0.007	Very Low
	0.8 – 0.9	14	0.016	Very Low
	1.1 – 1.2	18	0.034	Very Low
SS02	0.0 – 0.1	18	0.01	Very Low
	0.1 – 0.2	22	0.038	Very Low
	0.2 – 0.3	51	0.192	Low
	0.5 – 0.6	42	0.581	High
	0.8 – 0.9	35	0.554	High
	1.1 – 1.2	36	0.517	High
SS03	0.0 – 0.1	23	0.007	Very Low
	0.1 – 0.2	26	0.013	Low
	0.2 – 0.3	45	0.051	Medium
	0.5 – 0.6	38	0.215	Medium
	0.8 – 0.9	34	0.492	High
	1.1 – 1.2	32	0.412	Medium
SS04	0.0 – 0.1	35	0.045	Very Low
	0.1 – 0.2	40	0.071	Very Low
	0.2 – 0.3	32	0.160	Low
	0.45 – 0.5	19	0.339	Medium
SS05	0.0 – 0.1	20	0.016	Very Low
	0.1 – 0.2	23	0.012	Very Low
	0.2 – 0.3	20	0.009	Very Low
	0.5 – 0.6	22	0.006	Very Low
	0.8 – 0.9	20	0.006	Very Low
	1.1 – 1.2	21	0.005	Very Low
SS06	0.0 – 0.1	34	0.026	Very Low
	0.1 – 0.2	38	0.064	Very Low
	0.2 – 0.3	44	0.189	Low
	0.5 – 0.6	40	0.396	Medium
	0.8 – 0.9	48	1.160	Very High
	1.1 – 1.2	49	1.190	Very High
SS07	0.0 – 0.1	35	0.007	Very Low
	0.1 – 0.2	42	0.009	Very Low
	0.2 – 0.3	50	0.009	Very Low
	0.5 – 0.6	44	0.009	Very Low
	0.8 – 0.9	37	0.008	Very Low
	1.1 – 1.2	38	0.007	Very Low
SS08	0.0 – 0.1	21	0.015	Very Low
	0.1 – 0.2	47	0.016	Very Low
	0.2 – 0.3	49	0.026	Very Low
	0.5 – 0.6	35	0.085	Very Low
	0.8 – 0.9	38	0.592	High
	1.1 – 1.2	38	0.636	High
SS09	0.0 – 0.1	26	0.048	High
	0.1 – 0.2	47	0.365	Medium
	0.2 – 0.3	45	0.588	High
	0.5 – 0.6	41	0.750	High
SS10	0.0 – 0.1	~10-20#	0.049	Very Low
	0.1 – 0.2	~10-20#	0.220	Medium

Sample	Depth	Clay (%)	$EC_{1:5}$ (dSm^{-1})	Soil Salinity Rating
	0.2 – 0.3	~10-20#	0.310	Medium
	0.5 – 0.6	~20-40#	0.680	High
	0.8 – 0.9	~20-40#	0.792	Very High
SS11	0.0 – 0.1	16	0.005	Very Low
	0.1 – 0.2	16	0.008	Very Low
	0.2 – 0.3	20	0.042	Very Low
	0.5 – 0.6	33	0.521	High
	0.8 – 0.9	29	0.873	Very High

#Estimated range based on field texture

Soil EC measurements from 1 to 5 soil water dilutions ($EC_{1:5}$) are influenced by soil texture. Salts are more readily dissolved from light-textured (sandy) soils and less readily dissolved from heavy-textured (clayey) soils due to clay adsorption processes. To correct for this, EC1:5 can be converted to an estimated ECe (soil EC from a saturated paste extract) using the conversion factors provided by Shaw (1994). This data is summarised by soil type and horizon in Figure 5-11 and shows most soils are non-saline (ECe < 1.5 dS/m); the exceptions being the subsoils of the brown sodic Kandosols, the Sodosols and the Vertosols.

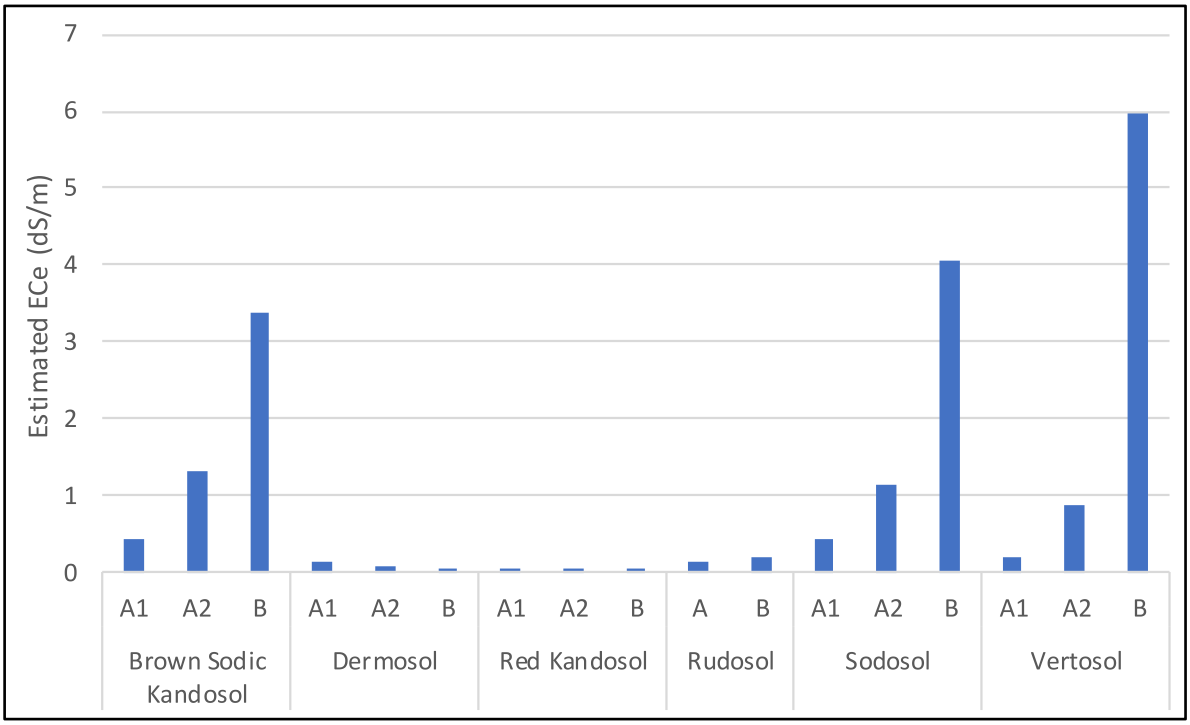


Figure 5-11 Soil salinity (estimated ECe) summarised by soil type and horizon

Soil pH Characteristics

Soil pH has a strong influence on the solubility and form of chemical compounds, the availability of ions in the soil solution as well as microbial activity. The optimum pH range for plant growth varies between species with a pH of 5.5–7.0 considered ideal for many native plants and pH 6.0–7.0 best for pasture grass. Plants are fairly tolerant of pH range and it is only if pH is less than 4.5 or greater than 9.0 that pH is likely to have direct effects on plant growth (DME 1995). At a pH outside the optimum range, indirect effects (due to the change in the availability of plant nutrients) can occur. The general interpretation of pH following Hazelton and Murphy (2007) is shown in Table 5-28.

Table 5-28 Soil pH_{H2O} ratings

pH	Rating
>9.0	Very Strongly Alkaline
9.0 – 8.5	Strongly Alkaline
8.4 – 7.9	Moderately Alkaline
7.8 – 7.4	Mildly Alkaline
7.3 – 6.6	Neutral
6.5 – 6.1	Slightly Acid
6.0 – 5.6	Moderately Acid
5.5 – 5.1	Strongly Acid
5.0 – 4.5	Very Strongly Acid

Soil pH measured from samples collected across the site ranged from Strongly Acidic at SS01 located south of Open Cut 1 to Very Strongly Alkaline at SS03 and SS04. Soil pH results are shown at Table 5-29 and these are summarised by soil type and horizon in Figure 5-12. The results suggest a correlation between soil pH and soil salinity, with the more alkaline conditions corresponding to more saline (and sodic) conditions.

Table 5-29 Soil pH characteristics

Sample	Depth	pH	Rating
SS01	0.0 – 0.1	5.3	Strongly Acid
	0.1 – 0.2	5.4	Strongly Acid
	0.2 – 0.3	5.5	Strongly Acid
	0.5 – 0.6	5.5	Strongly Acid
	0.8 – 0.9	5.6	Moderately Acid
	1.1 – 1.2	5.6	Moderately Acid
SS02	0.0 – 0.1	6.2	Slightly Acid
	0.1 – 0.2	6.0	Moderately Acid
	0.2 – 0.3	6.1	Slightly Acid
	0.5 – 0.6	7.6	Mildly Alkaline
	0.8 – 0.9	8.0	Moderately Alkaline
	1.1 – 1.2	8.0	Moderately Alkaline
SS03	0.0 – 0.1	6.3	Slightly Acid
	0.1 – 0.2	6.5	Slightly Acid
	0.2 – 0.3	7.0	Neutral
	0.5 – 0.6	8.3	Moderately Alkaline
	0.8 – 0.9	9.1	Very Strongly Alkaline
	1.1 – 1.2	9.1	Very Strongly Alkaline
SS04	0.0 – 0.1	7.0	Neutral
	0.1 – 0.2	7.6	Mildly Alkaline
	0.2 – 0.3	8.2	Moderately Alkaline
	0.45 – 0.5	9.5	Very Strongly Alkaline
SS05	0.0 – 0.1	6.8	Neutral
	0.1 – 0.2	6.7	Neutral
	0.2 – 0.3	6.6	Neutral
	0.5 – 0.6	6.6	Neutral
	0.8 – 0.9	6.7	Neutral
	1.1 – 1.2	6.7	Neutral
SS06	0.0 – 0.1	7.5	Mildly Alkaline
	0.1 – 0.2	7.9	Moderately Alkaline

Sample	Depth	pH	Rating
	0.2 – 0.3	9.0	Strongly Alkaline
	0.5 – 0.6	9.3	Very Strongly Alkaline
	0.8 – 0.9	9.1	Very Strongly Alkaline
	1.1 – 1.2	9.2	Very Strongly Alkaline
SS07	0.0 – 0.1	5.6	Moderately Acid
	0.1 – 0.2	5.7	Moderately Acid
	0.2 – 0.3	5.6	Moderately Acid
	0.5 – 0.6	5.6	Moderately Acid
	0.8 – 0.9	5.6	Moderately Acid
	1.1 – 1.2	6.6	Neutral
SS08	0.0 – 0.1	6.3	Slightly Acid
	0.1 – 0.2	7.2	Neutral
	0.2 – 0.3	7.3	Neutral
	0.5 – 0.6	7.4	Mildly Alkaline
	0.8 – 0.9	8.4	Moderately Alkaline
	1.1 – 1.2	8.5	Strongly Alkaline
SS09	0.0 – 0.1	6.4	Slightly Acid
	0.1 – 0.2	7.3	Neutral
	0.2 – 0.3	8.0	Moderately Alkaline
	0.5 – 0.6	8.9	Strongly Alkaline
SS10	0.0 – 0.1	6.6	Neutral
	0.1 – 0.2	7.4	Mildly Alkaline
	0.2 – 0.3	7.7	Mildly Alkaline
	0.5 – 0.6	8.7	Strongly Alkaline
	0.8 – 0.9	9.4	Strongly Alkaline
SS11	0.0 – 0.1	6.1	Slightly Acid
	0.1 – 0.2	6.3	Slightly Acid
	0.2 – 0.3	6.6	Neutral
	0.5 – 0.6	8.0	Moderately Alkaline
	0.8 – 0.9	8.6	Strongly Alkaline

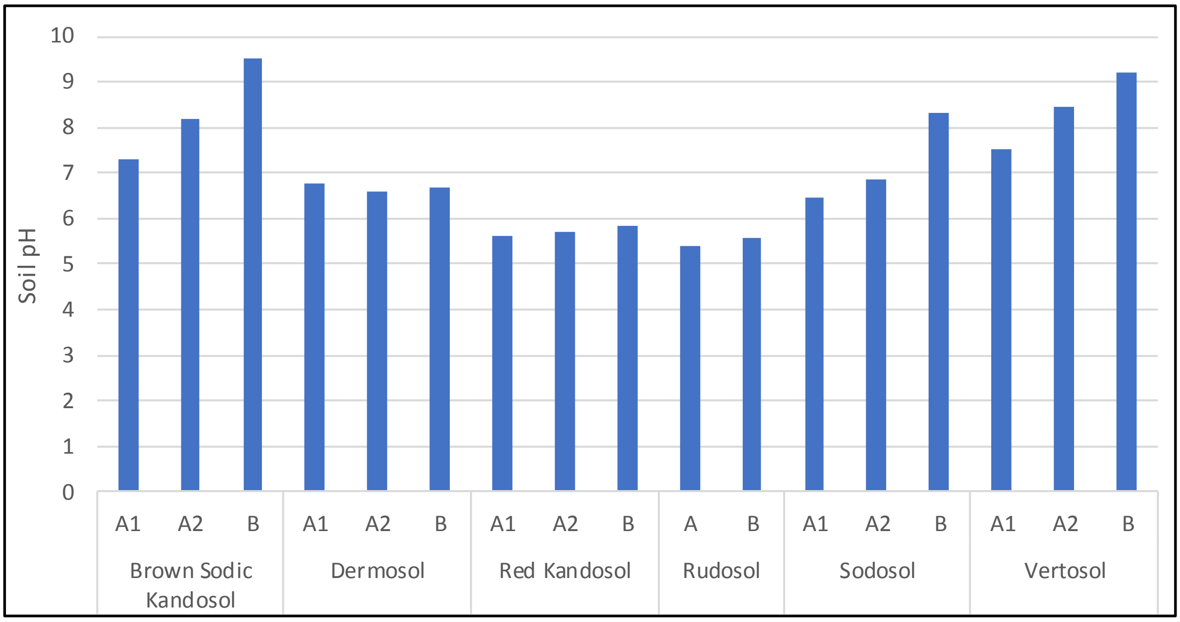


Figure 5-12 Soil pH_{H2O} averaged by soil type and horizon

Cation Exchange Capacity and Exchangeable Cations

Cation Exchange Capacity (CEC) is a measure of a soil's capacity to retain and release elements (e.g. nutrients) and is closely related to soil texture. A low CEC indicates a low potential for a soil to store and release nutrients. Guidelines for exchangeable cation test results specific to Queensland do not exist; however, the NSW Government Department of Environment, Climate Change and Water (NSW DECCW) provides guideline values for the interpretation of laboratory cation analysis (NSW DECCW, 2008). The NSW DECCW ranking for laboratory exchangeable cation test results are summarised at Table 5-30.

Table 5-30 Cation exchange capacity and exchangeable cations interpretation criteria

Analyte	Unit	Very Low	Low	Moderate	High	Very High
CEC	meq/100g	<6	6-12	12-25	25-40	>40
Exchangeable Calcium	meq/100g	<2	2-5	5-10	10-20	>20
Exchangeable Magnesium	meq/100g	<0.3	0.3-1.0	1-3	3-8	>8
Exchangeable Potassium	meq/100g	<0.2	0.2-0.3	0.3-0.7	0.7-2.0	>2.0
Exchangeable Sodium	meq/100g	<0.1	0.1-0.3	0.3-0.7	0.7-2.0	>2.0

The CEC and exchangeable cation results and ratings when compared to Table 5-30 are described in Table 5-31. The CEC data is summarised by soil type and horizon in Figure 5-13.

Table 5-31 Cation exchange capacity and exchangeable cations interpretation criteria

Sample	Depth	CEC		Exchangeable Calcium		Exchangeable Magnesium		Exchangeable Potassium		Exchangeable Sodium	
		Result	Rating	Result	Rating	Result	Rating	Result	Rating	Result	Rating
SSO1	0.0 – 0.1	2.3	VL	0.8	VL	0.5	L	0.4	M	<0.1	VL
	0.1 – 0.2	2.0	VL	0.7	VL	0.5	L	0.2	L	<0.1	VL
	0.2 – 0.3	1.2	VL	0.3	VL	0.4	L	0.2	L	<0.1	VL
	0.5 – 0.6	1.1	VL	0.1	VL	0.3	L	0.2	L	<0.1	VL
	0.8 – 0.9	1.7	VL	<0.1	VL	1.1	M	0.2	L	<0.1	VL
	1.1 – 1.2	2.0	VL	<0.1	VL	1.3	M	<0.1	VL	0.4	M
SS02	0.0 – 0.1	4.7	VL	2.4	L	1.9	M	0.2	L	0.2	L
	0.1 – 0.2	11.4	L	4.1	L	5.7	H	0.2	L	1.1	H
	0.2 – 0.3	15.5	M	5.1	M	7.9	H	0.3	L	2.0	H
	0.5 – 0.6	7.4	L	2.1	L	4.0	H	<0.2	VL	1.3	H
	0.8 – 0.9	7.2	L	2.1	L	3.6	H	<0.2	VL	1.5	H
	1.1 – 1.2	6.1	L	1.8	VL	3.1	H	<0.2	VL	1.3	H
SS03	0.0 – 0.1	4.8	VL	1.6	VL	2.5	M	<0.1	VL	0.3	L
	0.1 – 0.2	4.6	VL	1.3	VL	2.6	M	<0.1	VL	0.6	M
	0.2 – 0.3	7.9	L	1.8	VL	4.6	H	<0.1	VL	1.4	H
	0.5 – 0.6	5.8	VL	0.8	VL	3.3	H	<0.2	VL	1.7	H
	0.8 – 0.9	6.0	L	0.7	VL	3.2	H	<0.2	VL	2.1	VH
	1.1 – 1.2	6.9	L	0.8	VL	3.5	H	<0.2	VL	2.6	VH
SS04	0.0 – 0.1	12.5	M	2.8	L	7.4	H	0.3	L	1.8	H
	0.1 – 0.2	5.7	VL	1.1	VL	3.7	H	<0.2	VL	1	H
	0.2 – 0.3	4.8	VL	0.9	VL	3	H	<0.2	VL	0.9	H
	0.45 – 0.5	5.4	VL	1.2	VL	3.1	H	<0.2	VL	1.1	H
SS05	0.0 – 0.1	4.8	VL	1.6	VL	2.5	M	<0.1	VL	0.3	L
	0.1 – 0.2	8.7	L	5.8	M	2.0	M	0.9	H	<0.1	VL
	0.2 – 0.3	7.6	L	5.1	M	1.8	M	0.6	M	<0.1	VL
	0.5 – 0.6	9.0	L	6.2	M	2.3	M	0.4	M	<0.1	VL
	0.8 – 0.9	7.9	L	5.0	M	2.6	M	0.2	L	<0.1	VL
	1.1 – 1.2	6.4	L	3.7	L	2.4	M	0.2	L	0.1	L
SS06	0.0 – 0.1	5.3	VL	2.9	L	2.0	M	<0.2	VL	0.2	L

Sample	Depth	CEC		Exchangeable Calcium		Exchangeable Magnesium		Exchangeable Potassium		Exchangeable Sodium	
		Result	Rating	Result	Rating	Result	Rating	Result	Rating	Result	Rating
	0.1 – 0.2	5.3	VL	2.9	L	2.0	M	<0.2	VL	0.2	L
	0.2 – 0.3	9.9	L	4.9	L	3.9	H	<0.2	VL	0.9	H
	0.5 – 0.6	16.7	M	5.5	M	6.8	H	<0.2	VL	4.3	VH
	0.8 – 0.9	10.6	L	2.8	L	4.3	H	<0.2	VL	3.4	VH
	1.1 – 1.2	12.8	M	3.5	L	5.4	H	<0.2	VL	4.0	VH
SS07	0.0 – 0.1	2.7	VL	0.6	VL	1.8	M	0.1	VL	<0.1	VL
	0.1 – 0.2	2.9	VL	0.6	VL	2.1	M	<0.1	VL	<0.1	VL
	0.2 – 0.3	3.2	VL	0.5	VL	2.5	M	<0.1	VL	<0.1	VL
	0.5 – 0.6	2.9	VL	<0.1	VL	2.7	M	<0.1	VL	<0.1	VL
	0.8 – 0.9	2.6	VL	<0.1	VL	2.6	M	<0.1	VL	<0.1	VL
	1.1 – 1.2	2.6	VL	<0.1	VL	2.4	M	<0.1	VL	<0.1	VL
SS08	0.0 – 0.1	9.3	L	5.0	L	3.9	H	0.1	VL	0.3	M
	0.1 – 0.2	10.2	L	4.3	L	5.0	H	0.1	VL	0.7	M
	0.2 – 0.3	11.7	L	4.4	L	6.2	H	0.1	VL	1.0	H
	0.5 – 0.6	2.5	VL	0.4	VL	1.5	M	<0.2	VL	0.6	M
	0.8 – 0.9	6.2	L	0.7	VL	3.7	H	<0.2	VL	1.8	H
	1.1 – 1.2	8.5	L	1.0	VL	4.9	H	<0.2	VL	2.5	VH
SS09	0.0 – 0.1	-	-	-	-	-	-	-	-	-	-
	0.1 – 0.2	5.3	VL	0.7	VL	3.4	M	<0.2	VL	1.3	
	0.2 – 0.3	7.5	L	0.8	VL	4.6	H	<0.2	VL	2	
	0.5 – 0.6	6.7	L	0.8	VL	3.8	H	<0.2	VL	2.1	VH
SS10	0.0 – 0.1	-	-	-	-	-	-	-	-	-	-
	0.1 – 0.2	2.0	VL	0.3	VL	1.0	M	<0.2	VL	0.6	M
	0.2 – 0.3	5.8	VL	0.9	VL	3.1	H	<0.2	VL	1.8	H
	0.5 – 0.6	6.1	L	0.6	VL	3.1	H	<0.2	VL	2.3	VH
	0.8 – 0.9	7.9	L	1.5		3.8	H	<0.2	VL	2.6	VH
SS11	0.0 – 0.1	3.3	VL	1.4	VL	1.5	M	0.2	L	<0.1	VL
	0.1 – 0.2	3.0	VL	1.1	VL	1.6	M	<0.1	VL	0.2	L
	0.2 – 0.3	3.3	VL	0.8	VL	1.7	M	<0.1	VL	0.6	M
	0.5 – 0.6	-	-	-	-	-	-	-	-	-	-
	0.8 – 0.9	-	-	-	-	-	-	-	-	-	-

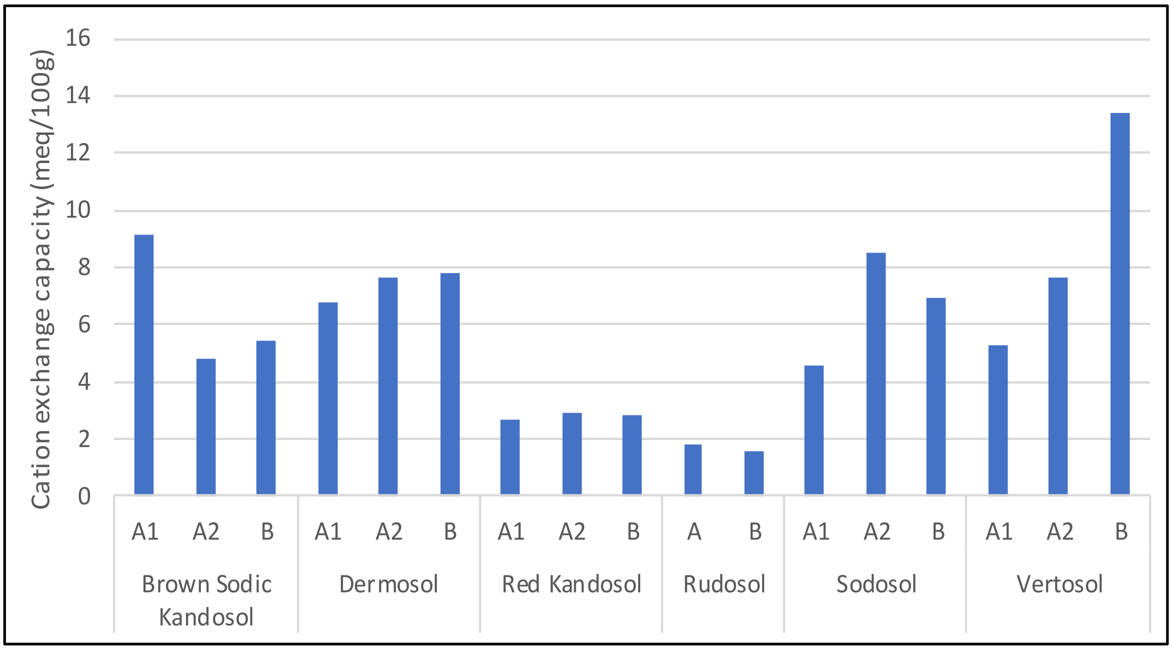


Figure 5-13 Average cation exchange capacities by soil type and horizon

The majority of soil samples across the Project area contain CEC levels that are considered to be Very Low (<6) to Low (<12), and particularly so in the sandy textured red Kandosol and Rudosol soils. The exception was moderate CEC levels being present in the B horizon of the Vertosols.

In terms of major cation concentrations, the following results were obtained:

- Exchangeable Calcium results were generally Very Low (<2) to Low (2–5) except for SS05 which was mostly rated as Moderate (5-10);
- Exchangeable Magnesium results were generally Moderate (1-3) to High (3-8) except for SS01 which was rated as Low (<0.3);
- Exchangeable Potassium rating levels were generally Very Low (<0.2) to Low (0.2-0.3), except for SS01 which had a single Moderate Rating (0.3-0.7) at a depth of between 0.0 and 0.1 and SS05 which ranged between Very Low (<0.2) to High (0.7-2.0); and
- Exchangeable Sodium levels varied across the site ranging between Very Low to Very High.

Phosphorus (P)

Phosphorus (P) deficiency is one of the most widespread nutrient deficiencies in Australian soils. Phosphorus forms part of the proteins in plant cells, so it is important in growing tissue where cells are actively dividing (such as the development of seedling roots, flowering and the formation of seed). Phosphorus-deficient plants appear as stunted, dark green plants with short, erect leaves and stout stems which often develop orange, red or purplish discolouration.

The interpretation of phosphorus test results is provided in terms of the soils plant response to phosphorus fertiliser application and is dependent on local conditions.

The guidelines summarised below provide a rating of a soil's likely response to the addition of phosphorus and provide an indication of phosphorus levels in soil corresponding to the response rating. The Department of Agriculture and Fisheries (DAF 2010) provides recommended phosphorus levels for the Western Darling Downs and Central Queensland regions which are applicable to the Project area.

Recommended available P levels for the Central Queensland regions are nominated in Table 5-32 (DAF, 2010).

Table 5-32 Value response ratings for soil bicarb P (mg/kg - Qld Western Downs)

Rating P	Response Most Likely, Marginal P	Response Likely Adequate P	Response Possible Good P	Response Unlikely
Total P	0.0-10	11-15	16-20	>20

The results and ratings of reactive P laboratory tests are shown in Table 5-33.

Table 5-33 Soil bicarb P response ratings and results (mg/kg – Central Queensland)

Sample	Depth	Reactive Phosphorus as P (mg/kg)	Rating
SS01	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS02	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS03	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS04	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS05	0.0 – 0.01	28	Response Unlikely
SS06	0.0 – 0.01	47	Response Unlikely
SS07	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS08	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS09	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS10	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS11	0.0 – 0.01	5	Response Most Likely, Marginal P

Soils analysed from the Project area exhibited reactive P levels less than 10 mg/kg which is consistent with the typical response of most Australian soils, except for SS05 and SS06 were rated as soils that were unlikely to have a response to the addition of phosphorus.

Nitrogen (N)

Nitrogen (N) occurs as several mineralised forms, some of which (nitrate and ammonia) are available to plants. Total nitrogen measures the mineralised forms and the majority contained in organic matter which is not immediately available to plants as a measure of the potential nitrogen source. Total Kjeldahl nitrogen (TKN); however, is the sum of free-ammonia and organic nitrogen that is readily available to plants, and this is the value that needs to be considered in the planning phase of the Project. The guidelines summarised in Table 5-34 provide a rating of a soils available nitrogen source (Rayment and Lyon, 2011).

Table 5-34 Ratings by weight for TKN

Rating	Very Low	Low	Medium	High	Very High
TKN % by weight	<0.05	0.05-0.15	0.15-0.25	0.25-0.5	>0.5

The results and ratings of TKN laboratory tests are presented in Table 5-35.

Table 5-35 Ratings of TKN % by weight and results

Sample	Depth	TKN (%)	Rating
SS01	0.0 – 0.01	0.073	Low
SS02	0.0 – 0.01	0.055	Low
SS03	0.0 – 0.01	0.044	Very Low
SS04	0.0 – 0.01	0.100	Low
SS05	0.0 – 0.01	0.099	Low
SS06	0.0 – 0.01	0.159	Medium
SS07	0.0 – 0.01	---	
SS08	0.0 – 0.01	0.091	Low
SS09	0.0 – 0.01	0.047	Very Low
SS10	0.0 – 0.01	0.045	Very Low
SS11	0.0 – 0.01	0.056	Low

TKN ratings within samples analysed across the Project area rated as either Very Low (<0.05%) to Low (0.05-0.15%), except for SS05 which rated as Medium (0.15-0.25%).

Total Organic Carbon

Total organic carbon (TOC) is a vital component of soils, as it not only represents the carbon content of soils but can indicate the nutrient holding capacity and fertility of a soil. The TOC ratings used in assessing soils, following Rayment and Lyons (2011) are shown in Table 5-36.

Table 5-36 Organic carbon ratings

Organic Carbon (%)	Rating
<0.5	Very Low
0.5 – 1.5	Low
> 1.5 – 2.5	Medium
> 2.5 – 5.0	High
> 5.0	Very High

The results and ratings of the TOC laboratory tests for each of the deep boreholes are shown in Table 5-37.

Table 5-37 Organic carbon results and ratings

Sample	Depth	Organic Carbon Result (%)	Rating
SS01	0.0 – 0.01	2	Medium
SS02	0.0 – 0.01	1.3	Low
SS03	0.0 – 0.01	1.1	Low
SS04	0.0 – 0.01	1.6	Medium
SS05	0.0 – 0.01	2.4	Medium
SS06	0.0 – 0.01	2.3	Medium
SS07	0.0 – 0.01	0.8	Low
SS08	0.0 – 0.01	1.9	Medium
SS09	0.0 – 0.01	1.4	Low
SS10	0.0 – 0.01	1.0	Low
SS11	0.0 – 0.01	0.9	Low

Samples across the Project site recorded TOC ratings of Low (<0.5%) to Medium (>1.5 – 2%).

Acid Sulphate Soils

ASS are generally associated with low energy coastal environments. ASS can; however, form inland when there are sources of sulphide and soils are saturated for long periods of time in favourable conditions. The CSIRO National ASS mapping illustrates that the bulk of EPC 1029 is described as having a low to extremely low probability of containing ASS. The National ASS mapping (Fitzpatrick et al. 2011) in relation to the proposed mine, and the location of the 10 m AHD contour is shown at Figure 5-14.

ASS are discussed in more detail at Section 5.10 Acid Sulphate Soil Management and Chapter 8 – Waste Rock and Rejects.

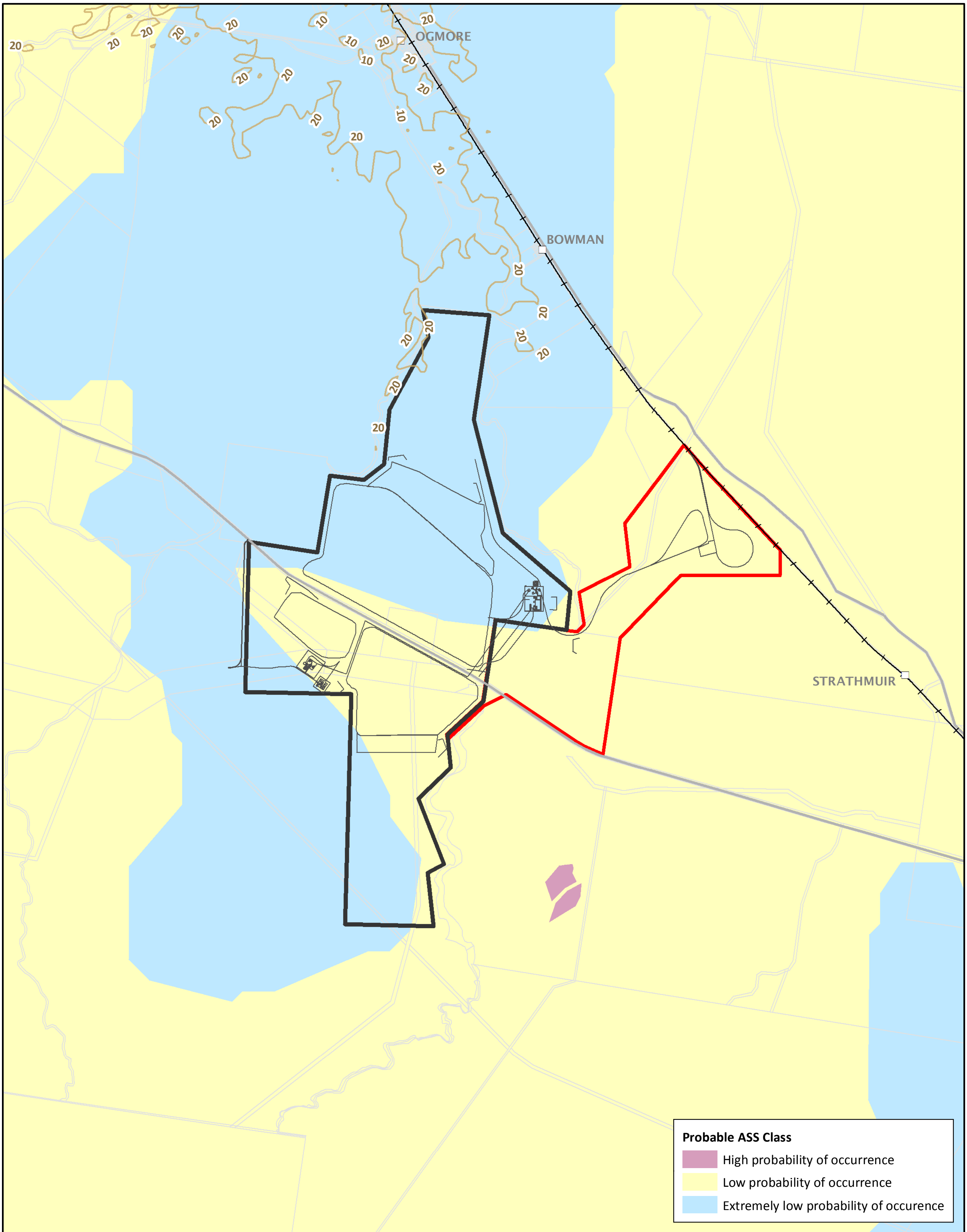


Figure 5-14

Probability of acid sulfate soil occurrence

Legend

- ML 80187
- ML 700022
- Contours
- Mine infrastructure
- Cadastral boundary
- Main Road
- North Coast Rail Line

0 1 2 km

Scale @ A4 1:80,000
Date: 06/12/18
Drawn: J Parnwell

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 R1 ASS occurrence_5-14.mxd 12/6/2018

5.5.5 Agricultural Land Suitability

5.5.5.1 Past and Existing Land Uses

Cattle grazing is the principal agricultural industry in the Project area. The current mapped agricultural land uses are shown at Figure 5-4. Important agricultural areas identified in the Queensland Agricultural Land Audit (DAF 2016) relevant to the Project are shown at Figure 5-15. It shows some areas with high potential for pasture production and an area in the centre of the mine suitable for intensive livestock production.

Based on historical studies carried out as part of the EIS (see Chapter 18 - Cultural Heritage) the first pastoral runs within the Project area were issued licenses in the early 1860s. Since then cattle grazing has continued across the broader Project area. This was confirmed through a review of information pertaining to land use derived from review of previous land use assessments, aerial photo interpretation and informal discussions with the existing landholders.

Cattle grazing, for both fattening and breeding of stock, has relied on stock dams, fencing and associated access tracks constructed within the Project area.

The Project area is suitable for beef cattle grazing on pastures. Whilst some areas are theoretically suitable for future cropping there is no intention to undertake cropping activities within the Mamelon property or the areas associated with the Project on the Brussels property and Strathmuir property.

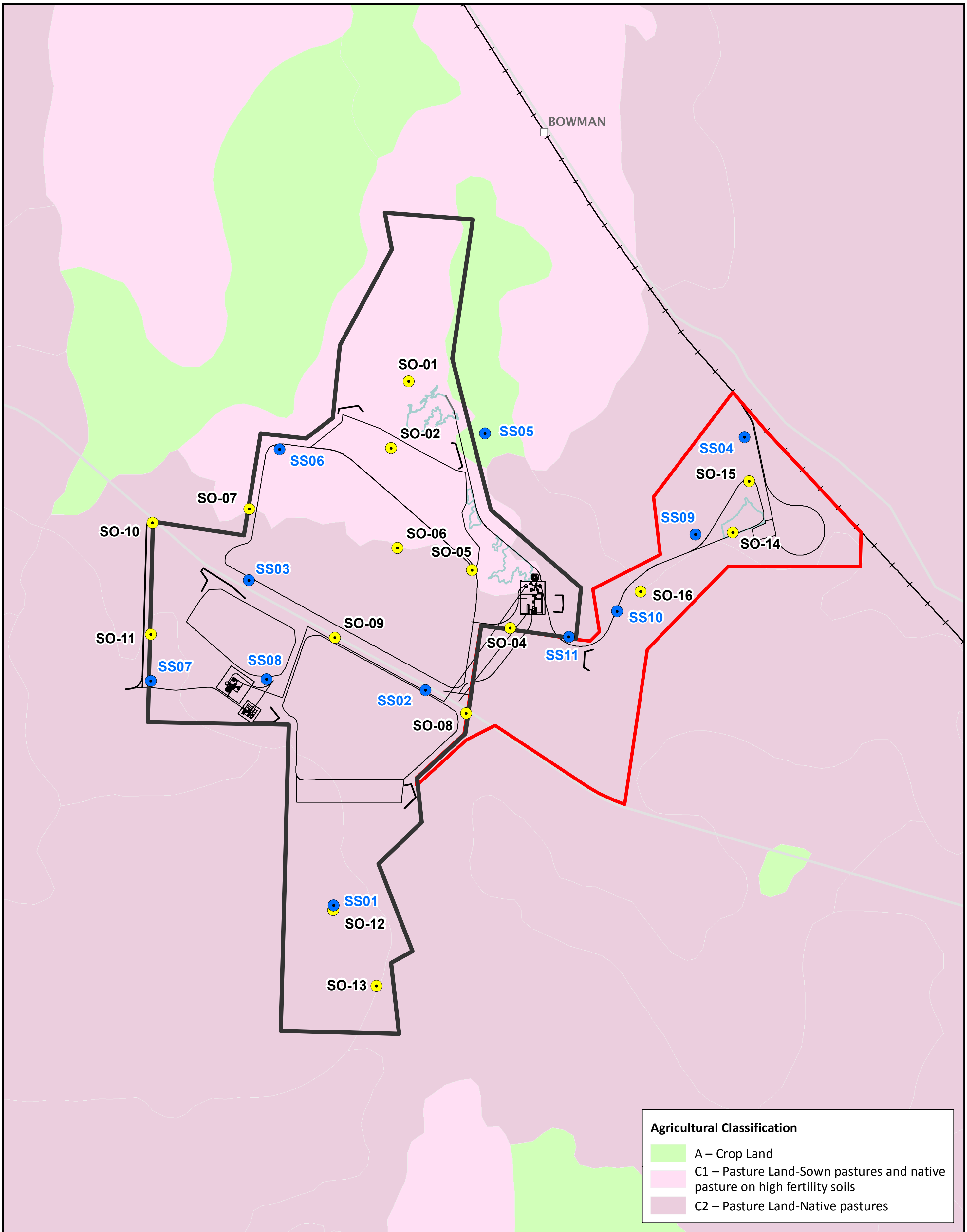


Figure 5-15

Mapped important agricultural areas

N

0 0.5 1 km

Scale @ A4 1:60,000
Date: 19/10/18
Drawn: Gayle B.

Legend

Soil Sample Location

- Observation Soil
- Subsoil Sample
- ML 80187
- ML 700022
- Mine infrastructure
- Main Road
- North Coast Rail Line
- Watercourse
- Dam

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018
Esri Basemaps, 2017

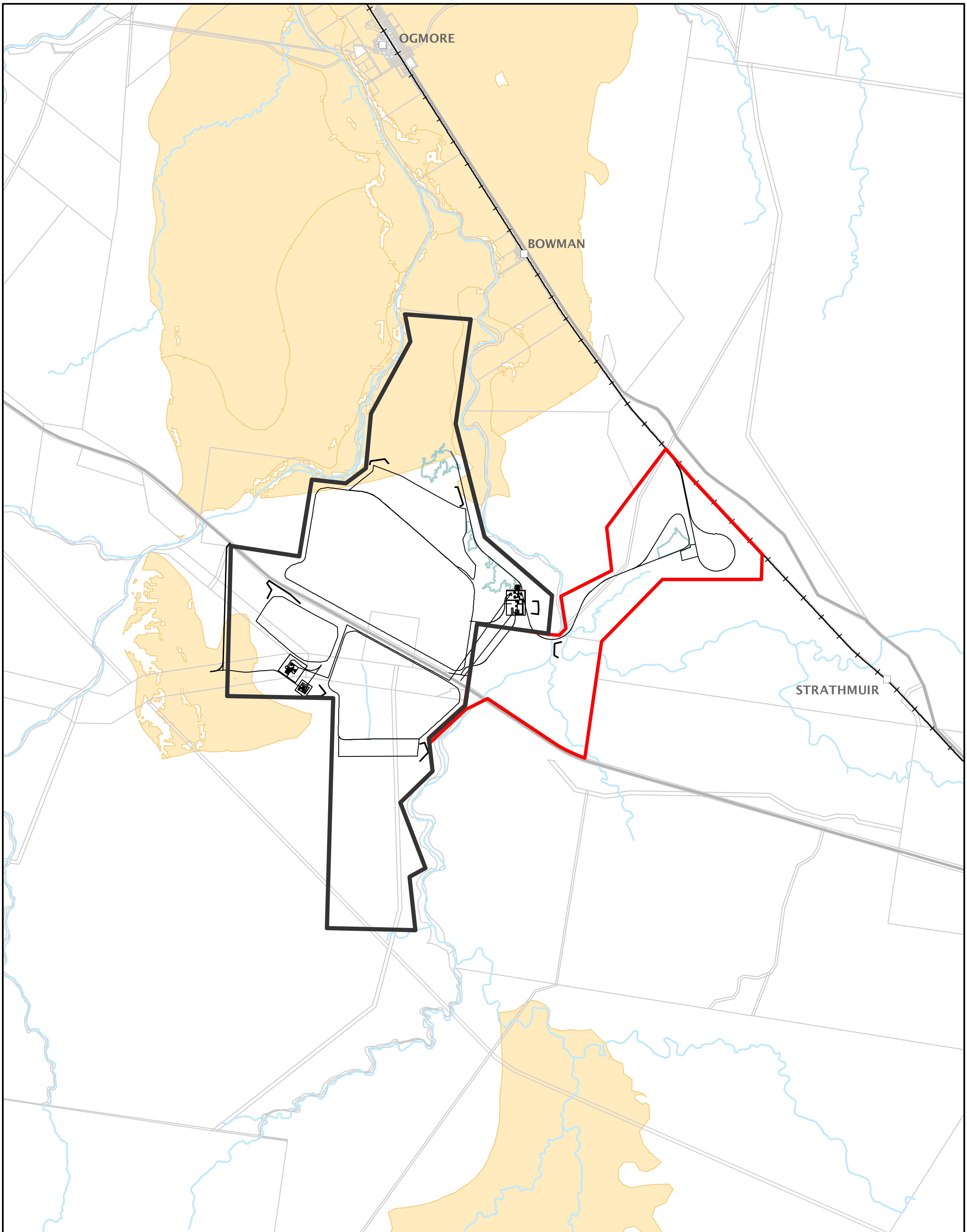
CDM Smith

5.5.5.2 Good Quality Agricultural Land

Classifying land suitability in Queensland is based on classifications provided in the LSAT Guidelines within the Technical Guidelines for Environmental Management of Exploration and Mining in Queensland (DME 1995) and is outlined in Table 5-2.

The Queensland Government's SPPs on GQAL (now superseded), SPP 1/92 Development and Conservation of Agricultural Land, and accompanying Planning Guideline: The Identification of Good Quality Agricultural Land (DPI/DHLGP 1993) are also taken into consideration when assessing GQAL. The policy calls for areas designated as GQAL to not be diminished unless there is a greater benefit to the community.

Mapped GQAL within the area of the Project is shown on Figure 5-16. Given grazing activities are the dominant agricultural land use in the areas, the mine activities and associated infrastructure has been positioned to avoid disturbance to mapped GQAL.



N

0 1 2 km

Scale @ A4 1:80,000
Date: 18/10/18
Drawn: Gayle B.

Legend

- Good Quality Agricultural Land
- ML 80187
- ML 700022
- Mine infrastructure
- Cadastral boundary
- Main Road
- North Coast Rail Line
- Watercourse
- Dam

Figure 5-16
GQAL impacted by the Project

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 R1 GQAL impact_5-16.mxd 10/18/2018

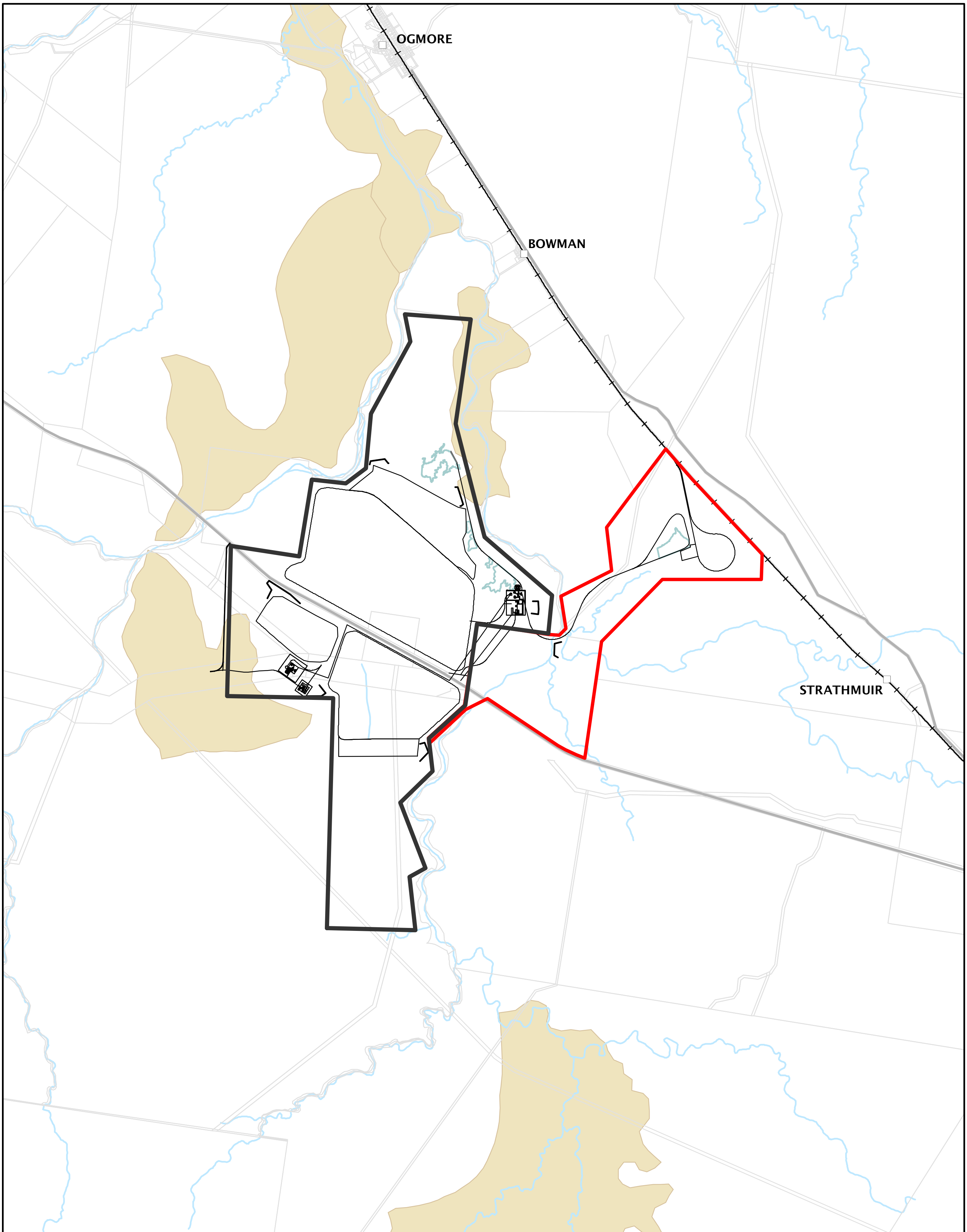
5.5.5.3 Strategic Cropping Land

The occurrence of mapped SCA near the Project is shown at Figure 5-17. The SCA is identified by the DNRME Strategic Cropping Land Trigger Map as SCL. Land mapped as SCL is land that is, or likely to be, highly suitable for cropping because of a combination of the land's soil, climate and landscape features. The SCA is an Area of Regional Interest under the RPI Act. The purpose of the RPI Act is to manage resource developments in areas of Queensland that contribute to the State's economic, social and environmental prosperity at a regional scale. No other Areas of Regional Interest are present within or adjacent to the Project footprint.

SCA have been divided into five zones to assist in determining whether land mapped as SCL on the SCL Trigger Map meets the SCL criteria as identified in Schedule 3 of the RPI Act. These zones lie within a broad band that adjoins the eastern coastline of Queensland, running from the New South Wales border to Mossman. Due to the diversity of agricultural and horticultural crops able to be grown across Queensland, the zones have been delineated to collectively accommodate this diversity. Of the zones of SCA, the Project site is situated in the Coastal Queensland Cropping Zone.

The RPI Act will apply to the Project for areas within the SCA. Section 19 of the RPI Act restricts the carrying out of a resource activity in the SCA unless the activity is permitted through a Regional Interests Development Approval. A resource activity is an activity authorised by a ML granted under the *Mineral Resources Act 1989* (MR Act). This authorisation will therefore apply to the Project if SCL is present. Notwithstanding, resource activities within the SCA are exempt from requiring an approval under the RPI Act when there is land owner agreement and the activity is not likely to result in a regional impact.

No cropping has historically occurred or is currently occurring, on Mamelon or the adjoining properties where SCL is mapped. Notwithstanding the absence of cropping activities within proximity to the Project, the potential impacts to SCL due to groundwater draw down have been considered as part of the updated groundwater impact assessment. The assessment identifies there will be no material impact to the areas of mapped SCL from groundwater draw down. The groundwater impact assessment is discussed in detail at SEIS Chapter 10.



Legend

- Strategic Cropping Land
- ML 80187
- ML 700022
- Mine infrastructure
- Main Road
- North Coast Rail Line
- Watercourse
- Cadastral boundary
- Dam

N

0 1 2 km

Scale @ A4 1:80,000
Date: 31/10/18
Drawn: Gayle B.

Figure 5-17
Strategic Cropping Land

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 R1 strategic cropping land__5-17.mxd 10/31/2018

5.5.6 Contaminated Land

As part of the desktop assessment, a search of the DES EMR and CLR database was undertaken to determine whether a notifiable activity had been undertaken within the Project area. The EMR provides information on historic and current land uses, including whether the land has been, or is currently used for a notifiable activity, or has been contaminated by hazardous material.

The CLR includes land that has been proven (through investigation) to be contaminated and is causing or has the potential to cause serious environmental harm. Therefore, land will only be recorded on the CLR when an investigation shows it is contaminated and action must be undertaken to remediate or manage the land.

There are no land parcels within the Project area that are listed on the EMR or CLR.

5.5.7 Landscape Character and Visual Amenity

5.5.7.1 Landscape Character

The Project area and surrounding terrain is classified as predominately flat or undulating. The topography typically ranges from 4.5 to 155 m AHD within the ML with the mine area located between 11.4 to 43.8 m AHD.

The land surrounding the Project area is predominately used for cattle grazing. The closest protected area is the Tooloombah Creek Conservation Park which is located approximately 1 km to the east. The areas of known or potential nature conservation values which are of State or regional interest and are within 30 km of the Project include Bukkulla Conservation Park, Marlborough State Forest, Mount Buffalo State Forest and Eugene State Forest.

The Project area consists of several wetlands of varying size. Most of these have been artificially created (‘turkey nest’ dams and dammed creek lines). There are two wetlands recorded as having high ecological significance located in the western portion of the ML, the more southern of which has been mapped as a Wetland Protection Area. A wetland listed in the Directory of Important Wetlands, Broad Sound, is located 8 km directly north, or 9.7 km downstream of the Project area. The lower Styx River forms part of the catchment of the wetland.

The Project is largely located within the Marlborough Plains subregion, one of the 13 subregions of the Brigalow Belt North bioregion. The southern portion of the ML occurs in the adjacent Nebo-Connors Ranges subregion. Large sections of the Brigalow Belt North bioregion have been cleared of remnant native vegetation for grazing, agriculture and mining. Remaining vegetation is generally confined to rockier hilly areas, linear strips of roadside vegetation, riparian vegetation and relatively small isolated remnants. Thus, clearing over the past 150 years has resulted in a highly-fragmented landscape with remnant vegetation patches separated by large expanses of cleared land.

Creeks and Drainage Lines

The mine area and TLF is situated within the lower catchments of Tooloombah Creek and Deep Creek, which are sub-catchments within the Styx River catchment. Both creeks feed directly into the Styx River (2 km north of the Project area) which discharges into the Broad Sound area. The haul road to the TLF crosses Deep Creek. Tooloombah Creek and Deep Creek are non-perennial or ephemeral, and only flow during and immediately following rainfall events.

There are two water features that surround the Project area which are defined as watercourses by DNRME, in accordance with the definition of a watercourse provided in the Water Act. These two watercourses are situated outside the ML and include:

- Tooloombah Creek; and
- Deep Creek.

Both Tooloombah Creek and Deep Creek are located outside the Project area, however several of their tributary drainage features reside within the Project area. These drainage features are minor in nature, are ranked as either first or second order drainage features and are classified as non-perennial. This implies that the drainage features do not continually contain water and the stream flow is seasonal in nature and directly following rainfall events. The Project surface infrastructure is predominantly located within the Deep Creek catchment. Clean water diversions of existing drainage lines are proposed to prevent contamination through contact with stockpiling, processing and mine pit areas. The diversions do; however, direct water to the same watercourse in which they would otherwise discharge to, albeit further downstream than the diversion discharge location. The proposed diversions are discussed in detail in Chapter 9 – Surface Water.

Surface water features within the Project area include:

- Minor un-named drainage lines feeding into Tooloombah Creek:
  - Two 1st order drainage lines
  - One 2nd order drainage line
- Minor un-named drainage lines feeding into Deep Creek:
  - Nine 1st order drainage lines
  - One 2nd order drainage line.

Vegetation

The Project is largely located within the Marlborough Plains subregion, one of the 13 subregions of the Brigalow Belt North bioregion. The southern portion of the ML occurs in the adjacent Nebo-Connors Ranges subregion. The Project area is located close to the boundary of the Brigalow Belt South bioregion located to the south. Vegetation within the Marlborough Plains subregion is dominated by alluvial plains and colluvial slopes, usually supporting woodlands characterised by Poplar Gum (*Eucalyptus platyphylla*), Ghost Gum (*Corymbia dallachiana*), Forest Red Gum (*E. tereticornis*) and paperbarks (*Melaleuca* spp.) with low rises supporting Narrow-Leaved Ironbark (*E. crebra*).

Large sections of the Brigalow Belt North bioregion have been cleared of remnant native vegetation for grazing, agriculture and mining. Remaining vegetation is generally confined to rockier hilly areas, linear strips of roadside vegetation, riparian vegetation and relatively small isolated remnants. Thus, clearing over the past 150 years has resulted in a highly-fragmented landscape with remnant vegetation patches separated by large expanses of cleared land.

Areas to the north and east of the Project area have been substantially impacted by vegetation clearing associated with cattle grazing activity. Connectivity between remaining tracts of vegetation is tenuously maintained by thin strips of riparian vegetation along creek lines such as Tooloombah Creek and Deep Creek which border the Project. Nevertheless, woodland and open forest habitat remaining in the south and east of the site remains contiguous with an extensive tract of remnant vegetation, which includes Tooloombah Creek Conservation Park. To the west of the Project remains extensive tracts of remnant forest associated with the nearby Broad Sound Range.

Vegetation within the Project area and immediate surrounds comprises:

- Heavily disturbed habitats that have previously undergone significant clearing for cattle production. Where this habitat occurs north of the Bruce Highway it is often dominated by patches of regrowth Brigalow;
- Substantial areas of less disturbed eucalypt woodland; and
- Smaller pockets of relatively closed canopy (open forest) vegetation generally with a dense weedy shrub layer. These are largely associated with the creek systems adjacent to the Project (ML) boundary.

Night Lighting

The rural location of the Project means that there is no existing night-time illumination of the land within the proposed development area. The largest source of night-time lighting emissions nearby is expected to be from vehicle movements on the Bruce Highway. It is not anticipated that light spill from the nearby towns of Marlborough and Ogmore would result in levels of glow in the night sky.

5.5.7.2 Visual Amenity Assessment

The VIA process utilised a combination of GIS topographical analysis and field surveys to determine the potential impact of the Project's components on various sensitive receptors (see Figure 5-18), including the towns of Ogmore and Marlborough, local roads and other sensitive receptors nominated below. An assessment of the sensitive receptors can be found in Table 5-38.

Ogmore Township

The Project is located approximately 10 km southwest of the Ogmore township. As discussed in Section 5.4.8, a theoretical assessment of visibility was undertaken from the Project mine area using a ZTV assessment at 5 m above ground level. ZTV is the theoretic assessment of visibility to or from a designated point in the landscape.

There are several topographical rises and vegetation between the town and the Project. The rises coupled with the vegetation between the points of interest means that the Project will not be visible from the Ogmore township. It is highly unlikely that the night lighting from the Project would be visible at Ogmore because of the lighting from traffic on the Bruce Highway and the township is already lit by some street lighting and this existing artificial lighting would restrict views of the wider night sky.

Homesteads

Six inhabited homesteads and the Ogmore township were identified as sensitive receptors within the study area (see Table 5-38). In addition, there are three uninhabited homesteads. The impact to homesteads were branded into two categories using the ZTV assessment. Homesteads and their view potential were rated:

- Potentially impacted: where Project components are located in ZTV. These areas require further assessment considering additional landscape buffers such as vegetation and other features; and
- Not impacted: where Project components are not located in ZTV. Site surveys were used where possible to determine whether the Project would be viewable from several sensitive receptor locations.

Other

Three uninhabited structures have been identified within the study area. One is a pump shed, one is a dilapidated dwelling and one could potentially be inhabited. Although the two dwellings are currently vacant, only one could potentially be inhabited in the future, while the other is unliveable due to being in a severe state of disrepair and is extremely unlikely to be renovated. Whilst at some later stage these dwellings may be utilised as residences, at this point in time neither are considered as receptors.

The Tooloombah Creek Service Station is considered a sensitive receptor for this visual assessment, given its proximity to the Project. The ZTV assessment identified that any infrastructure at a height of 5m at the designated point within the Project area will not be visible from the Tooloombah Creek Service Station.

It should be noted that the assessment used the ZTV findings, along with mathematics to further define the actual visual impact to the sensitive receptors. The human eye cannot see past 5 km into the horizon (at sea level) given the curve of the Earth's surface; however, if an object is at a greater height than sea level the distance the human eye can see is increased (Wolchover 2012). The mathematics behind this uses Pythagoras theorem to calculate the distance the human eye can see from a defined height (5 m for infrastructure) taking into account the earth's radius. As such, at a height of 5 m the infrastructure can be seen from up to 8 km away. There are many factors that can affect this result, and these are discussed in Table 5-38.

The mining operations will be visible to vehicles travelling in both directions along the Bruce Highway without any mitigation. Earthen mounds will be constructed from waste material derived from the overburden and established as screens between the Bruce Highway and the mining pits. The screens will be over-planted initially with a cover crop to control erosion and planted out with endemic native species as part of the progressive rehabilitation program. Native vegetation will be retained, to the extent practicable, between the Bruce Highway and the screens to further soften the visual influence of the screens to people travelling on the Bruce Highway.

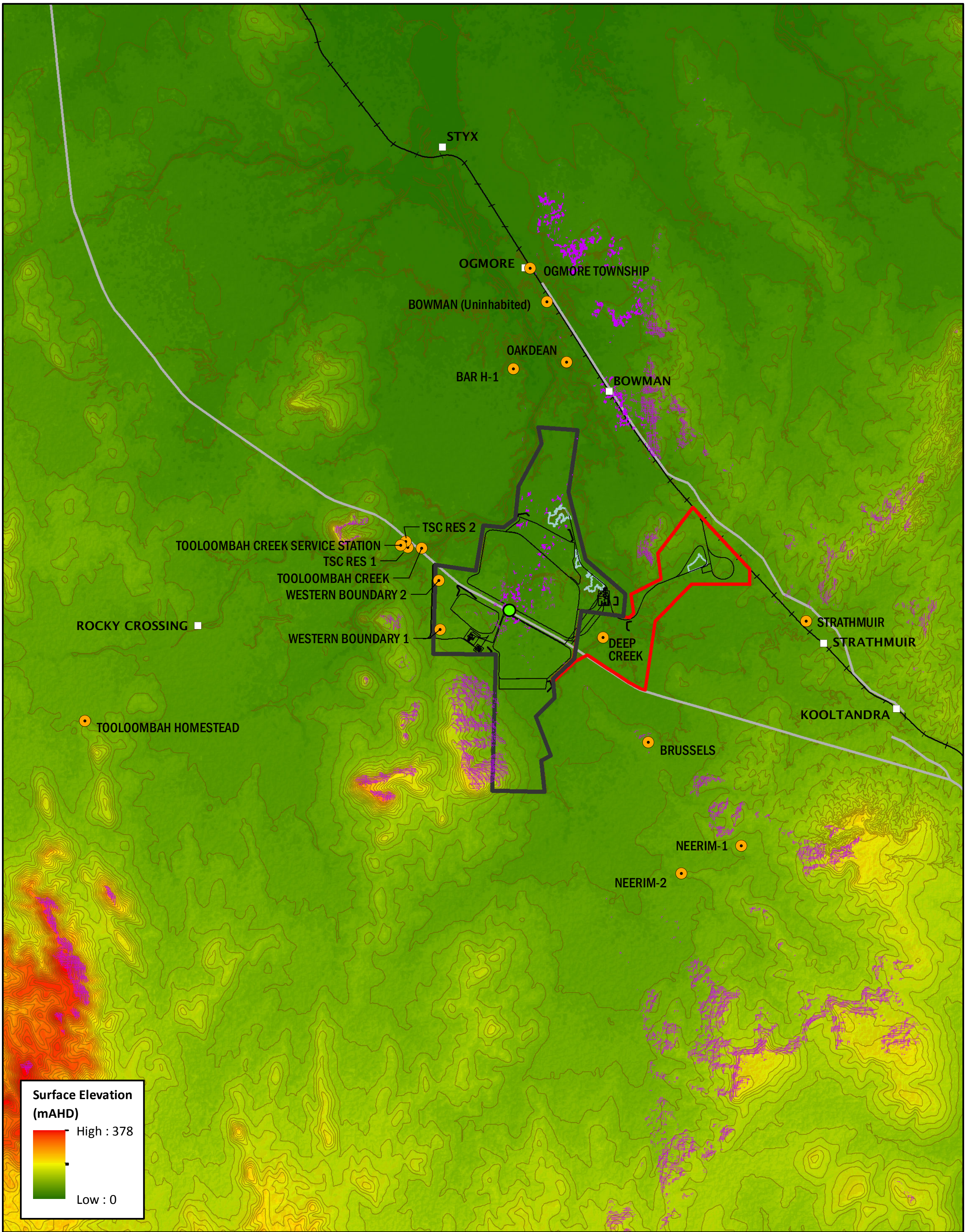


Figure 5-18
Viewshed modelling

N

0 1 2 km

Scale @ A4 1:135,000
Date: 13/11/18
Drawn: Gayle B.

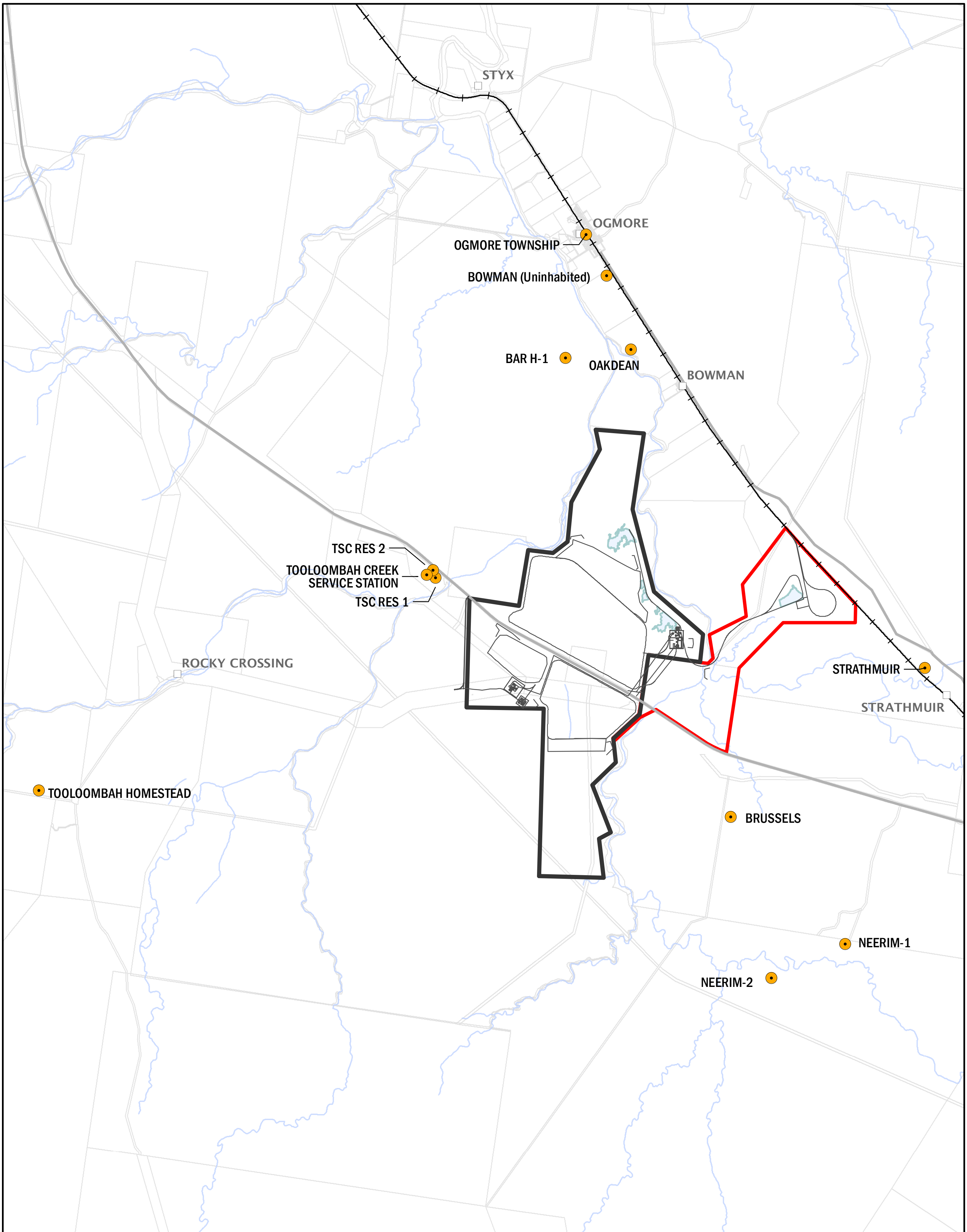
Legend

- Sensitive receptor
- ZTVI viewpoint
- Zone of Theoretical Visibility
- 10 m elevation contours
- Mine infrastructure
- ML 80187
- ML 700022
- Main Road
- North Coast Rail Line
- Dam

DATA SOURCE
QLD Open Source Data, 2018;
Waratah Coal, 2018;
1 Second SRTM v1.0 DEM
Geoscience Australia, 2011

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 R1 viewshed modelling_5-18.mxd 11/13/2018



N

0 1 2 km

Scale @ A4 1:110,000
Date: 19/10/18
Drawn: Gayle B.

Legend

- Sensitive receptor
- ML 80187
- ML 700022
- Mine infrastructure
- Cadastral boundary
- Main Road
- North Coast Rail Line
- Watercourse
- Dam

Figure 5-19
Sensitive receptors

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 sensitive receptors__5-19.mxd 10/19/2018

Table 5-38 Visual receptor analysis

Receptor name	ZTV Classification	Topography and existing natural elements	Visual impact
Ogmore Township	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Ogmore Township.	Nil
Oakdean	Potentially impacted Sensitive receptor is located within ZTV and is within 8 km from the Project area.	The Oakdean homestead is located approximately 5.5 km north of the Project area. The homestead and Project is separated by riparian vegetation associated with the Styx River as such the impact is expected to minimal as this vegetation will potentially screen the visibility of the Project. Lighting from the Project is likely to be visible given the proximity of the homestead to the Project.	Medium
Bowman (uninhabited)	Potentially impacted Sensitive receptor is located within ZTV and is within 8 km from the Project area.	The Bowman receptor is located approximately 7.5 km north of the Project area. The homestead and Project is separated by riparian vegetation associated with the Styx River as such the impact is expected to minimal as this vegetation will potentially screen the visibility of the Project. Lighting from the Project is unlikely to be visible given the proximity of the homestead to the Project.	Low
Strathmuir	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Strathmuir homestead.	Nil
Brussels	Potentially impacted Sensitive receptor is located within ZTV and is within 8 km from the Project area.	The Brussels homestead is located approximately 3.2 km southeast of the Project area. The homestead and Project is separated by riparian vegetation associated with the Deep Creek as such the impact is expected to minimal as this vegetation will potentially screen the visibility of the Project. Lighting from the Project is likely to be visible given the proximity of the homestead to the Project.	Medium

Receptor name	ZTV Classification	Topography and existing natural elements	Visual impact
Neerim-1	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Neerim-1 homestead.	Nil
Neerim-2	Potentially impacted Sensitive receptor is located within ZTV and is within 8 km from the Project area.	The Neerim-2 homestead is located approximately 7.7 km south of the Project area. The homestead and Project is separated by riparian vegetation associated with an unnamed creek as such the impact is expected to minimal as this vegetation will potentially screen the visibility of the Project. Lighting from the Project is unlikely to be visible given the proximity of the homestead to the Project.	Low
Tooloombah Creek Service Station	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Tooloombah Creek Service Station.	Nil
Bar H-1	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Bar H-1 homestead.	Nil
Bar H-2 (uninhabited)	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Bar H-2 infrastructure.	Nil
Bar H-3 (uninhabited)	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Bar H-3 infrastructure.	Nil

5.6 Sediment Load Assessment

Submissions made on the EIS sought further information regarding the potential sediment load that would report via Tooloombah Creek and Deep Creek, to the Styx River then to Broad Sound and then more broadly the GBRWHA because of the Project. The following sections provide a discussion and assessment of the existing sediment loads that are predicted to occur because of grazing on the Mamelon property. As Central Queensland Coal has committed to destocking the majority of the Mamelon property this will result in a material reduction in the potential sediment load reporting to the Styx River, and out to the GBR.

Purposely engineered and designed erosion and sediment controls as discussed in Section 5.11 will be established to prevent the release of sediments to Tooloombah Creek and Deep Creek, and then to the Styx River. It is important to note, little to no sediment controls exist on the Mamelon and Strathmuir properties in relation to managing the dispersal of sediments generated through the current grazing activities.

The following sections discuss the consequences of destocking the majority of the Mamelon property in terms of consistency with the Reef 2050 Plan and associated water quality programs for the Styx and Fitzroy Rivers. An assessment of erosion generated under the current grazing regimes is also discussed.

5.6.1 The Reef 2050 Plan

The Reef 2050 Plan is the overarching framework for protecting and managing the GBR from 2015 to 2050 (DotEE 2015). The plan is a key component of the Australian Government's response to the recommendations of the United Nations Educational, Scientific and Cultural Organisation World Heritage Committee (DotEE 2015). It includes a description of existing management arrangements, future steps for the protection and adaptive management of the reef, an implementation plan and an outline of the integrated monitoring and reporting program.

Seven overarching themes with associated actions, targets, objectives and outcomes are embedded into the plan. The seven themes are ecosystem health, biodiversity, heritage, water quality, community benefits, economic benefits and governance. Each theme and their associated actions have been reviewed for relevance to the Project. By meeting the Reef 2050 Water Quality Targets (WQT), the Project would contribute to improving ecosystem health and water quality.

5.6.2 Reef 2050 Water Quality Improvement Plan 2017 – 2022

The new five-year Reef 2050 Water Quality Improvement Plan 2017 – 2022 now aligns with the Australian and Queensland Governments' Great Barrier Reef 2050 Long-Term Sustainability Plan (DotEE 2015), agreed in 2015. The Reef 2050 Water Quality Improvement Plan is a joint commitment of the Australian and Queensland governments and is a collaborative program of coordinated projects and partnerships designed to improve the quality of water flowing to the GBR.

The Reef 2050 Water Quality Improvement Plan seeks to improve the water quality flowing from the catchments adjacent to the Reef. The Reef 2050 Water Quality Improvement Plan builds on previous water quality plans developed in 2003, 2009 and 2013 by:

- Including all sources of land-based water pollution: agriculture, industry, urban and public lands, while recognising that the majority of water pollution still arises from agricultural activities;

- Incorporating the human dimensions of change: our social, cultural and economic values and how they drive our adoption of actions to improve water quality setting individual targets for reducing water pollution from the catchments; and

- Enabling better prioritisation where the most management action is needed.

The outcome of the Reef 2050 Water Quality Improvement Plan is 'Reef water quality supports the outstanding universal value of the GBR, builds resilience, improves ecosystem health, and benefits communities.' The new targets define the reductions needed for each of the catchments by 2025. This is a new level of specificity from the Reef 2050 Long-Term Sustainability Plan targets that commit to achieving reductions of up to 80% in dissolved inorganic nitrogen and 50% in sediments.

Under the Reef 2050 Water Quality Improvement Plan, pollutant loads are assessed through the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program, using a combination of monitoring and modelling data. The Paddock to Reef Program includes catchment scale water quality monitoring of pollutant loads entering the GBR lagoon that is implemented through the Great Barrier Reef Catchment Loads Monitoring Program.

5.6.3 2017 Scientific Consensus Statement - Land Use Impacts on Great Barrier Reef Water Quality and Ecosystem Condition

The 2017 Scientific Consensus Statement provides the scientific understanding underpinning the design and implementation of the Reef 2050 Water Quality Improvement Plan. The 2017 Scientific Consensus Statement covers all land-based pollutant sources including urban diffuse, point source and industrial discharge. Notwithstanding all land based pollutant sources have been considered as part of the Consensus Statement, the emphasis is on the agricultural diffuse sources of pollutants as the dominant contributor of land-based pollutant loads at a regional and GBR-wide scale.

The overarching consensus is:

- Key GBR ecosystems continue to be in poor condition. This is largely due to the collective impact of land based runoff associated with past and ongoing catchment development, coastal development activities, extreme weather events and climate change impacts such as the 2016 and 2017 coral bleaching events; and

- Current initiatives will not meet the water quality targets. To accelerate the change in on-ground management, improvements to governance, program design, delivery and evaluation systems are urgently needed. This will require greater incorporation of social and economic factors, better targeting and prioritisation, exploration of alternative management options and increased support and resources (Waterhouse et. al, 2017).

Of relevance to this discussion, the consensus specifically concluded:

- The decline of marine water quality associated with land based runoff from the adjacent catchments is a major cause of the current poor state of many of the coastal and marine ecosystems of the GBR. Water quality improvement has an important role in ecosystem resilience; and

- The main source of the primary pollutants (nutrients, fine sediments and pesticides) from GBR catchments is diffuse source pollution from agriculture. These pollutants pose a risk to GBR coastal and marine ecosystems.

The consensus reported the greatest water quality risks to the GBR and coastal ecosystems are from discharges of:

- Nutrients, which are an additional stress factor for many coral species, promote crown-of-thorns starfish population outbreaks with destructive effects on mid-shelf and offshore coral reefs, and promote macroalgal growth;
- Fine sediments, which reduce the light available to seagrass ecosystems and inshore coral reefs; and
- Pesticides, which pose a toxicity risk to freshwater ecosystems and some inshore and coastal habitats.

The main source of excess nutrients, fine sediments and pesticides from GBR catchments is diffuse source pollution from agriculture, with other land uses, contributing relatively small but concentrated pollutant loads. At the regional scale, Fitzroy, the Wet Tropics and Burdekin are the major contributors of these river pollutant loads. Grazing contributes the largest proportion of sediment and particulate nutrients to the GBR primarily through sub-surface (gully, streambank and rill) erosion.

The Fitzroy catchment is one of several catchments which contribute to the highest exposure of coastal or marine ecosystems to pollutants. As such, it is considered a high priority area for reducing fine sediment and particulate nutrients.

5.6.4 Existing Great Barrier Reef Catchment Loads Monitoring

The Great Barrier Reef Catchment Loads Monitoring Program provides measures of annual loads (mass) of total suspended solids (TSS) and nutrients (nitrogen and phosphorus) from 14 priority basins, in six natural resource management (NRM) regions, that discharge to the GBR. For 12 of these priority basins annual pesticide loads and summed annual toxic loads of pesticides are also described.

The NRM regions and priority catchments are:

- Cape York region – Normanby catchment;
- Wet Tropics region – Barron, Mulgrave-Russell, Johnstone, Tully and Herbert catchments;
- Burdekin region – Burdekin and Haughton catchments;
- Mackay Whitsunday region – O'Connell, Pioneer and Plane catchments;
- Fitzroy region – Fitzroy catchment; and
- Burnett Mary region – Burnett and Mary catchments.

This monitoring program is part of the Reef Water Quality Protection Plan (Reef Plan), and the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef Program). It also provides load data to validate and calibrate catchment models, which assist in evaluating progress towards the water quality targets of Reef Plan.

Catchment loads have been monitored annually since 2009 and are variable between catchments and years depending on the variability in discharge together with land use and vegetation cover. Loads are calculated for the monitored area of each catchment and as such do not represent the total load discharged to the GBR lagoon.

The total annual monitored loads for all NRM regions and catchments are presented in Table 5-39. The relatively small load reported for the 2013-2014 period is attributed to very low end-of-system discharges, the lowest recorded between the 2006–2016 monitoring years (see Garzon-Garcia et al 2015).

Table 5-39 Total monitored loads – NRM regions and catchments

Period	Water quality parameter constituent loads			Source
	TSS (t)	TN (t)	TP (t)	
2015-2016	1,800,000	11,000	2,300	Huggins et al. 2017
2014-2015	2,400,000	12,000	2,900	Wallace et al. 2016
2013-2014	1,400,000	12,000	1,800	Garzon-Garcia et al 2015
2012-2013	9,600,000	34,000	9,400	Wallace et al 2015
2011-2012	5,600,000	28,000	7,800	Wallace et al 2015
2010-2011	20,000,000	100,000	32,000	Turner et al 2013
2009-2010	6,950,000	30,000	9,300	Turner et al 2013
Average load	**6,821,429**	**32,429**	**9,357**	

The Fitzroy NRM region is approximately 37 per cent of the total GBR catchment area (~423,122 km^2). The region is comprised of six drainage basins: Styx, Shoalwater, Water Park Creek, Fitzroy, Calliope and Boyne as shown on Figure 5-20. The annual monitored loads for the Fitzroy NRM area (Fitzroy catchment) which covers an area of approximately152,000 km^2 (with a monitored surface area of approximately 139,159 km^2) are presented in Table 5-40. No outputs specific to the Styx Drainage Basin are reported as part of the ongoing Great Barrier Reef Catchment Loads Monitoring Program. The percentage shown in Table 5-40 are the contribution the Fitzroy NRM area makes to the regional total annual monitored loads (Table 5-39).

Table 5-40 Monitored loads – Fitzroy NRM area (Fitzroy Catchment) (see Huggins et al 2017)

Period	Water quality parameter constituent loads						Source
	TSS (t)		TN (t)		TP (t)		
2015-2016	670,000	37.2%	3,300	30.0%	910	39.6%	Huggins et al 2017
2014-2015	900,000	37.5%	3,200	26.7%	1,300	44.8%	Wallace et al. 2016
2013-2014	52,000	3.7%	1,000	8.3%	160	8.9%	Garzon-Garcia et al 2015
2012-2013	2,500,000	26.0%	9,300	27.4%	3,700	39.4%	Wallace et al 2015
2011-2012	1,300,000	23.2%	6,400	22.9%	2,700	34.6%	Wallace et al 2014
2010-2011	7,000,000	35.0%	36,000	36.0%	15,000	46.9%	Turner et al 2013
2009-2010	3,563,583	51.3%	12,898	43.0%	5,321	57.2%	Turner et al 2012
Average load	**2,283,655**	**33.48%**	**10,300**	**31.76%**	**5,326**	**56.92%**	

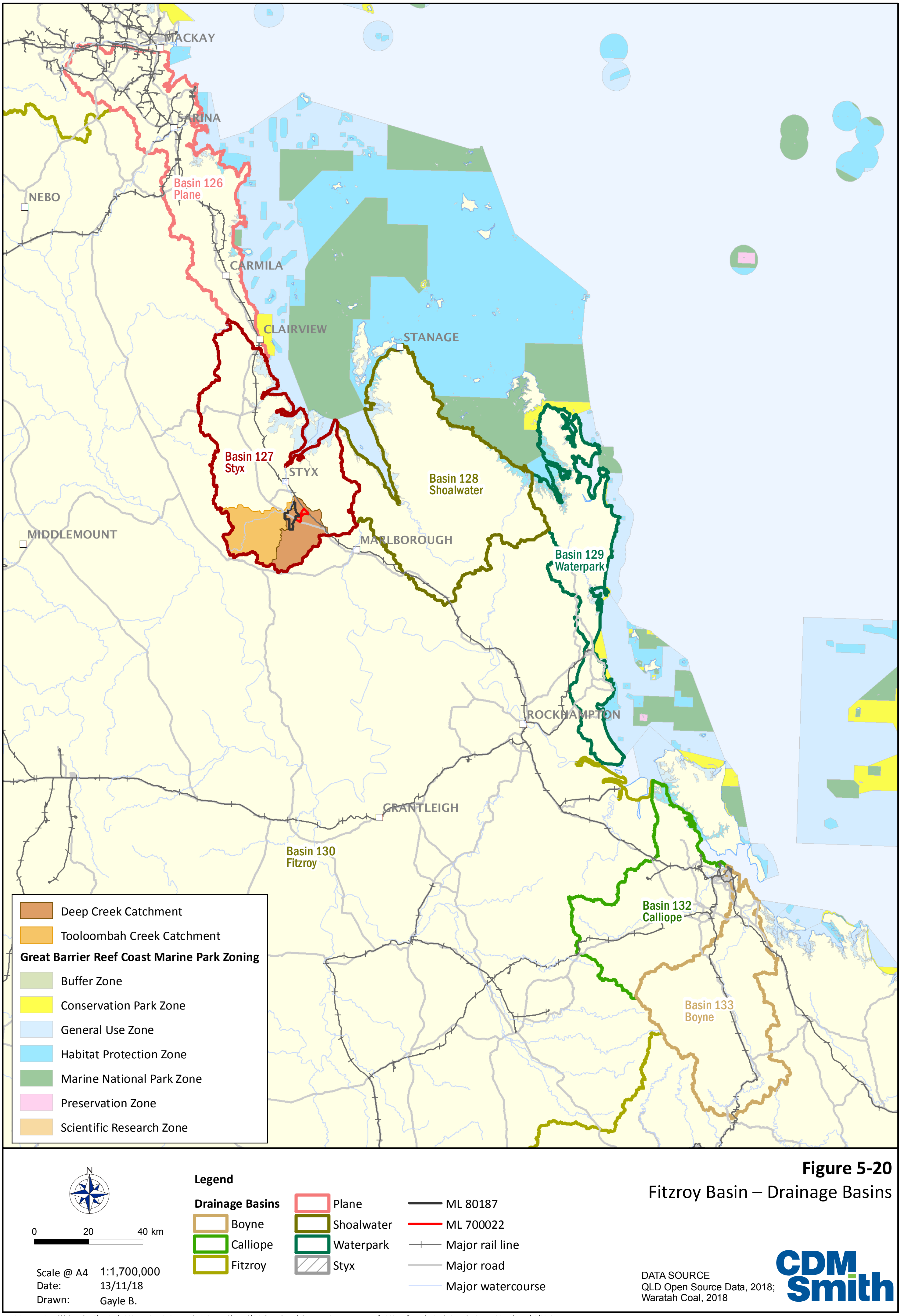


Figure 5-20

Fitzroy Basin – Drainage Basins

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 fitzroy basin_drainage basins__5-20.mxd 11/13/2018

5.6.5 Soil Loss Estimation – Grazing of Native Pasture

Surface water runoff is an important factor affecting off-site sediment transportation in grazed environments. Degradation of pastureland from cattle grazing and in particular overstocking of cattle and the clearing of woody vegetation can contribute to heightened rates of surface runoff and erosion. Shellberg and Brooks (2013) report cattle grazing as a primary agent for accelerating gully erosion on highly-erodible sodic soils. Increased runoff resulting in erosional processes can lead to on-site effects such as reductions to pasture productivity and off-site effects including the sedimentation of receiving waters and offsite habitats. Cattle grazing intensity and impacts are often concentrated along river frontage terraces and elevated floodplains often resulting in alluvial gullies eroding into terraces and elevated floodplains (Shellberg and Brooks 2013).

In this section an assessment of the potential mobilised sediment volumes that could be generated as a result of the erosional processes because of the existing cattle grazing on the Mamelon property are discussed. The results are particularly relevant given it is Central Queensland Coal's intention to remove grazing activities from the Mamelon property and to allow the natural regeneration of the vegetation outside of the mine disturbance area to replenish.

A key aspect of the destocking approach will be to allow the vegetation communities within the riparian corridors to regenerate without being subjected to ongoing grazing pressures. As vegetation coverage continues to increase within the riparian corridors and across the property more generally combined with the absence of grazing, the potential for sediments to mobilise reduces and will continue to do so. This is particularly important in the creek frontage areas, terraces and floodplains where dispersive or sodic soils prone to gully erosion occur (Shellberg and Brooks, 2013)

This has follow-on impacts by contributing to improving the water quality entering Broad Sound and the GBRWHA. Thereby providing a positive contribution to the future of the GBR by reducing localised nutrient and sediment run-off in the Great Barrier Reef lagoon, a key action in improving the health and resilience of the reef (CoA 2015).

5.6.5.1 Soil Loss Estimation

The mobilisation of sediments from grazed environments occurs through different mechanisms and at differing scales. Within the Project area the typical mechanisms that exist within the more frequently grazed areas are sheet erosion, gully erosion and stream bank erosion. Hillslope erosion is also a contributing mechanism within the Project area although these areas are not grazed to the same extent as the more productive undulating to gently undulating country.

In the absence of specific data for the Styx catchment, erosion estimations for land under grazing were undertaken using the HowLeaky? model developed for the Eden Bann Weir EIS. These estimations have been considered as a surrogate to estimate potential sediment loads leaving the Mamelon property due to grazing activities. The HowLeaky? model was set up using *inter alia* best available soil, vegetation and soil nutrient information for two representative soil types at Yaamba and Rockwood in Central Queensland. Land use and management comprised of three grazing regimes to represent potential current land use practice.

The results from the Yaamba analysis were considered appropriate for the assessment given the proximity to the Mamelon property and similarities in climate trends, land use and soil types. The grazing system parameters used for the assessment of sediment generation from grazing on Mamelon are described in Table 5-41. These grazing systems are considered appropriate as to what may occur at the Mamelon Property. Discussion regarding irrigation has been excluded from the assessment as irrigation is not a current land use undertaken at Mamelon.

Table 5-41 Grazing system parameters

Grazing System	Description
A - Stocking rates well within land systems production capability, resultant resilient grazing land use, infrastructure used to exclude stock from vulnerable areas. Very conservative stocking – typical cover in 60% October cover.	Grazing management recognises production capability and resilience of different land types and grazing adjusted accordingly. Landscape features all managed where appropriate (conservative grazing pressure, use of fire, summer spelling, riparian fencing, exclusion from gullies areas). Simulation conditions: I High green and litter cover all year with seasonal variation. Soil cover at 50-75% with peak in summer growing season. Summer spelling applied when pasture condition deteriorates Probably not realistic to maintain across all seasons. II Uses time series of soil cover derived from CGI (Satellite imagery).
B - Highly responsive stocking rates based on land condition and seasonal forecasts Low stocking – typical cover in 44% October cover, (B).	Grazing management recognises production capability of different land types and stocking adjusted accordingly (use of fire, summer spelling) Simulation conditions: Low stocking rate with 44% cover in October. This description mimics the low stocking rate from the Wambiana grazing study (O'Reagain et al, 2008 as reported in Coordinator-General, 2016).
C - Fixed stocking rates best suited to average conditions that result in over grazing in drier seasons High stocking - typical cover in 34% October cover.	Grazing management assumes uniform land resources, fixed stocking rates. Simulation conditions: High stocking rate with 33% cover in October. This description attempts to mimic the high stocking rate from the Wambiana grazing study (O'Reagain et al, 2008 as reported in Coordinator-General, 2016).
D - Stocking rates well above the land systems capacity to support grazing, even in average conditions. Degraded pasture composition Extreme stocking - typical cover in 20% October cover Poor soil.	Grazing management assumes uniform land resources, fixed stocking rates based on average to good seasonal conditions (results in over grazing and stock loose condition when rainfall deficits occur. Simulation conditions: Very high stocking rate such that total soil cover never exceeds 35% and gets as low as 15% at the end of the dry season. A poor soil type is used to describe hydrologic response resulting from scalds and degraded surface structure.

Annual sediment loads (reported as TSS) and event mean concentrations (EMC) for Yaamba were generated using the model and are presented in Table 5-42. Annual water balance summaries used for the modelling are provided in Table 5-43.

Table 5-42 Annual pollutant loads and EMC (Yaamba climate)

Landscape, land use and management	Runoff (mm)	Hill slope erosion (t/ha)	Annual off-site pollutant loads – Sediment (t/ha)	event mean concentrations – sediment (g/L)
Floodplains: mix of vertosol/sodosols; based on sodosol (loamy surface; moderate deep A, deep B; slowly permeable (group 210)); 1% slope, 100 m slope length.				
Low stocking pasture 44% October (B)	108	1.7	0.34	0.3
Moderate stocking pasture 34% October (C)	121	3.6	0.72	0.6
Excess stocking pasture 20% October (D)	139	7.9	1.60	1.1
Upland slopes: slopes with sodosols (shallow sandy surface; deep A, shallow B; slowly permeable (group 270)); 3% slope, 100 m slope length.				
Moderate stocking pasture 34% October (C)	123	9.3	1.90	1.5

Table 5-43 Annual water balance summary (Yaamba)

Landscape, land use and management	Runoff (mm/yr)	Soil evaporation (mm/yr)	Transpiration (mm/yr)	Drainage (mm/yr)
Floodplains: mix of vertosol/sodosols; based on sodosol (loamy surface; moderate deep A, deep B; slowly permeable (group 210)); 1% slope, 100 m slope length.				
Low stocking pasture 44% October (B)	108	351	331	23
Moderate stocking pasture 34% October (C)	121	359	307	26
Excess stocking pasture 20% October (D)	139	367	277	29

Landscape, land use and management	Runoff (mm/yr)	Soil evaporation (mm/yr)	Transpiration (mm/yr)	Drainage (mm/yr)
Upland slopes: slopes with sodosols (shallow sandy surface; deep A, shallow B; slowly permeable (group 270)); 3% slope, 100 m slope length.				
Moderate stocking pasture 34% October (C)	123	358	297	35

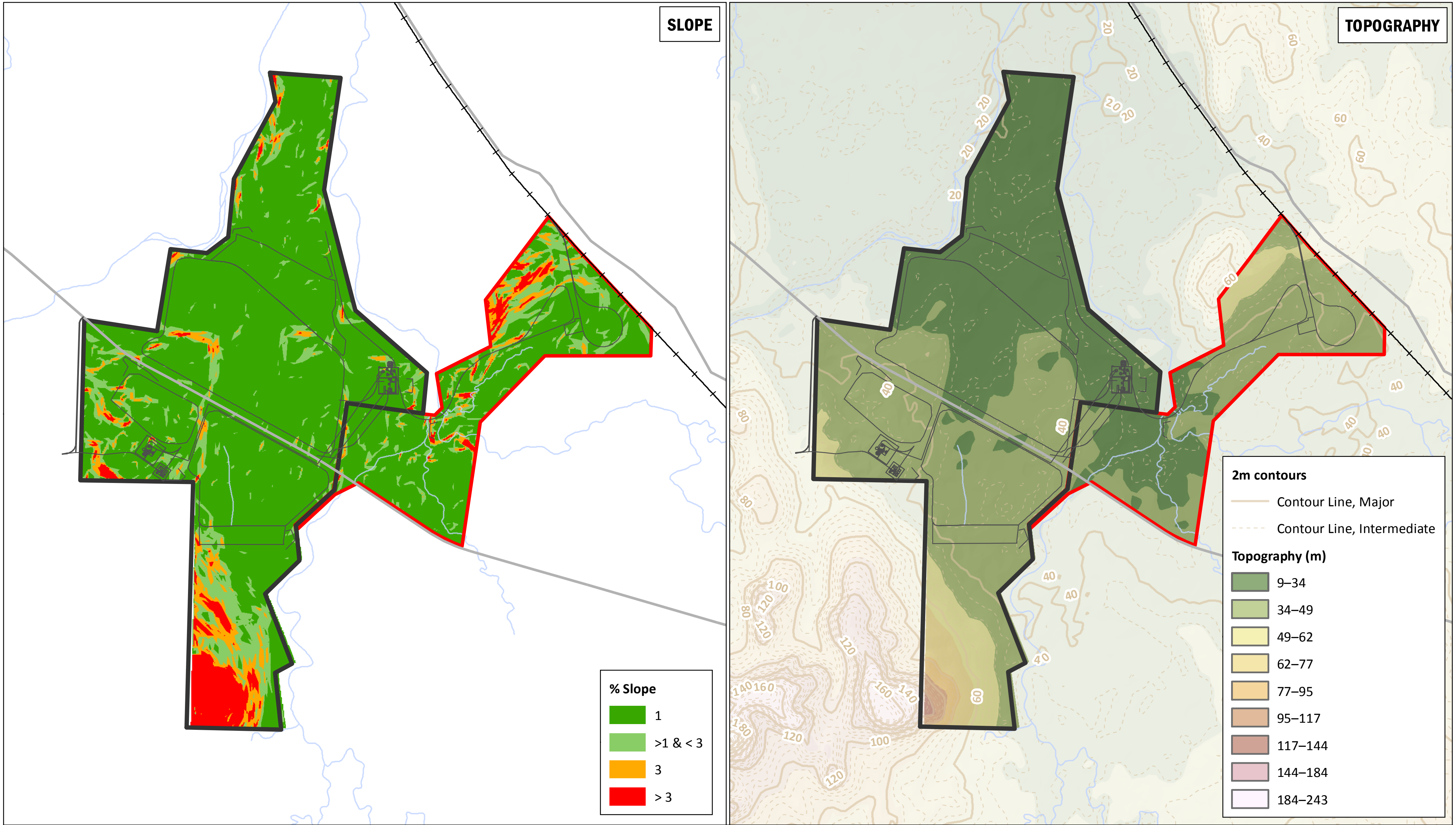
To assess the potential sediment generation that may result from grazing activities within the Project area, the slope within ML 80187 and ML 700022 was analysed. Slope was divided into four categories and the corresponding area in hectares is presented in Table 5-44. Slope categories 1% and 3% equate respectively to the “Upland Slopes” and “Floodplains” categories used in the HowLeaky? Model developed for the Eden Bann Weir EIS. An analysis of the slope and topography is shown at Figure 5-21.

Table 5-44 Slope assessment

Slope (%)	ML 80187 (ha)	ML 700022 (ha)
1%	1,748	535
>1 but <3%	287	139
3%	121	52
≥3%	113	26
Total area within ML (hectares)	**2,269**	**752**

Soil types used for the HowLeaky? Model developed for the Eden Bann Weir EIS and specifically for Yaamba were considered appropriate for this assessment. The majority of the “Floodplain” category is a mix of vertosol / sodosols and the “Hillslope” category is mostly sodosols which equate to the criteria used for Yaamba in the Eden Bann EIS model.

By using the same criteria used for the Eden Bann Weir EIS against the representative areas within ML 80187 and ML 700022 the estimated annual off-site sediment loads (t/ha) against three differing stocking regimes were derived. The results for ML 80187 and ML 700022 are presented at Table 5-45 and Table 5-46, respectively. The results should be considered as indicative rather than as absolute. To be consistent with the Eden Bann Weir approach areas of slope >1 but <3% and ≥3% were not assessed. This amounts to total areas of 400 ha and 165 ha on ML 80187 and ML 700022 respectively that would also likely contribute to the annual generation of sediment whilst under grazing.



N

0 1 2 km

Scale @ A4 1:77,500
Date: 19/10/18
Drawn: Gayle B.

Legend

- ML 80187
- ML 700022
- Mine infrastructure
- Main Road
- North Coast Rail Line
- Watercourse

Figure 5-21
Slope and topography comparison

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 5_Supp_Report_Land\1000111 R1 surface slope analysis__5-21.mxd 10/19/2018

Table 5-45 Estimated annual pollutant load for ML 80187

Landscape, land use and management	Runoff (mm/yr)	Hill slope erosion (t/ha)	Annual off-site pollutant loads – Sediment (t/ha)	Area (ha)	Estimated annual sediment generation (t/ha)
Floodplains: mix of vertosol/sodosols; based on sodosol (loamy surface; moderate deep A, deep B; slowly permeable (group 210)); 1% slope, 100 m slope length					
Low stocking pasture 44% October (B)	108	1.7	0.34	1,748	595
Moderate stocking pasture 34% October (C)	121	3.6	0.72		1,259
Excess stocking pasture 20% October (D)	139	7.9	1.60		2,797
Upland slopes: slopes with sodosols (shallow sandy surface; deep A, shallow B; slowly permeable (group 270)); 3% slope, 100 m slope length					
Moderate stocking pasture 34% October (C)	123	9.3	1.90	121	230

Table 5-46 Estimated annual pollutant load for ML 700022

Landscape, land use and management	Runoff (mm/yr)	Hill slope erosion (t/ha)	Annual off-site pollutant loads – Sediment (t/ha)	Area (ha)	Estimate annual sediment generation (t/ha)
Floodplains: mix of vertosol/sodosols; based on sodosol (loamy surface; moderate deep A, deep B; slowly permeable (group 210)); 1% slope, 100 m slope length					
Low stocking pasture 44% October (B)	108	1.7	0.34	535	182
Moderate stocking pasture 34% October (C)	121	3.6	0.72		385
Excess stocking pasture 20% October (D)	139	7.9	1.60		856
Upland slopes: slopes with sodosols (shallow sandy surface; deep A, shallow B; slowly permeable (group 270)); 3% slope, 100 m slope length					
Moderate stocking pasture 34% October (C)	123	9.3	1.90	52	99

The results of the assessment show that for areas of 1% slope under grazing regimes B, C and D as described at Table 5-41, the estimated annual sediment generation potential ranges between 595 to 2,797 t/ha and 182 to 856 t/ha for ML 80187 and ML 700022 respectively. For areas of 3% slope under grazing regime C as described at Table 5-41, the estimated annual sediment generation is 230 t/ha and 99 t/ha for ML 80187 and ML 700022 respectively.

It is important to note that the model outputs are generated on the assumption that the grazing regime and vegetative cover apply across the entire areas of 1% and 3% slope and that the run-off and hill-slope erosion coefficients are uniformly applied within the areas of 1% and 3% slope. In reality, these circumstances would not exist and as such, these outputs are considered to be indicative of the potential sediment loads that could be generated under each of the nominated grazing regimes.

Central Queensland Coal has committed to the destocking the majority of the Mamelon property to allow for the natural regeneration of vegetation across the property. The small portion of the property that is not proposed to be destocked is on land of >3% slope and was not considered in the assessment at Table 5-45. The destocking of Mamelon will allow for the natural regeneration of land undisturbed by the mine and allow for the continued progressive rehabilitation of land disturbed by the mine. Noting the Project will be implementing a wide range of specifically engineered and designed sediment control measures to prevent sediment from leaving the site, there is expected to be a significant reduction in mobilised sediments compared to that of the current grazing regime.

The RUSLE soil loss estimate calculations undertaken for the site (see Section 5.11) indicates potential soil loss rates ranging from 67 to 1,392 tonnes per hectare per year and erosion hazard categories ranging from very low to very high depending on soil characteristics and slope. Estimated soil loss rates assume no erosion and sediment controls are implemented. With the installation, operation and maintenance of drainage, erosion and sediment controls, at least 95% of sediments up to 0.045 mm diameter (i.e. ~64 to ~1,322 tonnes per hectare) would be captured and retained within the site under typical flow conditions through rapid settlement of coarse grained particles during all storm events and settlement of fine grained particles under controlled conditions. The resultant amount of sediment that would potentially not be contained vial engineered erosion and sediment controls would be between 3 to 70 tonnes per hectare. This represents a significant reduction in downstream sedimentation compared with the current grazing regimes implemented at the Mamelon property (i.e 3-70 tonnes per hectare incorporating erosion and sediments control versus between 595-2797 tonnes per hectare and 182-856 tonnes per hectare on ML 80187 and ML 700022 respectively.

It is expected that the reduction of mobilised sediments will continue post mining as the intention is to set aside the property for nature conservation purposes. A key aspect of the destocking approach is to allow the vegetation communities within the riparian corridors to regenerate without being subjected to ongoing grazing pressures. As vegetation coverage continues to increase within the riparian corridors and across the property more generally with the absence of grazing, the potential for sediments to mobilise reduces and will continue to do so.

5.7 Assessment of Project against Reef 2050 Water Quality Targets

An assessment of potential Project impacts against the Reef 2050 WQTs is provided in Table 5-47. The assessment takes into consideration the benefits associated with the installation of specifically designed and engineered erosion and sediment control measures (Section 5.11), the removal of grazing from the majority of the Mamelon Property, and the anticipated ongoing reduction in sediments reporting to the GBR associated with the change in land use.

Table 5-47 Assessment of Project impacts against the Reef 2050 water quality targets

Water Quality Target	Assessment
Water Quality Target 1	
At least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas, on the way to achieving up to an 80 per cent reduction in nitrogen by 2025.	The Fitzroy Basin catchment is not a priority area for nitrogen management as defined in the Reef Water Quality Protection Plan 2013 (State of Queensland 2013) (RWQPP). No further assessment against this WQT is required. Nevertheless, dissolved inorganic nitrogen loads are primarily associated with runoff from fertilised agricultural areas. Noting cattle will be removed from the vast majority of the Mamelon property there is an expected, albeit minor at the catchment scale, reduction on inorganic nitrogen loads reporting to the GBR.
At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50 per cent reduction by 2025.	The Fitzroy Basin is a priority area for suspended sediment management as defined in the RWQPP. The Project will result in a positive contribution to this target through the expected reduction in sediment load reporting to Tooloombah Creek and Deep Creek associated with the cessation of grazing activities and subsequent managed regeneration of native vegetation on the majority of the Mamelon property. While it is possible that some localised erosion may occur on site because of construction and operation of the mine it is considered that the potential sediment load contribution would be negligible given the specifically design and engineered erosion protection infrastructure that would be established across the Project disturbance areas. The erosion and sediment controls that would be established either as temporary infrastructure during construction and both temporary and permanent infrastructure during operations will reduce the potential for scour and erosion thereby minimising the potential to increase sediment loads.

Water Quality Target	Assessment
At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas.	The Fitzroy Basin is a priority area for suspended sediment management and the sediment target has been refined to include particulate nutrients (particulate nitrogen and particulate phosphorous) in priority areas (Queensland Government 2015). The Project would result in a positive contribution through a reduction in nutrients because of the cessation of grazing activities and subsequent managed regeneration of native vegetation on the majority of the Mamelon Property.
At least a 60 per cent reduction in end-of catchment pesticide loads in priority areas.	The Fitzroy Basin is a priority area for pesticide management as defined in the RWQPP. The Project would result in a positive contribution to this target through a reduction in fertilisers associated with the cessation of grazing activities on the vast majority of the Mamelon property. It is anticipated there will be an increase in the use of herbicides on the property to control a range of weeds listed under the *Biosecurity Act 2014*. Under the present regime there is little effort to control the spread of weeds across the Mamelon property. The Land Use Management Plan will include undertaking weed spraying to control weed species such as Rubber Vine and Parthenium. The potential increase will be of short duration and spatially limited to the ML areas and is anticipated to result in a negligible increase to the pesticide load reporting from the Fitzroy Catchment to the GBR.
Water Quality Target 2	
Ninety per cent of sugarcane, horticulture, cropping and grazing lands are managed using best management practice systems (soil, nutrient and pesticides) in priority areas.	The Project will result in a reduction of grazing lands, either as disturbed land associated within mining activities, or land where cattle have been destocked. The destocked land will positively contribute to achieving WQTs associated with increasing late dry season groundcover and increasing the extent of riparian vegetation.
Minimum 70 per cent late dry season groundcover on grazing lands.	The Project will result in an increase of the extent of late dry season groundcover through the cessation of grazing on the majority of Mamelon property. The destocking of cattle will enable vegetation to regenerate within the areas that will not be disturbed through mining activities.
The extent of riparian vegetation is increased.	The Project will result in an increase of the extent of riparian vegetation through the cessation of grazing on the vast majority of Mamelon property. The destocking of cattle and subsequent Project management of native revegetation will enable vegetation to regenerate within the riparian corridors associated with Deep and Tooloombah Creeks, both of which currently remain as narrow bands of vegetation within heavily cleared lands (as they occur adjacent to the ML). Project revegetation activities will also increase riparian vegetation along several smaller tributaries in the south of the property which are currently cleared.
There is no net loss of the extent, and an improvement in the ecological processes and environmental values, of natural wetlands.	Groundwater drawdown will not impact the mapped Wetland Protection Area on the property. The Project Water Management System and erosion and sediment control system will ensure that polluted / sediment-laden rainfall run-off from the Project infrastructure does not enter adjacent waterholes in Tooloombah Creek and Deep Creek. Groundwater drawdown may have minor impacts on waterholes on Tooloombah Creek and Deep Creek located close to the open cut areas. These waterholes will be monitored regularly within the Project Receiving Environment Management Plan for water height / extent. Where water loss is attributed to groundwater drawdown from the Project activities these waterholes will be replenished with treated water of a suitable standard to maintain current environmental values.
Water Quality Target 3	
By 2020, Reef-wide and locally relevant WQTs are in place for urban, industrial, aquaculture and port activities and monitoring shows a stable or improving trend.	The Project will not inhibit the development of reef-wide and locally relevant WQTs for urban, industrial, aquaculture and port activities. The Project alone will not materially contribute to long-term trends in water quality given the extensive land clearing and cattle grazing that occurs within all of the sub-catchments within the Styx catchment.

Water Quality Target	Assessment
Water Quality Target 4	
Water quality in the GBR has a stable or positive trend.	With specifically designed and engineered erosion and sediment controls in place, together with the destocking of cattle and subsequent managed regeneration of native vegetation on the vast majority of Mamelon property, no decline in the water quality of the GBR is expected as a result of the Project. In the long-term the Project may provide a positive improvement (i.e. minor and localised) in the water quality entering the GBR.
Water Quality Target 5	
Traditional Owners, industry and community are engaged in on-ground water quality improvement and monitoring	The Project will not inhibit the engagement of Traditional Owners, industry and community in on-ground water quality improvement and monitoring. Traditional owners have been engaged with the Project through the development of Cultural Heritage Management Plans.

5.8 Potential Impacts

This section describes the key components of the Project which could affect EVs associated with land. Management measures have been determined in response to these potential impacts and best reflect the requirements for land management throughout the construction, operation and rehabilitation phases of the Project. Specific mitigation measures have been provided for ASS and ESCs if disturbed. These are at Section 5.10 and 5.11, respectively.

The information contained in this section has been provided at a level of detail suitable for strategic planning. However, to make decisions about specific construction activities at the detailed planning phase a higher intensity soil survey will need to be undertaken within the disturbance areas and will be used to inform the Project-specific Rehabilitation and Mine Closure Plan.

5.8.1 Mine Area

The key infrastructure features associated with the mine area that will result in soil disturbance and will subsequently require management measures are outlined below. The type of impact has also been identified against the nominated infrastructure. Identified impacts to soil also include the contamination of soil. Construction of the Project infrastructure will have an overall effect on agricultural land uses. The mine area will disturb approximately 1,124.8 ha of land, which is defined as follows:

- Open Cuts 1 and 2 (land disturbance, soil quality, soil erosion);
- Two CHPPs and product coal stockpiles (land disturbance, soil quality, soil erosion);
- Two ROM coal stockpile area and ROM dump station (local waterways, land disturbance, soil quality, soil erosion);
- ROM coal haul roads and waste rock haul roads (local waterways, land disturbance, soil quality, soil erosion);
- Product coal and conveyor (local waterways, land disturbance, soil quality, soil erosion);
- Water supply infrastructure (topography, land disturbance, soil quality, soil erosion);
- Mine affected water dams, sediment affected water dams and clean water dams (topography, local waterways);
- Light and heavy vehicle internal roads (land disturbance, soil erosion);
- Night lighting of the MIA (light spill); and

- Buildings associated with the construction and operation of the mine (land disturbance, soil quality, soil erosion).

5.8.2 Haul Road and Train Loadout Facility

The key infrastructure features within the haul road corridor and TLF which will require soil disturbance and subsequent management measures are prescribed below. The haul road corridor (including Dam 4) will disturb 26 ha and the TLF 8 ha of land, which are defined as follows:

- 5.48 km haul road from the product stockpiles to the TLF including the return haul road loop (topography, local waterways, land disturbance, soil erosion);
- Access roads (topography, local waterways, land disturbance, soil erosion);
- Cross-drainage structures (topography, local waterways, land disturbance, soil quality, soil erosion);
- Sub-surface power, water and telecommunications services (topography, local waterways, land disturbance, soil quality, soil erosion);
- Construction of dams and sumps to collect surface runoff (topography, local waterways, land disturbance, soil quality, soil erosion);
- Rail loop connecting to the North Coast Rail line (topography, local waterways, land disturbance, soil quality, soil erosion);
- Night lighting of the TLF (light spill);
- Hardstand area to receive product coal haul trucks from the haul road (land disturbance, soil erosion); and
- Area for administration buildings, workshop, fuel storage and light vehicle parking (local waterways, land disturbance, soil, soil erosion).

5.9 Qualitative Risk Assessment

Potential impacts on the land resulting from a combination of construction of the proposed infrastructure and ongoing mining activities within the Project area have been assessed utilising the risk assessment framework outlined in Chapter 1 - Introduction. The risk impact assessment at Table 5-48 is a qualitative risk assessment that outlines the potential impacts, the initial risk, mitigation measures and the residual risk following the implementation of the mitigation measures. Soil management strategies in the form of mitigation measures are also identified.

For the purposes of this risk assessment, levels are defined as follows:

- Extreme – Extensive long-term harm with widespread impacts that are irreversible in 5 to 10 years. Significant non-compliances with the EA and/or other approval conditions that result in significant degradation to EVs;
- High – Major long-term and widespread harm that are reversible in <5 years. Non-compliances with the EA and / or other approval conditions that result in major degradation to EVs;
- Medium – Moderate environmental harm that is contained onsite or minor widespread harm that are reversible in <1 years. Non-compliances with the EA and/or other approval conditions that result in minimal degradation to EVs; and
- Low – Minor unplanned onsite harm that does not extend off-site. No non-compliances with the EA and/or other approval conditions.

Table 5-48 Qualitative risk assessment

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
Soil and Land Disturbance (Construction Operation and Decommissioning)	The Project will disturb 1,124 ha of land. The clearing of vegetation and other earthmoving activities associated with construction of the mine and mine facilities can initiate soil erosion if not done in a controlled manner, releasing sediments into nearby water systems and decreasing the overall value of the land. Minimising disturbance will be vital in minimising associated impacts to land and soils. The impacts resulting from each of individual disturbance activities will vary, however they are not anticipated irreversible. The key potential soil impacts that will affect the Project site are physical soil disturbance, contamination of soils and degradation of soils. The physical degradation of soil may occur because of the use of heavy machinery, leading to severely limited revegetation potential, decreased water infiltration and, in some instances, increased erosion. Soil quality can also be affected by poor topsoil stripping and handling. The clearing of vegetation and other earthmoving activities associated with construction of the Central Queensland Coal mine and mine facilities can initiate soil erosion if not done in a controlled manner, releasing sediments into nearby water systems and decreasing the overall value of the land.	High	To protect the surrounding environment, works will be undertaken in a manner such that the impact to soils, landforms and any receiving waters is minimal. This will be achieved by the scheduling of construction activities and the dedication of specific work areas. The following mitigation measures are proposed: ▪ No Go Zones shall be established prior to clearing / grubbing activities and maintained throughout the life of the Project. This will be achieved by installing physical demarcation along work area perimeters to visibly delineate the maximum allowable area of disturbance; ▪ All vehicle movements will be restricted to stabilised access locations. Stabilised access points and nominated construction and haul roads will prevent excessive ground disturbance from the movement of vehicles and machinery across the Project site; ▪ The scheduling of works will also assist in minimising ground disturbance by ensuring that activities are organised sequentially with areas of disturbance reflecting construction activities taking place at that time; ▪ No surfaces will be left open if they are not being worked on and all areas will have topsoil pulled back over and be suitably compacted once construction work in the area has finished. Grassed areas cleared for construction of any mine-related infrastructure will be re-contoured and landscaped once construction is complete to minimise erosion impacts; ▪ Where significant excavation is required, excavated material will be deposited upslope of the work and diversion measures to control soil and water flows will be installed (including banks and berms). Any diversion measures will discharge to a stabilised control or sedimentation trap;	Low

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
			▪ Excavations shall be kept open for the shortest period possible and this will be achieved by incorporating a more detailed construction schedule into the Project planning phase; ▪ Preserving as much of the vegetated areas and areas with stable grass cover will greatly reduce the soil disturbance and subsequent erosion hazard, as well as provide a natural sediment filter; and ▪ Sediment fences or other appropriate ESC will be installed downslope of any disturbed lands. The implementation of effective ESC measures (described in detail in Section 5.11) will assist in achieving further protection of the surrounding environment.	
Soil and Land Contamination (Construction, Operation and Decommissioning)	Contamination can affect future soil use and land suitability. If not managed correctly, contamination of soils may occur because of activities related to things such as the CHPP, ROM dump station and mine affected water dams. Storage of hazardous and other chemicals also presents a risk to soils as spills can result in significant contamination. ASS or PASS are not anticipated to occur within the Project area. As such there is very little, if any, risk of ASS-related contamination. If ASS is disturbed the measures outlined in Section 5.10 will be implemented.	Medium	The main objectives of the soil management measures nominated herein are to, near as practical, return the land to pre-existing environmental conditions by: ▪ Provision of appropriate spill control materials including booms and absorbent materials at refuelling facilities at all times to contain spills; ▪ Ensure all refuelling facilities and the storage and handling of oil and chemicals comply with relevant Australian Standards. Management and mitigation measures for wastewater are discussed in Chapter 7 - Waste Management; ▪ Ensure all staff are made aware of the potential for groundwater quality to be impacted and the requirement to report any spills; ▪ Establish procedures to ensure safe and effective fuel, oil and chemical storage and handling. This includes storing these materials within roofed, bunded areas to contain spills and prevent uncontrolled discharge to the environment; ▪ Appropriate waste rock and rejects management and disposal (see Chapter 8 – Waste Rock and Rejects, which addresses mineral waste management); ▪ As much as possible, avoiding impact to any areas of soil with sodic properties;	Low

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
			▪ Maintaining topsoil quantity and quality; ▪ Restoring land use and capability for conservation objectives; ▪ Returning the land to a stable landform (i.e. no major erosion); and ▪ Minimising dust generation.	
Erosion and Soil Stability (Construction Operation and Decommissioning)	Mining activities increase the potential risk of erosion when soils are being disturbed, particularly when soils are subject to flooding and wind, are sodic in nature, or are on steep slopes. Within the Project area erosion is most likely to occur in areas because of excavation activities, including: ▪ Cut and cover; ▪ Topsoil stripping and stockpiling of materials; and ▪ Construction of infrastructure areas including roads, machinery pads and dams. Across the Project site there are some areas with subsoils (B horizons) displaying strongly sodic or dispersive properties. These soil properties will further increase the likelihood of erosion occurring if not properly managed. Sodosols within the central section of the transport corridor have physical and chemical properties that make them relatively more susceptible to erosion (highly sodic). The risk of erosion on land within the transport corridor is most likely to occur following site clearance and prior to construction of the road.	High	ESC mitigation measures are discussed in detail in Section 5.11. An ESCP will be developed by a CPESC in accordance with relevant legislation and guidelines. This will relate to the whole Project and identify the risk of erosion and sedimentation within each area of the Project based on the soil type present. It is expected that greater ESC management will be required in areas of the transport corridor which have been identified as of higher erosion risk. The ESCP will include: ▪ Size and location of all ESCs; ▪ Design of ESCs to be able to cope with the required rainstorm event for the area; ▪ Areas requiring soil stabiliser; ▪ The period of maximum disturbance for each area (with critical works being scheduled for the dry season as much as practical); and ▪ Boundaries of areas to be cleared and clear delineation on Project drawings. Any sediment collection structures will be inspected at intervals prescribed in the ESCP and after each significant rainfall event. Soil stabiliser will be applied across the site in locations deemed necessary in the ESCP. The ESCP will specify the required application rate and frequency and this will be adhered to throughout the construction phase until soils are stabilised with permanent controls or are revegetated. Temporary and permanent stormwater and drainage controls will be designed to be able to withstand the required stormwater capacity for a given average recurrence interval storm event. All temporary controls must be in place and working prior to ground disturbance and construction activities commencing.	Low

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
			Dust suppression methods (application of water) for stockpiles, roads and other exposed surfaces will be implemented during the construction and operational phases. All direct runoff from contaminated surfaces (stockpiles) will be re-directed into environmental dams to avoid contamination to surrounding areas. A detailed ESCP will prepared by a CPESC. This will consider these variables in a seasonal context to measure (using the RUSLE) and manage the risk of soil erosion across the Project site. Soil conservation and site rehabilitation will also be integrated into the detailed ESCP.	
Visual Amenity (Construction Operation and Decommissioning)	The VIA assessment undertaken included 11 of the homesteads near the Project that had the potential to be impacted by changes in the visual landscape because of the Project. Of the 11 homesteads that the study comprised, none are at risk of visual impacts. Three homesteads (Oakdean, Brussels and Neerim-2) will have a low visibility of the Project. This is minimal since natural rises between the homesteads and the Project, and the existing vegetation, will provide a natural screen. In addition, an analysis has been undertaken to assess the impact the Project is likely to have on people travelling along the Bruce Highway and local road network surrounding the Project. The topography and existing vegetation in the area in unlikely to provide a natural screen, and as such mining operations will be visible from the road.	Low	No mitigation for visual amenity required.	Low
Night Lighting	Lighting impacts are expected to be high for the Brussels and Oakdean given their proximity to the Project. Lighting impacts are not expected at any other sensitive receptors.	High	Lighting to be used at the two MIAs will be designed to minimise upwards light spill. This will include the use of towers designed to a minimum height, positioning of towers to adequately illuminate working areas and directional shields attached to lamps to minimise horizontal and upwards spill.	Low

5.10 Acid Sulphate Soils Management

This section discusses potential risks and mitigation measures relating to potential acid sulphate soils (PASS) interaction associated with land based activities. Issues relating to the interaction with PASS associated with changes to groundwater are discussed in SEIS Chapter 10 - Groundwater.

Acid sulphate soil (ASS) is the common term given to soil and sediment of marine origin containing iron sulphides (principally iron pyrite), or products of the oxidation of sulphides. These soils are environmentally benign when left undisturbed in an aqueous, anoxic environment, but when exposed to oxygen the iron sulphides break down, releasing sulphuric acid and soluble iron. The release of acidic discharge to streams and rivers can impact both the natural and the built environment. Such effects include infrastructure being eroded away by the acid (such as bridge pilings and other structures in contact with the acidic ground and surface waters), death to aquatic life (such as fish kills and vegetation destruction) and a decrease in the quality of the water for humans and animal life.

Potential acid generation from sulphidic soils is largely confined to present and former wave-protected mangrove and salt marshes and tidal lakes and swamps where fine, very wet sediments can accumulate with organic debris. This is typically below 5 m above sea level, or below 5 m AHD.

ASS can be classified as:

- Actual Acid Sulphate Soils (AASS) which are soils that have already reacted with oxygen to produce acid; or
- PASS which is soil that contains iron sulphide but has not been exposed to oxygen (e.g. soil below the water table) and therefore has not produced sulphuric acid (although it has the potential to do so).

Visual or odorous indicators of the presence of ASS in excavated materials and surrounding waterways include the following:

- Iron staining on drain or pond, iron stained water;
- Sulphurous smell e.g. hydrogen sulphate or rotten egg gas;
- Unusually clear or milky blue-green drainage water flowing from the area (presence of aluminium);
- Corrosion of concrete or steel structures;
- Fish kills; and
- Dead, dying, or “stunned” vegetation.

5.10.1 Legislation and Guidelines

Relevant legislation and guidelines in relation to the management of PASS and AASS are:

- *Environmental Protection Act 1994* (EP Act);
- State Planning Policy (SPP 2/02): Planning and Managing Development Involving Acid Sulfate Soils;

- Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998 (C.R. Ahern et al. 1998);
- Queensland Acid Sulfate Soil Technical Manual; Legislation and Policy Guide (Moore NG et al 2004);
- Queensland Acid Sulfate Soil Technical Manual; Acid Sulfate Soils – Laboratory Methods Guidelines (Ahern CR et al. 2004);
- Queensland Acid Sulfate Soil Technical Manual Soil Management Guidelines v4.0 (Ahern C.R. et al. 2014) Water quality and water quality indicators are defined under the Environmental Protection (Water) Policy 1997 (EPP Water); and
- Water discharged to the environment will meet the standards set forth in the ANZECC/ARMCANZ Water Quality Guidelines (2000) prior to being discharged.

5.10.2 Expected Occurrence of PASS or AASS

The CSIRO National ASS mapping illustrates that ML 80187 and ML 700022 are described as having a low to extremely low probability of containing ASS. The National ASS mapping (Fitzpatrick et al. 2011) in relation to the proposed mine, and the location of the 10 m AHD contour is shown at Figure 5-14. The Project area straddles the low to extremely low ASS categories and is located beyond the 20 m contour (see Figure 5-14). CSIRO mapping shows only small pockets of high probability of ASS occurrence (e.g. around 7 km downstream of the Project, below Ogmore).

Geochemical characterisation was undertaken for a total of 195 samples (including overburden, potential rejects, and fine coal reject samples) from 15 bore holes covering a range of depths from 11.6 meters below ground level (mbgl) to 147 mbgl in various lithologies. The majority of samples were classifiable as non-acid forming (NAF). A total of four samples had positive Net Acid Production Potential (NAPP), two of which were classifiable as potentially acid forming (PAF; with ANC / MPA ratio <2 and NAPP >10 kg H_2SO_4/t), two as low capacity PAF (with Sulphide-sulphur (SCR) >0.2 % and NAPP between 0 and 10 kg H_2SO_4/t) and one sample was classified as uncertain (UC; with ANC / MPA ratio <2 and NAPP <0 kg H_2SO_4/t).

There was no discernible trend for which type of materials (waste rock or potential coal reject) would be more likely to be PAF. As such fine coal rejects (21 samples) were also analysed to provide an indication of the acid potential and composition of the coal processing waste stream. Similar to the potential rejects and waste rock results the fine jects were largely classifiable as NAF with ANC / MPA ratios indicative of negligible risk. The acid potential for the fine rejects (tested to date) were summarised as follows:

- One sample was potentially acid forming (PAF-low capacity) (with NAPP 4.2 kg H_2SO_4/t) – this sample was located outside of the mining lease and nearby to Ogmore;
- All other samples were non-acid forming (NAF) (most with relatively high buffering capacity); and
- Seven samples were acid consuming with acid neutralization capacity greater than 100 kg H_2SO_4/t.

Based on the assessments undertaken to date, the project disturbance area has a low to extremely low probability of containing ASS. A more detailed discussion in regard to the geochemical characterisation is at Chapter 8 – Waste Rock and Rejects.

5.10.3 Acid Sulphate Soil – Groundwater Interaction

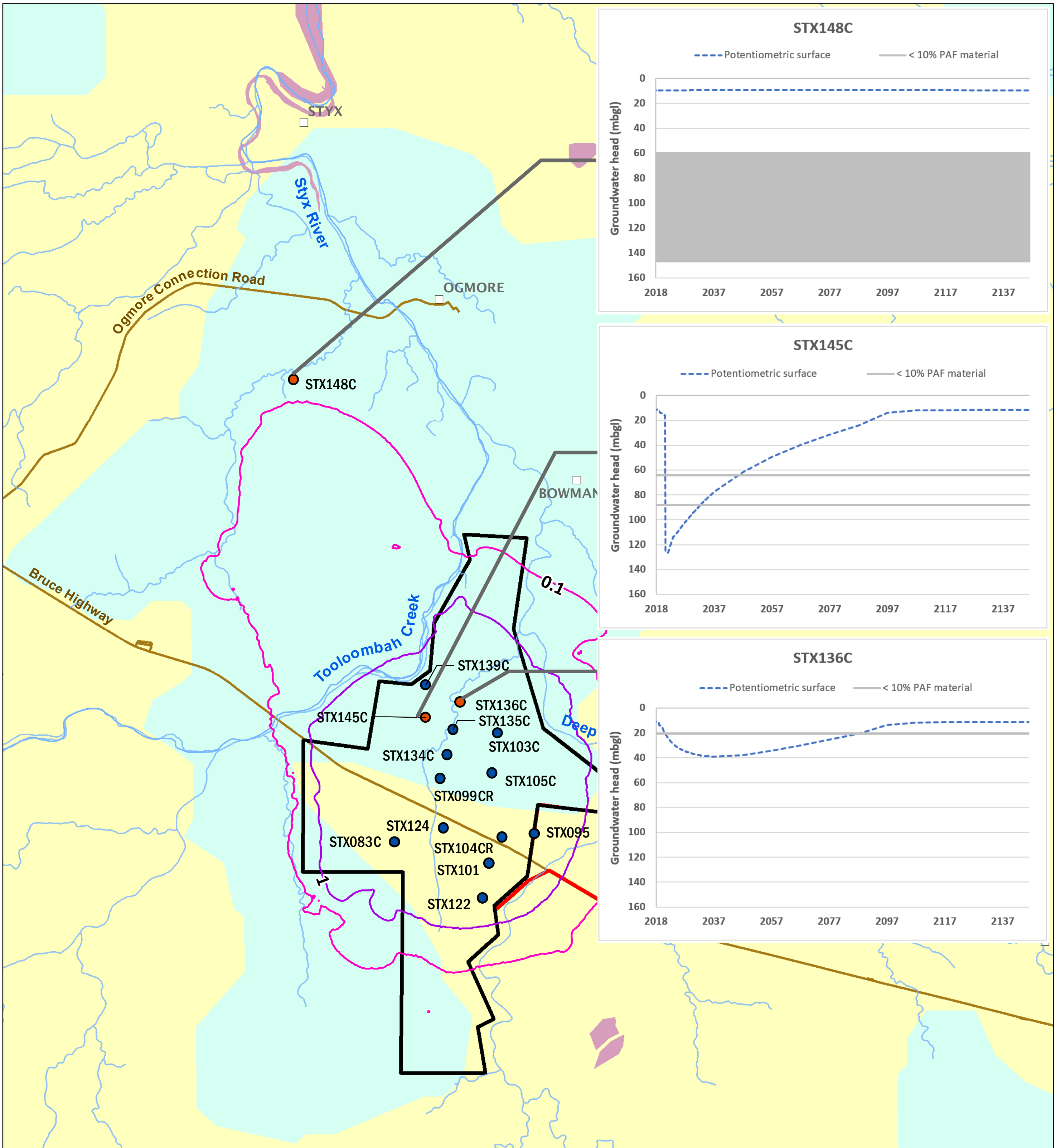
Figure 5-23 presents a map identifying the spatial distribution of ASS potential and shows the probability of ASS in the Project area is low to extremely low. Also presented is the predicted maximum drawdown contours (0.1 and 1 m), and mineral exploration holes where the potential for acid generation from encountered geological materials has been tested (sample depth range and depth where Potentially Acid Forming (PAF) materials have been identified.

Geochemical testing indicates predominantly Non-acid Forming (NAF) materials (less than 10% PAF materials) have been identified, which is consistent with the mapping undertaken by CSIRO (2011). Note that the predominantly NAF materials are logged as occurring more than 15 m below ground surface within the Styx Coal Measures. The testing also indicates the waste rock has some neutralising capacity (see Chapter 8 – Waste Rock and Rejects for more detailed assessment).

The hydrographs presented on Figure 5-23 show the depth intersection of largely NAF materials as well as:

- Outside the ML (one location), PAF materials occur more than 40 m below the water table at all times during and following mining, which is more than 40 m below predicted drawdown depth;
- The full drawdown intersection at one location (STX145C, within Open Cut 2) might expose some material having a low probability of PAF material. However, this will be mined; and
- Some exposure of low probability of PAF material may occur very close to the northern limit of Open Cut 2 pit (STX136C) due to drawdown. However, this will also be mined.

The analysis indicates the potential for ASS exposure in response to mine dewatering is low. The areas most at risk of exposure of ASS occurs within the ML where drawdowns of more than 10 m are predicted, and any development of acid drainage in this area will drain toward the mine pits during mining and post-mining recovery. Back filling of mine pits with materials have neutralising capacity will provide adequate management of this risk.



Styx drillhole geochemical characterisation

- 0% PAF (NAF)
- <10% PAF

CSIRO Probable ASS Class

- High probability of ASS occurrence
- Low probability of ASS occurrence
- Extremely low probability of ASS occurrence

Borehole	No. of samples	Sample depth range (m)	Lithology of PAF samples	Sample classification
STX136C	11	14 - 74.6	Sandstone (Pyritic) (20.35 - 20.6 m)	91% NAF and 9% PAF
STX145C	17	14 - 128.6	Mudstone/Siltstone (64 - 64.5 m) and Siltstone (87.8 - 88.2 m)	94% NAF and 6% PAF
STX148C	11	59.6 - 147	Sandstone (Pyritic)	79% NAF, 14% uncertain and 7% PAF (low capacity)

N

0 1 2
Kilometres

Scale @ A4 1:100,000
Date: 13/11/18
Drawn: A. Aird

Legend

- Town
- 0.1m predicted drawdown
- 1m predicted drawdown
- Watercourse
- Main road
- ML 80187
- ML 700022

Figure 5-22
Maximum predicted water table drawdown and potential occurrence of acid sulfate soils

DATA SOURCE
QLD Open Source Data, 2018;
CSIRO, 2011;
Geofabric v2.1, Bureau of Meteorology, 2012

CDM Smith

BRUGGEMANNGD B:\1000111_Styx_SEIS_post-submission\GIS\DATA\MXD\FINAL\1000111 ASS_& _Max_DD_R3.mxd 11/13/2018

5.10.4 Potential Impacts from PASS or AASS

Oxidation of PASS material can result in generation of AASS. The generation of AASS can result in the release of sulphuric acid and iron into the soil and groundwater. This in turn can release aluminium, nutrients and heavy metals (particularly aluminium, iron and arsenic) stored within the soil matrix. Once mobilised in this way, the acid, metals and nutrients can seep into waterways, killing fish, other aquatic organisms and vegetation and can degrade concrete, steel pipes and structures to the point of failure. Additionally, low levels of impact include reduced hatching, decline in growth rates, skin and health impacts for aquatic life.

PASS oxidation can result in medium to long-term changes in soil chemistry. Changes in soil chemistry may affect the water quality of tidally influenced areas located at the mine, resulting in reduced biodiversity and potentially death of flora and vegetation. In addition to environmental impacts there is a risk of land sterilisation and deterioration of existing infrastructure should the soil become acidic.

The risk of disturbing PASS is assessed as low, given the low to extremely low probability of the site containing ASS. Notwithstanding, where there is a potential to disturb PASS, works will require the implementation of management controls.

Any activities that have potential to lower the water table may enhance the oxidation of sediments. Where the excavation is below the water table and into potential PASS material, drawdown of the water table may expose PASS material. This can result in the oxidation of PASS and acid generation. The potential impact on groundwater due to dewatering activities include change in pH of soil and water, changes to water quality and changes to the hydraulic regime. This is discussed further in SEIS Chapter 10 - Groundwater.

Project elements will be designed to minimise excavations where practicable.

5.10.5 Management Action Planning

Notwithstanding the geochemical analysis suggests the project disturbance area has a low to extremely low probability of containing ASS, the following outlines the indicative management approach that will be adopted by the Project should PASS or AASS be disturbed. It is anticipated that the Project's EA may require an Acid Sulphate Soil Management Plan (ASSMP) be prepared. The following information will form the basis of the ASSMP.

Should an ASSMP be required, the Plan will be reviewed by the mine environmental manager and revised every year, or, because of:

- Any changes to regulatory or statutory requirements;
- Any significant change to the proposed construction locations;
- Development of open cut mining areas; and
- Any incident that requires reporting.

ASS Action Criteria

In accordance with Queensland guidelines, the action criteria (Table 5-49) define when ASS disturbed during the construction phase of the Project will need to be managed. Soils with existing plus potential acidity below the action criteria may still be ASS but may not require management.

The highest laboratory result will be used to assess if the relevant action criterion level (%S and mol H+/t) has been met or exceeded. Soils that meet or exceed the criteria in Table 5-49 will require treatment and management. Both (%S and mol H+/t) are obtained from the Chromium Suite analysis and both are applicable to determining ASS risk.

Table 5-49 ASS action criteria for three broad soil textures

Type of Material Sum of Existing and Potential Acidity			
Texture range	Approx. clay content (%)	1–1,000 tonnes material disturbed	
		%S-equiv. (oven-dried basis)	Mol H+/t (oven-dried basis)
Fine: Medium to heavy clays and silty clays	>40	0.1	62
Medium: Sandy loams to light clays	5-40	0.06	36
Coarse: Sands to loamy sands	<5	0.03	18

Noting no PASS is anticipated to be encountered during land based activities the texture range will need to be assessed on a case by case basis. The following target performance criteria will be met for ASS that have been treated using neutralisation:

- The acid neutralizing capacity (ANC) of the treated soil will exceed the existing plus potential acidity of the soil by at least a safety factor of 1.5. Chromium Suite analysis will provide the appropriate rate of liming required to achieve the target performance criteria, inclusive of the 1.5 safety factor;
- The soil pH (pHKCl) will be derived from the Chromium Suite testing and results will be greater than 6.5 after neutralization to achieve the target performance criteria; and
- Excess neutralising agent will stay within the treated soil until all acid generation reactions are complete and the soil has no further capacity to generate acidity. The Chromium Suite analysis will confirm that sufficient buffering capacity exists to prevent further acidification in the treated soil.

Management of ASS Material During Construction

The likelihood of disturbing PASS is assessed as low to extremely low probability. Notwithstanding, the strategy to manage ASS disturbances during construction is avoidance. Where disturbance of ASS occurs, the adopted strategies will be:

- Minimisation of disturbance; and
- Neutralisation.

If PASS is disturbed during construction, excavated material will be segregated and tested (see following section) at the rate of one sample per 500 m^3. Excavated soils determined to contain ASS will be immediately neutralized with lime at the excavation site and managed at the excavation or segregated and isolated from uncontaminated soil and treated at a purposely designed and constructed ASS treatment area. Areas where fill may be placed on PASS will be monitored for any surface disruption outside of the immediate work area.

If ASS is present it will be treated during construction if small volumes are found or transported to the ASS treatment area and treated with lime. Where neutralisation is required, the laboratory analysis will provide the appropriate liming rates required to increase the pH to meet the action criteria. Once neutralization is completed the mine environmental manager would determine the replacement of the material at the area of excavation or use of the material onsite at another location. Following treatment, the soil will be reused on site.

The following sections provide an overview of the actions to be taken should ASS be disturbed during construction. A contingency plan listing potential events that may arise during construction activities and activities that will be undertaken if unexpected conditions occur is included at Table 5-50.

Table 5-50 ASS contingency plan

Unexpected Conditions	Action
Possible ASS identified in unexpected locations.	1. Stop excavations in that area; 2. Assess the material for the presence of ASS including field testing and laboratory analysis; and 3. Follow treatment management procedures if confirmed as being ASS using field screen testing.
Validation testing results show neutralisation of the ASS was not effective.	1. Re-assess liming rates, and add additional lime to material; and 2. Re-test to check effectiveness.
Field screening results and laboratory testing do not appear to correlate.	1. Re-test by undertaking additional field screening tests and laboratory testing to calibrate the field screening tests; and 2. Check samples for the presence of shells that can on occasion lead to false negatives. Remove shells and re-test as the presence of shells does not necessarily mean that the soil will have sufficient natural buffering.
The validation testing results indicate too much lime has been added, and the soils are alkaline.	1. Remediate soils before re-use; 2. Remediation would compromise mixing additional ASS with the material (i.e. use the excess lime to neutralise more ASS; and 3. Re-test using field testing and validation testing in accordance with QASSIT Guidelines.
The bund for the ASS treatment area is damaged	1. Repair the bund as soon as possible; 2. Clean-up any ASS that has migrated from the treatment area and return to the treatment area; and 3. Check the surrounding area for impact from the ASS and / or leachate and undertake remedial action as necessary.
Unexpected storms and early onset of the wet season.	1. Other unexpected events which may affect the outcome of the ASS treatment would likely also affect other aspects of the work such as unexpected storms and the early onset of the wet season. Where considerable delays are experienced (i.e. several months) all excavated ASS will be limed using an increased rate based on laboratory data.

A schematic summarizing the assessment phases and mitigation options is provided at Figure 5-23.

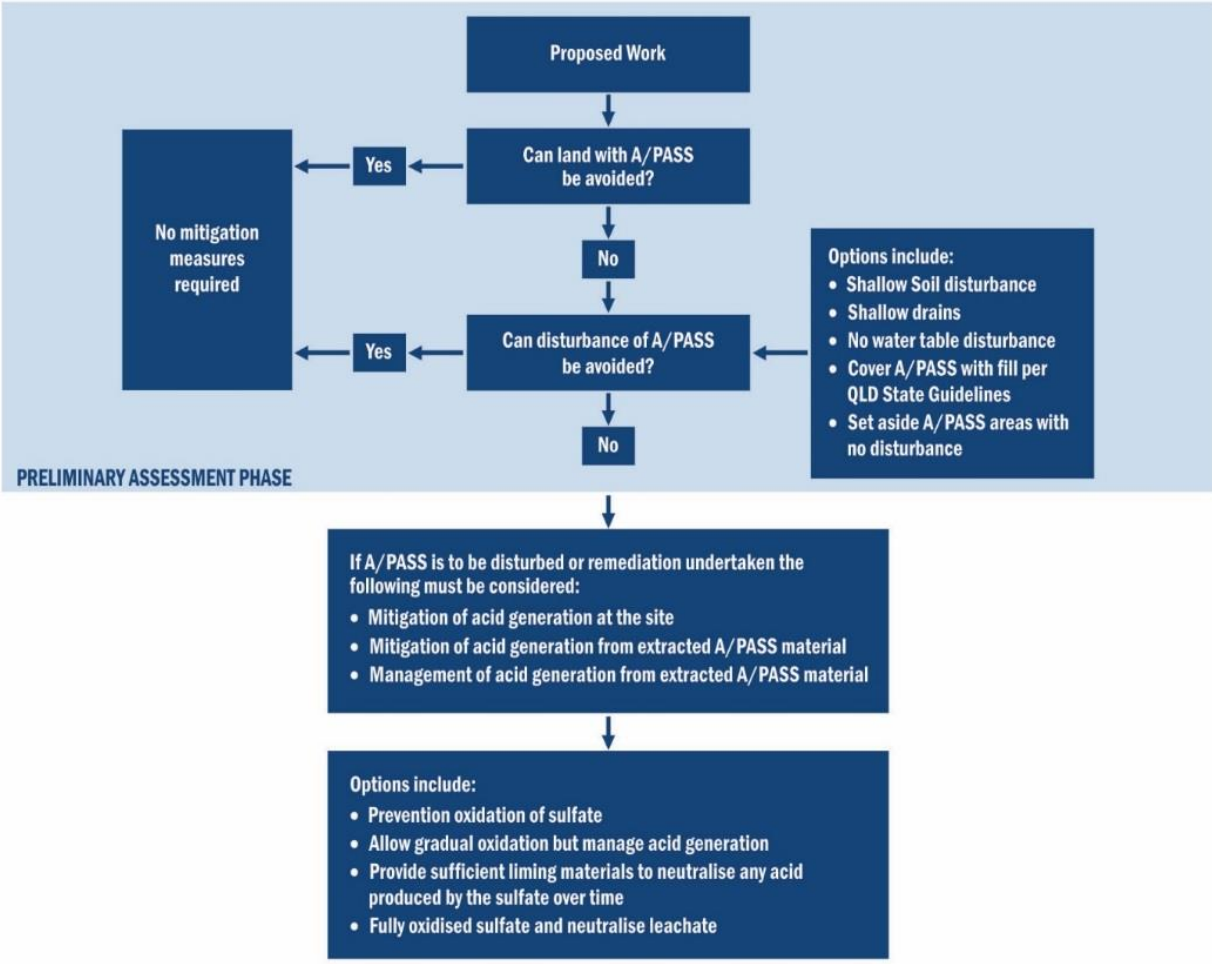


Figure 5-23 ASS assessment phases and mitigation options

ASS Treatment During Excavation

If only small amounts of ASS are encountered during excavations, this material will be managed by treating with neutralizing lime immediately as it is excavated. The treatment will include:

- Applying lime over the edges of the excavation at a rate of 5 kg lime/m^2 and depending upon the intent of construction place clean fill or other cover on the area;
- Applying lime on the excavated ASS that is to be returned to the excavation at a rate of 5 kg lime/m^2, mixing the lime and controlling leachate;
- Return treated ASS to the excavation; and
- Repeat the procedure as needed throughout the excavation activities.

ASS Treatment at the Designated Treatment Area

If large quantities of ASS are encountered during excavations a designated ASS treatment area will be established to accommodate the temporary storage and treatment of this material. The size of the treatment area will depend on the amount of ASS encountered. The ASS treatment area will be developed and located at the mine and will be based on availability of sufficient and suitable area.

The treatment area will be protected from stormwater runoff, be constructed with a compacted or other liner to prevent leaching into the soil and have a 400 mm bund to prevent stormwater runoff except to lime-lined drains and a leachate pond. The Queensland standards will be followed for stockpile areas including:

- Any stockpile will be located at least 30 m from the nearest surface water;
- Stockpiles will be designed to ensure hydraulic isolation with an approved impermeable barrier or compaction;
- 5 kg/m^2 of lime will be worked into the surface soils of the containment area to safeguard against acid leakage into the subsurface;
- The treatment area will be compacted to minimize the potential for water infiltration;
- ASS will be spread in the treatment area in approximately 300 mm thick layers. Lime will be incorporated into the ASS at a rate sufficient to neutralise the acid (starting rate will be 100 kg lime/m^3 ASS and increased/decreased as necessary);
- A leachate / runoff collection system will be incorporated into the treatment area design;
- All leachate / runoff collected in leachate ponds will be monitored and treated appropriately prior to release to keep pH in the range of 5 – 8.5;
- Stockpiles and bunds will be inspected at least daily to ensure they are functioning, and materials or leachate are not causing contamination outside the treatment area;
- Sufficient amounts of lime and other materials will be procured for neutralization and emergency situations (i.e. 16 tonnes as an initial volume which is equivalent to a single truck and dog capacity); and
- Stockpiles and treated material will be kept moist or otherwise stabilized to prevent blowing and to minimize the potential for oxidization.

Validation testing of the treated material will be carried out by obtaining representative composite samples, at a rate of one sample per 500 m^3, for laboratory testing using the suspended peroxide oxidation-combined acidity and sulphate (SPOCAS) method or combined S_{cr} plus acid neutralization capacity 9-ANC test method. A total potential acidity test result of 0 mols H^+/t together with an average acid neutralization capacity value of 1.5 times the theoretical amount of lime necessary to neutralise the total of any existing and potential acidity is the target for validation testing.

The SPOCAS or combined chromium reducible sulphur plus acid neutralization capacity test methods will be carried out to determine the inherent soil self-neutralising capacity of the sample being tested if large quantities of shell matter are discovered in any soil. Details of analysis and selection of method will be chosen in consultation with the mine environmental manager and analytical laboratory.

Because acid can be transported by stormwater, excavation works in confirmed areas of ASS would be conducted during dry periods when practical to minimize the risk of overflow with sudden or heavy rain.

Transport vehicles used to haul ASS will be designated for this use only, to prevent cross contamination with clean material. The beds of these vehicles will, where practicable, be lined with a layer of lime which will be inspected by the contractor and replenished on a regular basis. Vehicles will be covered, where practicable, to prevent loss or leakage. Prior to leaving the mine, wheels and external surfaces will be inspected and cleaned where required, to remove residual ASS materials.

Excavations where ASS is found will be protected to prevent stormwater intrusion. This can be accomplished in many ways with the most effective means being employed considering topography, slope and the surrounding conditions. The mine development will already incorporate appropriate drainage design prior to the commencement of excavation activities to minimize the stormwater erosion potential.

The treatment of ASS would be undertaken progressively in the designated treatment area as shown in Figure 5-24. The treatment area will be bunded with a compacted material to minimize erosion and direct impact by ASS. The bunds will also minimise surface water runoff entering or leaving the treatment area. The division of the treatment area into cells should large volumes of ASS be disturbed, may expedite the treatment process as material can be allotted to different cells as excavation works progress, resulting in a staged treatment process. When depositing ASS into the treatment area the material will be placed to avoid contact with the leachate collection drains and bunds, to ensure the drainage functions appropriately.

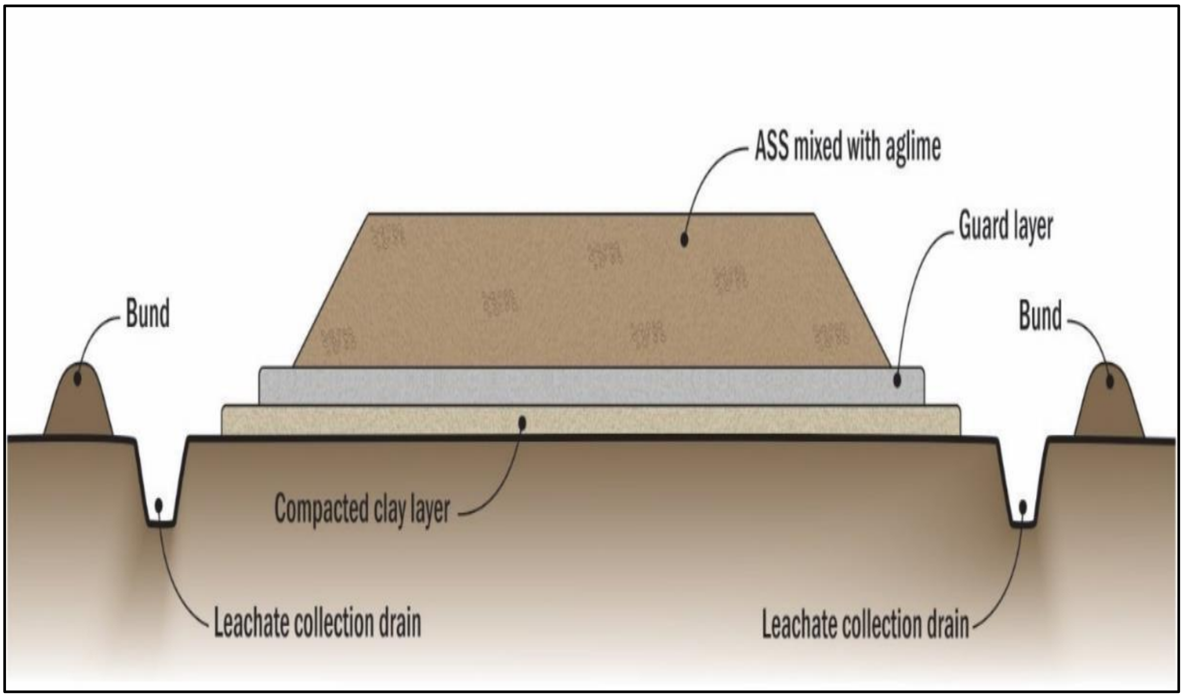


Figure 5-24 ASS treatment area layout

Once ASS material has been placed in the treatment area it would be allowed to drain (with leachate directed into the leachate management system) and then dosed with a neutralizing agent (lime). The lime will be thoroughly mixed with the soil. Additional quantities of lime above the calculated dosing rate may be required from time to time to allow for difficulties in mixing and to act as a back-up buffer under such situations. The effectiveness of the adopted dosing rate would be confirmed by the regular sample screening of treated material using pH and peroxide pH field tests, with additional lime added as needed.

As a precautionary measure, treatment works involving lime would not be conducted during excessively windy conditions, unless the material can be appropriately conditioned to prevent dust generation. After ASS has been treated it may be used as fill at the mine depending upon the characteristics necessary for the different types of fill.

Placing Fill on PASS

The placement of inert fill on top of areas potentially containing ASS may occur. Fill placement will utilize best management practices, such as placement in lifts and mechanical compaction, to create a permanent working surface. If evidence of ASS intruding on the surface is observed a remediation plan will be prepared.

Managing ASS Leachate

Water exposed to ASS and found to have a pH of <5.0, including water generated from ASS treatment, will require collection and management. Any leachate generated during the treatment operations will be directed to either collection tanks or ponds and treated in the following manner:

- Leachate and runoff from excavation areas containing ASS, ASS stockpiles and ASS treatment areas will be captured and contained or directed to leachate treatment tanks or ponds prior to discharge. Valves or gates will be installed at the discharge location/s for all tanks / ponds and operated manually by a suitably trained person;
- Treatment and neutralization will be accomplished with dissolved lime slurry, hydrated lime, quicklime or other suitable reagents, with the liming rate determined following assessment of actual pH levels. Discharge of leachate / runoff may occur when the pH of the leachate / runoff has been steady for 24 hours at a pH of 5.0 to 8.5;
- If hydrated lime or quicklime is utilized for neutralization, controls will be implemented, such as regular pH testing, to ensure that overdosing does not occur so pH of the leachate does not rise above pH 8.5;
- Personnel conducting ASS and leachate treatment will be trained in handling chemicals and test equipment;
- pH of leachate / runoff treated in-situ in excavations will be measured daily or whenever the flow rate changes. pH results will determine the application rate for neutralisation lime and the amount of treatment in the tank or pond system prior to discharge; and
- Treated leachate will be discharged at approved discharge locations within the pH range 5.0 – 8.5.

An incident reporting procedure will be implemented to record, investigate and report any spills or unscheduled discharges and releases. When an incident occurs, or is discovered, it will be immediately reported to the mine environmental manager, who will coordinate efforts with the construction manager/s to correct the condition. Contingency measures will be developed (e.g. the erection of bunds around excavation areas, linings for drainage systems), based on an assessment of the mine environmental manager, to eliminate future occurrences.

A vehicle wash down area comprising a hardstand with drainage will be constructed for trucks / equipment handling ASS adjacent to a temporary leachate tank / pond so that truck wash down water can be collected for treatment. Water would be appropriately treated, including for low pH or other contaminants, prior to disposal and be consistent with the quality characteristics outlined in the Project’s approvals.

Monitoring

Regular visual monitoring of work areas would be undertaken to identity signs of ASS oxidation. This monitoring would include looking for signs of:

- Unexplained scalding, degradation or death of vegetation;
- Unexplained death or disease of aquatic organisms;
- Areas of green-blue water or extremely clear water indicating high concentrations of aluminium;
- Formation of the mineral jarosite and other acidic salts in exposed or excavated soils;
- Rust coloured deposits on plants and on the banks of drains, water bodies and watercourses indicating iron precipitates;
- Excessive corrosion of concrete and / or steel structures in contact with soil or water;
- Black to very coloured waters indicating de-oxygenation; and
- Any sulphurous smells, e.g., hydrogen sulphide or rotten egg gas.

5.10.6 ASS Management Decommissioning

Decommissioning of any ASS stockpile areas, treatment pads, leachate / runoff tanks or ponds and associated drainage channels will be accomplished once all ASS excavations and treatment of stockpiled material is complete. The following actions will be undertaken during decommissioning of the ASS management areas:

- Bunding and underlying materials will be neutralized as determined through soil / water sampling of these areas;
- In-situ neutralization will be conducted for discharge of residual leachate in drains from ASS stockpile areas, treatment pad areas and leachate treatment ponds (if used in place of tanks), following stabilization at pH between 5.0 and 8.5 for a period of 24 hours using lime or other material;
- Restoration of the ASS leachate treatment tank / pond area following soil sampling to determine if treatment is required to complete neutralisation. Backfill material may be from treatment and stockpile areas which have been validated as ASS free; and
- Restored treatment areas will be revegetated or used for another approved post-treatment land use.

Once final treatment and restoration is completed a closeout report will be prepared and submitted to the Department of Environment and Science (DES) on request.

5.10.7 Closeout Reporting Requirements

All records of soil testing will be held by the mine environmental manager. These records will include the in-field and laboratory analyses of all samples, the pH prior to and after testing, the volume of material treated and the volume of lime added.

An ASS Closure Report will be prepared at the completion of the construction activities, including finalizing the treatment of any remaining ASS. The ASS Closure Report will be retained onsite as evidence of the management methodologies implemented during construction. The ASS Closure Report would detail, but not necessarily be limited to:

- The soil and water management measures undertaken at the construction area;
- The volume of soil, groundwater and leachate treated at the ASS treatment area;
- The amount of neutralising agent used during works;
- The results of soil validation and monitoring programs;
- The results of dewatering effluent monitoring programs;
- The results of the groundwater monitoring program (plus surface water body monitoring program where applicable), with particular emphasis on trends in water quality (graphs of water quality data will be presented to aid the identification of trends);
- A discussion of the effectiveness of management strategies employed at the site;
- A discussion of any potential risks to human health or the environment; and
- A discussion of any remedial measures needed.

The checklist at Table 5-51 outlines the information which would be considered when preparing an initial closure report.

Table 5-51 ASS closure report checklist

Reports Sections	Information to be included
Introduction	▪ Background; ▪ Objectives of the ASS Management Plan (ASSMP); ▪ Summary of ASS investigations; and ▪ Summary of site works.
Site identification	▪ Co-ordinates of site boundaries (Northings /Eastings—specify datum set); ▪ Locality map; and ▪ Current site plan showing any existing infrastructure, scale bar, north arrow, local environmentally significant features, 'stages' of development.
Details of the construction activities	▪ Full description of development; ▪ Site lay-out plans and cross-sectional diagrams for the development; and ▪ Details of the responsible parties (i.e. contract managers and contractors).
Geology and hydrogeology	▪ Description of geology and hydrogeology encountered during ground disturbing activities; ▪ Discussion of any discrepancies between the geology and hydrogeology expected to be encountered and that which was encountered (where applicable); ▪ Depth to groundwater table; ▪ Direction of groundwater flow; ▪ Direction of surface water runoff; ▪ Groundwater discharge location; ▪ Groundwater quality; and ▪ Groundwater/surface water interaction.
Details of site works	▪ Full description of ground disturbing activities which were undertaken, including both soil and water disturbance (including volumes, depths, duration, locations); ▪ Volume of soil and groundwater (if treatment was required) treated at the site; and ▪ Amount of neutralising agent used during works.
Adherence to ASSMP	▪ Details of whether environmental performance objectives were met;

Reports Sections	Information to be included
	▪ Details of ASS management strategy implemented at the site including confirmation that the site works were carried out in accordance with the ASSMP; ▪ Identification of and justification for any deviations from the DES approved ASSMP (where applicable); ▪ Details of the implementation of any contingency plans (where applicable); and ▪ Photographs of site works confirming adherence with ASSMP (e.g. photos of excavation, soils being stockpiled and treated, water treatment systems).
Basis for adoption of assessment criteria	▪ Table listing all selected assessment criteria and references; ▪ Rationale for and appropriateness of the selection of criteria; and ▪ Assumptions and limitations of criteria.
Monitoring results	▪ Results of all soil, groundwater and surface water monitoring programs; ▪ Full discussion of the results of the groundwater monitoring program (plus surface water body monitoring program where applicable) with particular emphasis on trends in water quality (graphs of water quality data will be presented to aid the identification of trends); ▪ Results of soil treatment validation program (where applicable); ▪ Calibration certificates or calibration results; ▪ Copies of original laboratory result certificates including NATA accreditation details; ▪ Discussion of any discrepancy between field observations and laboratory analyses results; and ▪ Site plan showing all sample locations, sample identification numbers and sampling depths.
Ongoing monitoring	▪ Ongoing soil, groundwater, and/or surface water monitoring requirements.
Conclusions and recommendations	▪ Brief summary of all findings; ▪ Full discussion of the effectiveness of management strategies employed at the site; ▪ Assumptions used in reaching the conclusions; ▪ Extent of uncertainties in the results; ▪ Discussion of any remedial measures required (where applicable); and ▪ Recommendations (where applicable).

5.11 Erosion and Sediment Control Management

This Erosion and Sediment Control (ESC) management framework has been developed to outline the key principles for managing erosion and sediment control issues during construction of the Project. This will form the basis for an Erosion and Sediment Control Plan (ESCP) which will be prepared by an appropriately qualified person and implemented prior to the commencement of construction.

The key objectives of this erosion and sediment control management framework are to:

- Minimise the water quality impacts from erosion and sedimentation through implementing best practice management techniques;
- Outline the principles of ESC management during construction; and
- Outline the required testing and monitoring related to ESC during construction.

This section discusses the temporary erosion and sediment control management strategy for the construction phase of the Project. Operational mine site water management infrastructure is discussed in Chapter 9 – Surface Water.

During mine construction and operation, sediment can be mobilised and transported by surface water during rainfall events, ultimately discharging into Tooloombah and / or Deep Creek drainage lines and potentially impacting water quality and aquatic habitats. Erosion and sedimentation during the operation phases is most likely to occur from stormwater runoff from the coal stockpile, mine infrastructure area (MIA) and from ongoing earthworks associated with the maintenance of roads and dams. Stormwater runoff will be captured in appropriately designed structures and contained for treatment to avoid off site sedimentation and associated adverse impacts to the receiving environment.

Soil erosion is the wearing away of earth surfaces by the action of external forces, and includes erosion caused by water, rainfall, wind and other geological agents. It includes such processes as detachment, entrainment, suspension, transportation and mass movement. Sedimentation is the deposition of sediment displaced by various erosion processes. The susceptibility of an area of land to erosion is a function of the soil type, soil cover, topography and slope, rainfall intensity and land use.

Although erosion occurs naturally, anthropogenic disturbances may result in accelerated rates of erosion which can result in detrimental effects on the receiving environment and water quality. Construction activities associated with mine site development including land clearing, soil stripping, and earthworks have the potential to increase erosion and sedimentation. Mine components that would potentially generate sediment include:

- Access and haul roads;
- Stockpiles (topsoil, waste rock, ROM and product coal);
- Bunds and embankments;
- Open cut mine pits;
- Coal handling and preparation (CHPP) areas;
- Mine Infrastructure Areas;
- Infrastructure and activities at the Train Loadout Facility; and
- Water management infrastructure (dams, environmental dams, drains, diversion banks).

Controls for these areas are discussed further in Section 5.11.6 and details for the construction, operation and maintenance of ESCs will be included in the ESCP. The main objective of the ESCP is to set out strategies to control soil erosion and sediment generation close to the source and thereby minimise the potential for mine activities to adversely affect downstream water quality.

5.11.1 Guiding Principles

Erosion and sediment control management is based on principles designed to minimise the overall environmental impact of the proposed mine development. The objective is to minimise the pollution of surface waters resulting from construction and operation activities and includes the incorporation of specific measures and structures to minimise erosion and sedimentation associated with the Project, to be implemented in conjunction with a range of management techniques. The guiding principles for Erosion and Sediment Control are as follows and have been adopted from Best Practice Erosion and Sediment Control (IECA 2008).

- Appropriately integrate the development into the site;
- Integrate erosion and sediment control issues into site planning and construction planning;
- Develop effective and flexible ESCPs based on anticipated soil loss, weather, and construction activities;
- Minimise the extent and duration of soil disturbance;
- Control water movement through the site;
- Minimise soil erosion;
- Promptly stabilise disturbed areas;
- Maximise sediment retention on the site;
- Maintain all ESC measures in proper working order at all times; and
- Monitor the site and adjust ESC practices to maintain the required performance standard.

Vegetation clearing and earthworks will expose the land to varying levels of erosion due to the combined effects of surface slope and form, soil type, surface run-off potential and wind erosion over time.

5.11.2 Erosion and Sediment Control Planning

An ESCP will be developed and implemented prior to the commencement of construction. The ESCP will be developed in accordance with Best Practice Erosion and Sediment Control (IECA 2008) and the EHP Stormwater Guideline: Environmentally Relevant Activities (2014) and will contain standard erosion control measures as well as specific measures applicable to particular areas. Details will be provided on the construction methods, material specifications, dimensions, expected performance outcomes and the proposed staging for installation of controls. The ESCP will also detail the monitoring, maintenance and reporting program for erosion and sediment control structures and practices.

The ESCP will include, as a minimum, the following control measures:

- Installation of sediment control devices downslope of any disturbed areas;
- Diversion of clean water around disturbed areas;
- Policies to avoid and minimise earthmoving activities during intense rainfall events;
- Installation of drainage and erosion control devices; and

- A construction and operations plan that minimises the extent and duration of soil disturbance.

The ESCP will be focussed on construction activities in the initial development area to the east of the Bruce Highway in accordance with the mine schedule. A follow-up ESCP will be developed prior to the commencement of construction activities to the west of the Bruce Highway currently scheduled for 2027. The ESCP will consider and address the variables in a seasonal context to measure (using the Revised Universal Soil Loss Equation (RULSE)) and manage the risk of soil erosion from all activities associated with the mine, haul road and TLF. Soil conservation and site rehabilitation will also be integrated into the detailed ESCP.

The ESCP will be prepared as a Primary ESCP with the overarching management strategy for erosion and sediment control, supported by a series of Progressive ESCPs. As construction and operation activities progress, specific information on the location and installation of ESC measures will be provided in the Progressive ESCPs. Progressive ESCPs will generally be required where a new stage of construction or operations activities commence, for higher risk activities such as installation of major drainage structures or waterway crossings, and for situations where controls require adjustment to achieve a required outcome or in relation to changes in seasonal rainfall erosion risk.

Progressive ESCPs will be developed at the stage where specific site based risk are able to be assessed in the field to determine appropriate control measures and locations. Progressive ESCPs will be developed by a suitably qualified person and controls will be inspected following implementation to verify conformance to documented requirements and standard drawings.

5.11.3 Erosion Hazard

The site erosion hazard and risk are important in determining the appropriate erosion and sediment controls to be implemented throughout Project construction and operation. Soil erosion hazard can be described as the susceptibility of a parcel of land to the prevailing agents of erosion and soil erosion risk is the likelihood of environmental harm occurring due to disturbance activities of the Project.

The RUSLE is used to assess the erosion hazard for each project sub catchment (IECA 2008). The RUSLE is often used to estimate the average long term annual soil loss resulting from sheet and rill erosion under a series of specified conditions. The RUSLE formula is as follows:

A = K x R x LS x P x C, where (Table 5-52):

Table 5-52 RUSTLE erosion hazard

RUSTLE Factor	Description	Value	Comment
A	Estimate soil loss (t/ha/yr)	Variable	As per catchment calculations
K	Soil erodibility factor	0.05	0.05 adopted – worst case with increase to allow for dispersive soils
R	Rainfall erosivity factor	5,750	5750 adopted based on the 2yr 6hr event
LS	Slope length/gradient factor	Variable	Based on catchment characteristics
P	Erosion control practice factor	1.3	Construction phase default
C	Ground cover management factor	1.0	Adopted – worst case representing no appreciable cover

Each of the Project construction areas has been divided into sub-catchments based on nominated surface water flow directions and topography. For each of the sub-catchments, soil loss calculations have been completed using the slope gradients and lengths. The calculations have used conservative slopes i.e. steepest disturbed, allowing the nominated ESCs to be sufficient for the worst-case scenario. These will be recalculated based on final design and incorporated into the Primary ESCP.

5.11.3.1 Soil Erodibility (K factor)

The texture of the soil varied across the site, with soils being classified as loams through to sandy clays. Based on Table E4 in the IECA Guidelines, a K-factor of 0.05 has been adopted across the site for soil loss calculations. This is a conservative number as it reflects the worst-case scenario from laboratory testing of site soils (Dermosol loam, 0.04) and allows for a 20% increase to the K-factors to account for potential dispersive soils.

5.11.3.2 Rainfall Erosivity (R factor)

Rainfall erosivity (R factor) is a measurement of the energy associated with rainfall events and the ability of the rainfall to cause erosion. The two-year ARI six-hour rainfall event (14.4 mm) was determined using the Bureau of Meteorology Intensity Frequency Duration design rainfalls tool and site location coordinates and this has been used to calculate the R-factor for the Project using the following formula:

$$R = 164.74\ (1.1177)^{S}\ S0.6444\ \text{(IECA, E3.2)}$$

Where: S: is the two year ARI, six-hour rainfall event (mm).

The annual R factor is 5750 based on the 2 year, 6 hour storm event. The monthly percentage erosivity values for nearby Rockhampton have been used from IECA Table E2 and are presented in Table 5-53 (IECA Table E2).

Table 5-53 Monthly rainfall erosivity factors

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Project	20.9	21.9	13.5	3.9	4.5	2.5	1.8	1.9	1.6	4.6	7.5	15.5	100

Monthly R factor values have been calculated based on the monthly percentage erosivity values in Table 5-53 and these are presented in Table 5-54.

Table 5-54 Monthly and annual rainfall erosivity (R-factor) values

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Project	1202	1259	776	224	259	144	104	109	92	265	431	886	5750

Source: IECA 2008 Guidelines, E3.2

Using the monthly R factor values from Table 5-54, the wet season (December to March) R value is 4,123 and the dry season (April to November) R value is 1,627. The indicative construction schedule for the higher erosion risk construction activities is from April to December, however the annual R-factor has been used to allow for any changes to the construction schedule. The typical dry season (April to November) R-Factor is 1,627 which accounts for 28.3% of the annual rainfall erosivity for the Project area. Where practical, high risk disturbance activities such as vegetation clearing will be undertaken during the dry season.

5.11.3.3 Slope Length / Gradient (LS factor)

The LS factor is a numerical representation of the length-slope combination. The Project area is characterised by slopes from 0.6 – 6%. This represents the topography at the commencement of project construction, with ongoing earthworks during construction and operation to significantly affect both slope gradient and slope length. For processing areas, haul roads, ROM and associated ancillary areas, slopes will reduce, or remain similar to the natural landform (i.e. < 4 %), whereas side slopes of the waste rock dumps will be >10 %.

5.11.3.4 Erosion Control Practice (P factor)

The P-factor measures the combined effect of all support practices and management Variables, as well as structural methods for controlling erosion (IECA 2008). A P-factor of 1.3 has been applied to each of the sub-catchments, which represents a compacted and smooth surface and is the default construction phase condition.

5.11.3.5 Ground Cover and Management (C factor)

The ground cover and management factor measures the level of soil surface protection provided by various groundcovers, including vegetation, rock, hardstand, paving, soil binders, matting and associated non-erodible material. The C-factor for each sub catchment will vary depending the level of stabilisation and management of surfaces exposed by construction and operation. The C-factor measures the combined effect of all the cover and management variables and non-structural methods for controlling erosion. A C-factor of 1.0 has been adopted which represents no appreciable cover and is the worst-case scenario.

5.11.3.6 Soil Loss Estimation

Soil loss for the site is estimated using the RUSLE as an indicator used in the determination of sediment control standards for the Project and to predict average soil loss rates resulting from sheet and rill flow. Soil losses calculated by RUSLE are considered best estimates based on long term average rainfall records and represent the amount of soil that would likely be lost without any erosion and sediment controls in place. With appropriate erosion and sediment controls installed and maintained on site in accordance with the ESCP, soil loss will be greatly reduced. Construction works likely to pose a significant erosion risk will be undertaken between April and December where practicable to coincide with the typically dryer months of the year.

Site parameters used in potential soil loss calculations are shown at Table 5-55. Potential soil loss calculations and the associated erosion hazard for defined project areas are provided in Table 5-56.

The proposed site layout is reflected in the key project components as described in Chapter 3 – Project Description. Following development, the mine pits will contain all runoff and sediment internally. Mine water storage dams and environmental dams are not included in soil loss calculations as any sediment will be contained within these structures and no additional sediment control devices are required.

Table 5-55 Site parameters

Site parameters	
IECA Design rainfall event	5 days (85th percentile)
Annual rainfall	890mm
5-day, 85th %ile rainfall event	41.4mm (Rockhampton)
EHP Design event: 10 yr 24hr storm	10.6mm/hr (254.4mm)
Soil type	Type D (dispersible) (worst case)
Rainfall erosivity (R-factor)	5,750 (Annual)
Soil erodibility (K-factor)	0.05
Erosion control practice (P-factor)	1.3 (compacted and smooth)
Cover factor (c-factor)	1 (0% cover)

Table 5-56 Potential soil loss and erosion hazard

Parameter	Mine Pits	Waste Rock Dumps	CHPP areas	Dam and mine access roads	Power supply	Conveyor	Haul road to TLF and Dam 4	Rail loop and spur line
Characteristics	Drains internally	Waste rock dumps	Compacted gravel surface	Compacted gravel surface	Easement	Easement	Compacted gravel surface	Compacted gravel surface
Catchment area (ha)	747.7	243.3	27.8	12.4	1.4	5.8	26	8
Undisturbed area (ha)	0	0	0	0	0	0	0	0
Rainfall erosivity (R)	5,750	5,750	5,750	5,750	5,750	5,750	5,750	5,750
Soil erodibility (K)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Slope length (L)	200	200	80	10	40	40	20	40
Slope gradient (S)	4	8	2	2	2	2	4	2
Length gradient (LS)	1.48	3.72	0.41	0.18	0.31	0.31	0.44	0.31
Erosion control (P)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Ground cover (C)	1	1	1	1	1	1	1	1
Standard treatment	Contained runoff	High % rock	Compacted Hardstand	Soil stabilised	Soil stabilised / Vegetated	Soil stabilised / Vegetated	Soil stabilised	Soil stabilised
Potential soil loss (t/ha/yr)	555	1,392	152	67	116	116	163	116
Potential soil loss (m^3/ha/yr)	427	1070	117	52	89	89	126	89
Soil loss class	5	6	2	1	1	1	2	1
Erosion hazard	High	Very high	Low	Very low	Very low	Very low	Low	Very low

5.11.4 Erosion Risk

Conducting an erosion risk assessment provides important information pertaining to the required ESC standards to be applied to a site. The approach that has been adopted throughout the erosion hazard assessment is one that allows the worst-case scenario to be identified considering available information around construction timing.

As the mine is in a sub-tropical climate, soil erosion management shall be undertaken in a two-season approach - wet season (December to March) and dry season (April to November). The erosion risk based on average monthly rainfall depth (recorded for nearby Marlborough) and monthly rainfall erosivity (recorded for Rockhampton) referenced from the International Erosion Control Association (IECA) – Best Practice Erosion and Sediment Control Guidelines (2008) are shown in Table 5-57. Generally, the erosion risk is highest from December to March and is lowest from July to September.

Table 5-57 Erosion risk based on monthly rainfall erosivity

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall erosivity	1202	1259	776	224	259	144	104	109	92	265	431	886
Erosion risk	High			Moderate		Low			Very low	Moderate		High

Source: IECA 2008 Table 4.4.5

5.11.5 Erosion and Sediment Control Requirements

The recommended erosion and sediment control measures are based on the erosion hazard and erosion risk. Climate data for the Project area indicates a distinct wet season from December to March, with a drier period from June to September with the erosion risk lower during these months.

Erosion and sediment control measures must be fully implemented prior to or immediately following ground disturbing activities. Table 5-58 summarises the ESC requirements for all stages of project construction and operation across the calendar year. Typical measures to be implemented during the Project are discussed in Section 5.11.6 below, with specific design, timing and location to be provided within the Progressive ESCPs. At all times, reasonable and practical measures shall be taken to apply best practice erosion control to completed earthworks or to otherwise stabilise such works, prior to anticipated rainfall-including existing unstable, undisturbed, soil surfaces under the management or control of the building or construction works.

Table 5-58 Erosion and sediment control requirements during construction

Erosion Risk	Rainfall erosivity	Months	ESC Requirements
Very Low	0-60	Sep	▪ Land clearing limited to eight weeks of work if rainfall is reasonably possible. ▪ Disturbed soil surfaces stabilised with minimum 60% cover within 30 days of completion of works if rainfall is reasonably possible. ▪ Unfinished earthworks are suitably stabilised if rainfall is reasonably possible, and disturbance is expected to be suspended for a period exceeding 30 days. ▪ Sediment controls installed and maintained.

Erosion Risk	Rainfall erosivity	Months	ESC Requirements
Low	60+ to 100	Jun, Jul, Aug	▪ Land clearing limited to maximum eight weeks of work. ▪ Disturbed soil surfaces stabilised with minimum 70% cover within 30 days of completion of works within any area of a worksite. ▪ Unfinished earthworks are suitably stabilised if rainfall is reasonably possible, and disturbance is expected to be suspended for a period exceeding 30 days. ▪ Sediment controls installed and maintained.
Moderate	100+ to 285	Apr, May, Oct, Nov	▪ Land clearing limited to maximum six weeks of work. ▪ Disturbed soil surfaces stabilised with minimum 70% cover within 20 days of completion of works within any area of a work site. ▪ Staged construction and stabilisation of earth batters (steeper than 6H:1V) in maximum 3m vertical increments wherever reasonable and practicable. ▪ Unfinished earthworks are suitably stabilised if rainfall is reasonably possible, and disturbance is expected to be suspended for a period exceeding 20 days. ▪ Sediment controls installed and maintained.
High	285+ to 1500	Dec, Jan, Feb, Mar	▪ Land clearing limited to maximum four weeks of work. ▪ Disturbed soil surfaces stabilised with minimum 75% cover within 10 days of completion of works within any area of a work site. ▪ Staged construction and stabilisation of earth batters (steeper than 6H:1V) in maximum 3m vertical increments wherever reasonable and practicable. ▪ Soil stockpiles and unfinished earthworks are suitably stabilised if disturbance is expected to be suspended for a period exceeding 10 days. ▪ Sediment controls installed and maintained.

Source: Adapted from IECA Table 4.4.7

5.11.6 Erosion and Sediment Control Measures

An effective ESC strategy considers the interrelated processes of drainage control (minimising water flows through erosion prone areas), erosion control (minimising the detachment of sediment), and sediment control (capturing sediment displaced by up-slope erosion processes). Therefore, the key strategies adopted in the ESCP will involve diversion of water flowing into disturbance areas, minimising erosion within the disturbance areas, and trapping the majority of sediment that is generated before it is mobilised off site.

The following steps will be taken to minimise sedimentation during the active phase of the site:

- The Project has been designed to ensure surface water flows into creeks are maintained as close as possible to natural conditions;
- Diversion drains and banks will be used to redirect any "clean" surface water flows around the main site areas. This minimises the potential for erosion by limiting the amount of water flowing through the disturbance areas and protects infrastructure from flooding during extreme events. Design and sizing of diversion drains, banks and culverts is discussed further in Chapter 9 – Surface Water;
- Exposed soil surfaces will be engineered to minimise erosion potential. This will be achieved through careful material selection, slope grading, and other surface treatments; and
- Any sediment-laden water within the disturbance areas will be captured and treated in a manner which minimises amount of sediment released into the surrounding environment.

Stormwater runoff containment devices, namely environmental dams, function to capture dirty water runoff generated from disturbed areas such as stockpiles and the MIA and CHPP areas. Environmental dams are sized based on the 10-year ARI, 24-hour rainfall event in keeping with the DES Stormwater Guideline (EHP 2014). Environmental dams will have a low flow perforated riser-pipe outlet to discharge treated water to the receiving environment. Environmental dams are located at both MIAs, overburden stockpiles and the TLF. MIA drainage sumps and proprietary oil removal devices are proposed to capture runoff from truck wash and workshop areas for treatment and reuse or disposal.

Runoff intercepted by or generated from haul roads will be captured in table drains and conveyed longitudinally towards culvert structures. In areas of steeper grade, sediment transport can be effectively managed using check-dam structures within the drain. Where haul roads cross drainage gullies or the Deep Creek watercourse, an appropriately sized culvert will be provided, allowing for fish passage where relevant.

Clean water runoff from local catchments will be diverted around open pit mining areas for events up to and including the 0.1% AEP (1: 1,000-year ARI) design flood. The volume of stormwater entering open mine pits and becoming mine affected water is therefore effectively limited to that rain which falls directly on the open pit area. Precipitation received in the open pits will be dewatered to an ex-pit storage for reuse or discharged to receiving waters as controlled discharges under conditions licensed by the Environmental Authority.

The key ESC infrastructure proposed for this site includes:

- Clean water diversions - Diversion drains and bunds are proposed to divert clean water runoff around the mine affected areas, including the open pits and waste areas;
- Dirty water diversions - Dirty water drains collect runoff from waste rock stockpiles and processing facilities within the vicinity of the CHPP, ROM and MIA, and discharge to the CHPP environmental dams and waste area environmental dams. These dirty water drains will be sized to capture runoff generated from a 24 hour 1 in 10-year ARI event;
- Environmental dams - Environmental dams (sediment basins) around the project collect catchment runoff and transfer water to the MIA Dams. Each of the CHPP and MIA's, waste areas and TLF have an environmental dam. Environmental Dams are sized to capture the 1 in 10-year ARI 24 hr duration storm event in accordance with The DES Stormwater Guideline (EHP 2014); and
- Culvert crossings - The proposed haul road connecting the MIA and CHPP 2 with the TLF crosses several drainage gullies, therefore requiring cross-drainage culvert infrastructure. The crossings are conceptualised as box culvert crossings with capacity to pass a minimum 1 in 10-year ARI design discharge. Discharges above the design event will pass over the box culvert as a floodway-type arrangement.

The following factors were taken into consideration when determining the level of ESC protection required:

- The properties of the surface materials;
- Local rainfall patterns (depths, intensities, recurrence intervals);
- The nature of the landforms being protected;
- The sensitivity of the receiving environment;

- The risk rating guidelines described in IECA (2008);
- The EHP Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (2016);
- The EHP Stormwater Guideline for Environmentally Relevant Activities (2014); and
- Stakeholder requirements.

Temporary ESC diversion drains will be designed with capacity to convey a 1:100-yr peak flow event. This level of protection is above and beyond the 1:10-yr design standard recommended in the ESCP guidelines (IECA 2008) and has been adopted to ensure that more than adequate protection is provided throughout the life of mine. Temporary structures include all diversion drains and sediment traps that will be removed at mine closure, such as those installed around the plant area.

All permanent ESC structures (i.e. the main site diversion banks around open cut mine areas) will be designed to withstand a 1:1,000-yr peak flow event in keeping with the EHP Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (2016). All environmental dams will be designed as Type 1 sediment basins. These are flow-through type basins, designed to remove 90 % of material > 0.045 mm in diameter (silts), and with a sediment storage zone that is 50% of the volume of the water settling zone.

The installation of all ESC measures has been scheduled to maximise protection throughout all phases of site development. Control measures will be put in place prior to soil disturbance wherever practical and will remain in place for the duration of the expected disturbance. Land clearing will be scheduled for the dry season to minimise exposure to rainfall, where practical.

The main site diversion banks in particular will be designed to be installed in stages. The main diversion banks will be installed progressively as the pits are developed. These features will remain in place after site closure. The smaller diversion drains associated with each of the infrastructure areas will be installed shortly after the areas are cleared and reshaped for construction. These features will be removed after the infrastructure areas are decommissioned and the areas are ready for rehabilitation.

Flow diversion banks and drains will be constructed to divert all clean water surface flows around the main work areas to minimise the potential volume water that will need to be managed within the site. The following diversions will be designed:

- Diversion banks will be constructed along the upslope edge of the pits to divert the majority of "clean" surface water around the site. These will be constructed in stages, as the pits are developed;
- Smaller diversion drains are planned for the management of surface water flowing into the MIA and CHPP areas. Alternatively, these smaller areas may be constructed on raised pads to place all sensitive infrastructure above the expected 1:100-yr flood level, thus avoiding any need for diversion drains; and
- No diversion drain is required for the ROM pad, as it will be sufficiently built-up such that no surface water will be able to flow into the area.

The critical design factor for surface water diversions is the expected peak flow rate. Peak flow rates typically occur during short, intense storms (e.g. a 1:100-yr, 10 min event at 246 mm/hr) rather than during longer storm events (e.g. 1:100-yr, 72 hr event averaging 7.16 mm/hr). The main site diversion banks will be designed to convey a 1:1,000-yr peak flow event, and all temporary drains will be designed for a 1:100-yr peak flow event, and critical rainfall durations ranged from approximately 5-70 min. All diversion banks and drains will be constructed from compacted select, consolidated, competent local soil materials.

All diversion banks will be designed assuming a 10:1 gradient (0.10 m/m slope) on the upslope side, and a 3:1 gradient (0.33 m/m slope) for the constructed bank. All diversion drains will be designed assuming an 8:1 gradient (0.13 mm/m slope) on both sides of the drain. Gentler construction angles will increase the design capacity of these features so long as the design flow depth is maintained. Discharge from each diversion structure will be via a level spreader or rock chute, to ensure that the concentrated surface flow is transitioned back to sheet flow in a way that minimises erosion downslope of the outlet.

5.11.6.1 Minimising Erosion on Disturbed Surfaces

Constructed Landforms

The constructed landforms (i.e. the waste rock stockpiles) represent the largest erosion risk areas and will be constructed with slope angles that are steeper than the surrounding natural land surfaces and are therefore considered the largest potential sources of eroded sediment. The primary strategy for minimising erosion on these landforms is to construct them with low batter slope angles and using erosion-resistant materials, where practical.

All constructed landforms will be designed by a suitably qualified person. As a guiding principal, the outer slopes will consist of several ≤ 10-metre-high lifts. Each lift will be shaped to an approximate 15° slope angle. The upper surface will be designed to be inward sloping to keep any rainfall on the upper surface from running down the slopes. Some progressive rehabilitation may occur (e.g. placement of topsoils, revegetation, etc.) during the active mine phase.

Operational Works Areas

The main operational work areas, such as the plant and stockpile areas, will be gently sloping to flat (<1% slope gradient). Generally, the control of raindrop impact erosion is more important than the control of surface water velocity on flat land (IECA 2008), and thus these areas will be constructed by compacting the competent local soil profile, which is expected to provide some natural armouring capacity, given the high gravel content in these soils. Sediment traps will be installed to collect and remove any sediment that is generated from these areas.

Stockpiles

Topsoil stockpiles will be constructed no higher than 2 m and subsoil stockpiles no higher than 10 m with a slope of ≤ 15° This will help to minimise erosion from the stockpiles by limiting the length and steepness of the outer stockpile slopes. Stockpiles to be retained for a period of greater than three months, and which have not naturally established a groundcover, will be bunded around the perimeter to minimise sediment mobilisation.

Roads

Haul roads will be built up in most areas, so that they are above the natural land surface. They will be designed to be water shedding to avoid flow accumulation which can lead to scouring, and erosion of the road surface and embankments. Haul roads will be constructed using compacted competent local soil materials, which are generally high in gravel content and are therefore considered to be relatively erosion resistant. Sandstone or waste rock material will be additionally utilised where the upper soil profile is found to be unsuitable for road construction.

The haul roads are expected to be sprayed with saline water to minimise dust generation, and this saline water will improve the structural integrity of the roads, such that negligible sediment will be available for erosion and runoff. Any access or haul roads crossing the surface water diversion structures (e.g. the access road, and haul roads between the northern pit and Waste Rock Stockpile 1a) will be constructed in such a way that they do not interfere with the functioning of the diversions (e.g. use of whoa-boys, bridges, or culverts). Compacted low pass floodways will be installed along the main access road in the lowest-lying areas to maintain the integrity of the road surface.

Dust Control

Wind erosion will be controlled through a combination of rock cover and water spraying. Rock cover on the waste rock stockpile surfaces will be achieved through the placement of waste rock material. Most of the other disturbance areas are to be constructed using compacted competent local soils, which consist of a significant fraction of gravels to help armour the surfaces. Surfaces that require additional dust control measures, particularly areas that receive a significant volume of vehicle traffic, will also be periodically sprayed with water, as required.

Only non-saline or brackish water will be used wherever practicable, particularly in the vicinity of topsoil stockpiles; however, saline water may be used along the main haul roads due to the sheer volume of water and frequency to which dust suppression will likely occur. Any additional cleared areas that are not required during the operation of the mine will be progressively rehabilitated according to the site rehabilitation strategy. This will restore a native plant cover to the land surface, thus reducing the risk of dust generation from exposed bare soil surfaces.

5.11.6.2 Sediment and Drainage Controls

Site specific controls and locations will be nominated within the ESCP. There will be a variety of permanent and temporary drainage structures in place that will control and manage the flow of water across the site and prevent the discharge of uncontrolled water from the site. The controls are nominated below. If the design life of ESCs nominated is expected to be exceeded, a review of the controls will be required to determine whether they are still adequate or to revise controls as necessary.

Erosion control measures shall be installed prior to clearing and grubbing operations, wherever possible. Where access to an area is required prior to installation, erosion control measures shall be installed concurrently with clearing operations. Control measures shall be installed within 48 hours of clearing operations.

Once clearing and grubbing, and sediment control devices are installed (i.e. silt fences, inlet/outlet protectors), ditches and channels with accompanying environmental dams shall be constructed, followed by appropriate slope stabilisation controls, placement of rock rip-rap in selected areas, and seeding of slopes and stockpiles, where required.

Environmental Dams

Environmental dams will capture rainfall runoff from the two MIA, TLF and overburden dump areas. The primary function of the environmental dams is to capture sediment laden runoff for sediment removal. A perforated riser pipe outlet is proposed to allow gravity draining of the sediment dam within 48 hours of filling.

Environmental dams are operational during construction and operation of the mine. The environmental dams allow for the capture, treatment and discharge of stormwater generated from the site during a rainfall event which does not exceed the design criteria. Water from the environmental dams will be preferentially used in the mine operation activities, including dust suppression and top up of the MIA process water ponds. Where rainfall exceeds that design criteria, excess water may be transferred to the larger on-site water dams, or safely pass via an emergency spillway to allow discharge to avoid flooding. Even when the environmental dams are full of water, sediment laden stormwater runoff continues to be conveyed through the ponds for continued settlement of coarse-grained particles contained in the flow. The environmental dams will be emptied of sediment prior to the commencement of the wet season to maximise the available storage capacity.

Environmental dam design and management is in accordance with the following principles:

- The site has been divided into 18 storm water management sub-catchments;
- Site drainage ditches are designed for a minimum 1 in 10 year ARI 24 hour storm event;
- Runoff from undisturbed areas will be diverted to naturally vegetated areas via clean water diversions; and
- Stormwater drainage from within the disturbed area that may contain sediments will be conveyed to the environmental dams via drainage channels designed for a minimum 1 in 10 ARI, 24 hour storm event.

Sediment control structures (i.e. "sediment basins") will be installed in each of the main infrastructure areas to collect and remove sediment from runoff water. Each of the sediment basins will be located at an elevation below the associated disturbance area, and each disturbance area (where required) will be reshaped and bunded so that all drainage is directed into the sediment basin.

All sediment basins will be designed as Type 1 sediment basins, according to the ESCP Guidelines (IECA, 2008). As discussed in the ESCP Guidelines, these types of sediment control measures should be designed to maximise the filtration of sediment-laden water during periods of light rainfall, and the settlement of sediment-laden water during periods of moderate to heavy rainfall. In general, the lighter the rainfall, the higher the expected quality of discharge water.

All sediment traps have therefore been designed to remove ≥ 90% of particles ≥ 0.045 mm in diameter (fine sands) during the design rainfall event. This is above and beyond the design level outlined in the ESCP Guidelines (IECA, 2008), which recommend the sediment traps be designed for "average" site conditions (i.e. sized for half of the 1:1-yr peak flow event). As ≥ 70 % of the soil volume is made up of sand-sized particles, the sediment traps will be able to remove the majority of sediment generated during larger storm events. This design further allows for the removal of particles as small as 0.02 mm diameter (silts) under average flow conditions (i.e. the 1:1-yr peak flow event).

The sediment traps are designed as flow-through cells and are sized such that the retention time of water in the basin is matched to the settling velocity of the critical particle size. Sediment traps will have a minimum length to width ratio of 3:1, a settling zone depth of 0.6 m, a sediment storage zone depth of 0.6 m, and a freeboard requirement of 0.3 m. Discharge from the sediment traps will be via a rock-armoured spillway, sized for the 1:100-yr peak flow rate.

Clean Water Diversions

Clean water is defined as run off from catchments undisturbed by mining and non-mining activities. The mine has been designed to avoid any diversions of defined watercourses of high environmental value, namely Deep Creek and Tooloombah Creek. However, low order tributary gullies that discharge into Deep Creek and Tooloombah Creek and the transect the ML are to be diverted around mine affected areas. These clean water diversions are aimed at maintaining the health of defined watercourses of higher environmental value and to reduce contamination of otherwise clean water runoff.

Flow Diversion Banks

Diversion banks and berms are earth structures and assist in reducing site erosion by reducing the length of slope (and the potential soil loss), increasing the time of concentration of overland flow, directing overland flow to a stable outlet point and directing run-on water around the construction site. These structures are very effective at protecting the site from erosion damage and form a critical part of the ESCP. They are relatively simple to construct and are to be implemented during all stages of th3e construction program where appropriate. Diversion banks are particularly important during the clearing stage of construction.

The size of the construction catchments will be broken up using flow diversion banks placed at regular intervals down the slope with the intent of slowing the flow of water and divert surface runoff to the receiving environment. Recommended maximum spacing of drainage systems down exposed, non-vegetated or recently seeded slopes are provided at Table 5-59. Flow diversion banks are only required in those areas where clearing takes place. If no clearing is done outside of nominated areas, surface water can continue to flow through existing vegetation to the receiving environment as it naturally does pre-clearing.

Table 5-59 Maximum flow diversion bank spacing

Batter slope (percentage)	Horizonal spacing (m)	Vertical spacing (m)
1	80	0.8
2	60	1.2
4	40	1.6

Source: IECA Table 4.3.2

Reconstruction of Slopes

Steep slopes and batters will require stabilisation during construction, particularly slopes for the environmental dams, soil disposal areas, new roadside ditches or channels and areas with potentially wet soils. Terracing, geotextile, or geo-matting shall be used where required, in combination with riprap at drainage points and with seeding and mulching, where possible.

Surface roughening techniques, such as walking a hillside with tracked equipment, may also be employed to minimise erosion potential for slope faces. Although a reduced batter grade is more desirable from a potential erosion perspective, this also increases the footprint of the alignment which has other environmental implications associated with additional clearing.

Prior to revegetation, any steep batters have the potential to suffer from extensive erosion resulting in downslope sedimentation. Accordingly, construction of batters requires careful consideration of erosion and sediment control issues.

Vegetation Buffers

Buffer strips of vegetation will be left intact, wherever possible, between construction works and wetland and/or creek boundaries to help protect water quality. Where possible a 15 m wide vegetated buffer will be left in place during clearing to allow a natural filter between exposed soils and wetland areas. Buffers shall also be established where possible in known sensitive areas.

Central Queensland Coal will destock most of the property, limiting grazing to already cleared areas in the south-west and south of the property. This area encompasses approximately 1,000 ha. The remaining area, including the creek lines which lie adjacent to the mine area, will be managed and allowed to regenerate. In the longer term this measure will contribute to localised water quality improvements through long-term restoration of this habitat and allowing vegetation to regrow along the riparian zones along Deep Creek and Tooloombah Creek (which are presently mostly cleared) will capture sediment run-off from the property. The restoration of cleared areas will also reduce soil erosion on cleared areas of the property thereby reducing the entrainment of sediment entering the creek lines during heavy rainfall events.

Sediment Traps

Where runoff from the construction area is unable to be diverted to sediment basins, sediment traps will be used to filter and intercept runoff leaving the site. These sediment traps include a variety of measures including rock socks, mulch, rock checks, sand bags and sediment fences. Sediment traps shall be installed where needed between construction areas and existing water bodies to provide protection against sediment lose where required.

Sediment traps shall be installed as per design details to intercept and detain flow of sediment-laden runoff. The condition and functionality of these sediment fences shall be monitored as part of the regular and storm follow-up inspections. Maintenance shall include repairing/replacing damaged sediment fencing and removal of sediment if necessary.

Road Drainage and Inlet/Outlet Filters

Drainage ditches shall be constructed where required to allow the efficient drainage of adjacent construction areas. Inlet and outlet filters shall be installed to protect storm drains from clogging and/or obstructions, and to maintain runoff water quality consistent with existing conditions. Outfall locations shall be protected to prevent scouring.

Dewatering

Stabilisation measures such as scour protection will be implemented so that dewatering of construction excavations and pits does not result in erosion and sedimentation. Examples of scour protection measures include rock mulching, gravelling and use of erosion control blankets or geofabric. Dewatering of construction excavations will be undertaken with controls in place to avoid accidental pumping of sediment from the base of the excavation.

Stabilised Site Exit Points

During clearing and construction, all site exit points will be stabilised with rock pads or have vibration grids installed to collect sediment from vehicles exiting the site and avoid tracking of sediment onto public roads. The stabilised site exits shall be maintained and cleaned or repaired as necessary to ensure they are working efficiently.

5.11.7 Construction Management

The management measures provided below are recommended to be implemented by Central Queensland Coal to minimise the potential erosion risk of the Project. The measures are focussed on the construction activities during the first 10 years of the Project and are relevant to the initial mine development and all associated infrastructure located on the eastern side of the Bruce highway. Work on Open Cut 1 and associated infrastructure located to west of the Bruce Highway is not anticipated to commence until 2027. Prior to the commencement of these construction activities, an updated ESCP will be prepared and certified.

5.11.7.1 Pre-Construction Management Measures

General mitigation measures to limit the impacts of land disturbance include the following:

- As an overriding principal, minimising all land disturbance, including vegetation clearance, to only that immediately required to achieve development requirements;
- Where possible, vehicle movements will be restricted to existing roads to minimise ground and vegetation disturbance;
- ‘No Go Zones’ will be shown on the ESC Design Drawing and marked on site prior to any clearing;
- An ESC briefing will be provided as part of the site induction. All relevant personnel shall be trained in the requirements of the most current ESCP;
- Installation of perimeter ESCs will be done prior to any construction;
- Works will be scheduled to minimise the area of active disturbance at any one time; and
- Nominated ESCs will be installed in predetermined locations and downslope of any disturbed lands.

Vegetation Clearing

All clearing works will be conducted in accordance with the following vegetation and soil management requirements:

- Land clearing limited to an area of land suitable to complete eight weeks’ worth of construction work if rainfall is predicted (as per IECA Table 4.4.7);
- Maximum of 50 days after commencement of site stabilisation, for identified areas, before specified minimum ground cover (e.g. organic or rock mulch, synthetic blankets, vegetation or combination thereof) is achieved in all areas except for active areas including haul roads;
- Root stock will be retained in the ground after clearing to reduce erosion and to facilitate rapid rehabilitation, where possible. This is excluding areas of permanent infrastructure, access routes, where operational activities may be impacted, and mining pits where root stock would cause an issue for coal quality;
- Vegetation will be progressively cleared where practical to minimise the area of soil exposed;
- Identify, isolate and protect all mature native vegetation where appropriate. Protected vegetation areas will be identified and clearly marked out on site before commencing clearing works; and

- Vegetation that is cleared is to be preferentially mulched and used to stabilise exposed soils on site or strategically placed to provide habitat for fauna where possible.

Earthworks

It is anticipated that civil works required during the construction phase for Open Cut 2, MIA1, CHPP2 and the TLF, and associated infrastructure on the north eastern side of the Bruce Highway will be completed in approximately seven months from commencement; however, there may be requirements for further civil works during the operations and decommissioning phases. Typical civil works that will be undertaken as part of the development include, civil earthworks, installation of permanent and temporary drainage, and trenching and laying of reticulated services and any other underground pipelines and services. All earthworks and ground disturbances will conform to the following minimum standards:

- Use of any existing clearings through riparian vegetation, if any, will be maximised while new clearing is minimised;
- Construction activities in or around watercourses will cease if a risk assessment indicates that any forecast rainfall event could cause unacceptable environmental harm or impact on safely. Construction activities may not recommence until a site inspection has determined that the watercourse has returned to stable flow (or no flow) conditions; and
- Diverting uncontaminated storm water run-off around areas disturbed by construction activities and/or other potentially contaminating activities.

Access Tracks

- Existing tracks or final access road alignments will be used whenever possible. The duplication of parallel/multiple tracks or turnouts are to be avoided;
- Access track drains are to discharge runoff water in a manner which does not lead to erosion or movement of sediment to surface waters;
- Vehicle movement over both retained vegetation and newly cleared areas where the topsoil is yet to be stripped will be minimised;
- Suitable sheeting material will be placed on all internal haul roads to provide additional cover and minimise sediment runoff, as well as providing suitable all-weather access;
- Maximum permitted vehicle speeds identified in the site HSE will be adhered to;
- All construction vehicles, plant and equipment will be permitted only within designated construction areas, and will not be allowed within any ‘No-Go’ or environmentally sensitive exclusion zones; and
- Vehicle movement within the site will be required to remain on designated site access routes whenever possible.

Construction of new access tracks may be required during construction. Where possible, access tracks will be constructed to:

- Maintain a vegetation buffer between any access tracks and nearby watercourses;
- Be positioned along contour lines limiting grade changes;

- Minimise the disturbance of existing ground; and
- Limit construction taking place across existing drainage lines, where construction across drainage lines is unavoidable, provide a means for the transport of water preventing concentrated runoff.

5.11.8 Construction Phase Management Measures

Site clearance activities will be staged during the construction phase on an as needed basis to coincide with construction requirements and to minimise the extent and duration of cleared areas at any one time. Suitable soil resources for use in rehabilitation will be stripped from areas where construction and mining operations will occur. Topsoils and subsoils will be stripped, handled and stored in a manner in line with industry best practice to prevent the deterioration of soil quality. Where practical, Central Queensland Coal will undertake construction activities with a high potential to create erosion risk during the drier months, generally between April and December.

The ESCs nominated in this plan are to be in place before any clearing and construction works take place and must remain in place until final rehabilitation has been completed and a stable site achieved. The following mitigation measures will be implemented during construction:

- Surface water run-on will be diverted around the perimeter of work areas to the extent possible;
- ESC awareness briefings will occur as part of site inductions. All relevant personnel shall be trained in the requirements of the most current ESCP;
- All reasonable and practicable measures will be implemented to control flow velocities in such a manner that prevents soil erosion along drainage paths and at the entrance and exit of all drains and drainage pipes during all storms up to the relevant design storm discharge; and
- Dust suppression measures (use of water trucks and spraying stockpiles with suitable soil binders) will be implemented.

Topsoil Stockpile Management

Appropriate management of topsoil stockpiles is required to minimize the potential for sediments to mobilise during storm events. The following mitigation measures will be implemented to avoid losing materials from stockpiles during periods of rain:

- Stockpiles will be located at least 100 m away from drainage lines / waterways;
- Stockpiles which are exposed for prolonged periods or have been identified as problem soils will be stabilised where required using chemical surface stabilisers or by other acceptable methods e.g. vegetation;
- Excavated soil will be stockpiled separately from other materials (e.g. vegetation), where it can be readily recovered for reuse; and
- Stockpiles will not impede natural or constructed surface drainage channels or access tracks.

Soil Treatment

Maintaining the integrity of the topsoils stripped prior to construction is integral for final rehabilitation, as these soils area necessary for future regeneration of vegetation. Compaction, because of stockpiling soils for extended periods of time or handling wet soils, may greatly reduce soil quality. The following mitigation measures will be implemented to avoid impacting topsoils:

- In areas where there is little topsoil or there is evidence of existing salinity, topsoil may be ameliorated with mulch, or another approved ameliorant (i.e. gypsum) to facilitate revegetation;
- No topsoil stripping works will occur during significant rainfall events or when significant rainfall events are expected;
- Topsoil stripping will be timed in accordance with site conditions, once topsoil moisture following the wetter months has decreased enough to minimise compaction issues;
- Where practicable, soils will be replaced in the order of excavation;
- The height of topsoil stockpiles will be no more than 2m in height with suitable batters (generally 1:3);
- Topsoil stockpiles will be located on the high side of slopes and are to be located away from subsoils; and
- Topsoil will not be used as backfill material.

Surface Water Management

The following measures will be implemented to manage impacts to local waterways:

- Average slope gradients will be maintained as close as possible to pre-existing slope gradients, whilst allowing for natural drainage;
- The erosion potential of longer slopes will be minimised using contour diversion berms;
- Slope gradients adjacent to waterways will be minimised;
- Where it is not possible to maintain riparianwetland vegetation, any vegetation that has been cleared near waterways will be removed from the area and stockpiled away from the watercourse with appropriate erosion controls;
- All water that discharges to a waterway will meet water quality criteria, as listed in the Central Queensland Coal EA;
- Any earthworks that are being carried out near drainage lines will be revegetated and stabilised immediately on completion of the work wherever possible and will minimise slope gradients while maintaining appropriate drainage requirements in areas adjacent to drainage lines; and
- Temporary earth banks (or other appropriate controls) will be installed along cleared slopes, diverting dirty water away from drainage lines and into vegetated areas.

Dust Control

Dust will be maintained using water trucks on haul roads and sprays will be used if required to control dust at topsoil and product stockpiles.

5.11.9 Inspection and maintenance

Site inspections will be undertaken in accordance with the frequencies shown in Table 5-60 when active construction activities are taking place. Normal routine inspections of the construction area will be performed weekly when active construction activities are taking place. Active construction areas will be inspected at least once per week. An example weekly ESC Inspection Checklist is provided in Table 5-61.

Table 5-60 Summary of monitoring, trigger values and corrective actions

Monitoring Measure	Frequency	Trigger value	Corrective Action
Inspection of sediment fences, ESC devices, disturbed areas, topsoil stockpiles	Weekly	Structural integrity is retained. 70% capacity of sediment fences remains and 50% capacity for drop inlet structures remains	▪ Maintenance to restore capacity of ESC device and then address source instability. ▪ Other corrective actions as appropriate determined on a case-by-case basis.
Inspection of the integrity of diversion bunds, sediment fences and stormwater drainage channels to verify their condition and effectiveness.	Weekly in response to rainfall events (>25mm in 24 hours (maximum once a day))	Structural integrity is retained. 70% capacity of sediment fences remains and 50% capacity for drop inlet structures remains	▪ Maintenance to restore capacity of ESC device and then address source instability.
Inspection of stormwater discharge outlets from site.	Weekly	No offsite build up of sediment on land. No offsite scouring to the bed or banks of any watercourse or land.	▪ Inspect ESC measures in the catchment draining to the stormwater discharge to ensure they are functional and that the capacity is retained. ▪ Undertake maintenance or repairs as necessary. ▪ Review the adequacy of the installed ESC measures in the catchment draining to the stormwater discharge and assess whether additional measures could be practicably implemented.
Inspection of the integrity and capacity of environmental dams.	Weekly	Accumulation of gross pollutants (litter and waste). Sediment accumulation such that 70% of capacity of environmental dam.	▪ Remove accumulated gross pollutants and sediment to restore capacity of environmental dam.

Observations made during inspections, along with data captured during environmental monitoring events (i.e. water quality monitoring) will be used to identify required preventative and/or corrective actions. The information will be used:

- To document compliance with the ESCP and the Project's EA conditions; and
- As the rationale for modifying the ESCP so that the necessary changes to control measures and/or procedures can be developed and implemented to avoid findings of future potential non-compliance.

Once a preventative or corrective action is identified the closeout of the action is to be tracked to ensure actions are addressed in a timely manner to minimise the likelihood of recurrence.

The erosion control devices shall be maintained on a regular basis as directed by the site environmental manager. The effectiveness of strategies and controls will be monitored by environment and construction staff daily. Maintenance may include replacing structures that are not functioning properly and will be identified through regular site inspections and the development of corrective actions. An example ESC weekly checklist is provided at Table 5-61 and an example pre-wet season checklist is provided at Table 5-62. Water quality monitoring will be undertaken in accordance with the Project's EA conditions.

Table 5-61 Example weekly ESC inspection checklist

Weekly ESC Inspection Checklist			
Type of Inspection			
Routine			
Rainfall Event (Before)			
Rainfall Event (After)		(cm of rain/duration)	
Intermittent Dewatering			
Area Inspected:			
Inspected BY:		Date	
Item No.	Inspection Items	Compliant (Yes / No)	Comment
1	Have the management practices identified in the ESCP been installed according to specification and in the identified locations		
2	Is there any evidence that sediment is leaving the construction site? If yes, specify		
3	Is there any evidence of erosion on fill slopes, temporary stockpiles? If yes, specify		
4	Do any sediment trapping / filtering devices (i.e. sediment fence) require repair or clean-out to maintain proper function? If yes, specify		
5	Do any velocity reduction devices (i.e. rip-rap aprons) require repair or clean-out to maintain proper function? If yes, specify		
6	Do any runoff diversion features (i.e. lined swales, storm drain inlet protection) require repair or clean-out to maintain proper function? If yes, specify		
7	Do any area in which temporary or permanent vegetative stabilisation measures are being taken show signs of bare spots, insufficient growth or germination? If yes identify locations and specify remedial action (e.g. irrigation, fertilisation, seeding, mulching, maintenance)		
8	Are on-site traffic, parking, equipment laydown, supply and waste storage restricted to those areas specifically designated for those purposes?		
9	Is there any evidence of sediment, debris or mud tracked out of the construction areas?		
Note: Attach additional sheets if needed to identify plans for corrective actions, expected date of implantation, who is to perform the work and any other relevant specifics			

Table 5-62 Example pre wet season ESC inspection checklist

Pre Wet Season Inspection Checklist			
Type of Inspection: weekly, pre-wet season, weekly during wet season			
Rainfall Event (Before)			
Rainfall Event (After) (cm of rain/duration)			
Area Inspected:			
Inspected BY:		Date	
Item No.	Item	Compliant (Yes / No)	Comment
1	Are site conditions nominated in the Environmental Authority consistent with those assumed within the approved ESCP?		
2	Was the full perimeter of the work site inspected?		
3	Site inspections and monitoring are being carried out at appropriate times and intervals.		
4	Site access is controlled, and the number of access points minimised.		
5	Adequate drainage and sediment controls exist at site entry/exit points.		
6	Adequate drainage, erosion and sediment controls have been placed around the site compound.		
7	Appropriate drainage and sediment controls are installed prior to new areas being cleared or disturbed.		
8	Site personnel have ready access to the ESCP.		
9	ESC measures are being installed in accordance with the approved ESCP.		
10	Adequate supplies of ESC materials stored on-site: such as wire, stakes, sediment fence fabric, filter cloth, clean aggregate		
11	Temporary access roads are stabilised where appropriate.		
12	Sediment deposition is not observed external to the Project area.		
13	Chemicals and petroleum products appropriately stored on site.		
14	Emergency spill response plan has been prepared for the site.		
15	Oil/petroleum spill containment/response kits available on-site where appropriate.		
16	Waste receptors have been emptied and located in approved locations.		
17	Any contaminated site water, liquid waste and wash-off water has appropriately disposed of to ensure it will not enter any waterways and stormwater systems.		
18	Waste water from construction activities such as wash water, de-watering operations, and dust control has been appropriately captured, treated and disposed of.		
19	Stripped topsoil has been stockpiled and is appropriately controlled to minimise the risk of sediment/turbid water discharge.		

20	Stockpiles located at least 5 m away from top of watercourse banks.		
21	Long-term soil stockpiles adequately protected against wind and rain.		
22	Stockpile sediment control (*Filter Fence* or *Sediment Fence*) is appropriate for the soil type and site conditions.		
23	Drainage Control measures are consistent with the ESCP.		
24	Drainage Control measures are being adequately maintained in proper working order at all times.		
25	Up-slope "clean" water is being appropriately diverted around/through the site in a non-erosive manner.		
26	Stormwater runoff diverted away from unstable slopes.		
27	Flow diversion channels/banks stabilised against erosion.		
28	Flow not unlawfully discharged onto an adjacent property.		
29	Earth batters are free of erosion.		
30	Catch Drains: (a) Adequate depth/width; (b) Adequate flow capacity is being maintained; (c) Stabilised against soil scour; (d) Clear of sediment deposition; (e) Appropriate grass length is being maintained; and (f) Water discharges via a stable outlet.		
31	Channel Linings (mats): (a) Lining is well anchored; (b) Mats overlap in direction of flow; (c) Lining is appropriate for flow conditions; and (d) No damage to the mat by lateral inflows.		
32	Check Dams: (a) Flow is passing over the dams and not around them; (b) Check Dams are not causing excessive channel restriction; (c) Rock Check Dams are not used in shallow drains; and (d) Check Dams are appropriately spaced down the drain.		
33	Temporary Watercourse Crossings: (a) Sediment runoff from the approach roads is controlled; and (b) Likely damage to the crossing and the stream caused by possible overtopping flows is considered acceptable.		
34	Erosion Control measures are consistent with the approved ESCP.		
35	Erosion Control measures are being adequately maintained in proper working order at all times.		

36	Erosion Control Blankets: (a) Blankets are well anchored; (b) Blankets overlap in direction of stormwater flow; (c) Blanket strength is appropriate for site conditions; (d) Synthetic blanket reinforcing will not endanger wildlife; (e) Blankets not damaged by lateral inflows; and (f) Blankets protected against movement by winds.		
37	Mulching (light): (a) Minimum 70% coverage of soil surface; (b) Suitable tackifier used on steep slopes; and (c) Drainage controls preventing mulch displacement.		
38	Mulch (heavy): (a) Minimum 100% coverage of soil; (b) Minimum depth adequate to control weeds; and (c) Drainage controls preventing mulch displacement.		
39	Soil Binders: (a) No adverse environmental impacts observed.		
40	Sediment Control measures are being adequately maintained in proper working order at all times.		
41	Sediment control *Buffer Zones* are protected from traffic and are free of excessive sediment deposits.		
42	Neighbouring properties are being adequately protected from sedimentation.		
43	Entry/Exit Points: (a) Control measures are constructed to appropriate standards; (b) Excessive sediment removed from sediment traps; (c) Excessive sedimentation is not evident on roadway; and (d) Stormwater drainage is controlled such that sediment is not being washed onto the adjacent roadway.		
44	Sediment Fences: (a) Bottom of fabric is securely buried; (b) Fabric is appropriately overlapped at joints; (c) Fabric is appropriately attached to posts; (d) Support posts are at correct spacing (2 m or 3 m with backing); (e) Sediment Fence does not cause flow diversion / bypass; (f) Sediment Fence has regular returns; (g) Lower end(s) of fence is/are returned up the slope; (h) Sediment Fences are free of damage; (i) All fences are free of excessive sediment deposition; and (j) Fences are adequately spaced from toe of fill banks.		
45	Rock Filter Dams (Sediment Traps): (a) Excessive sediment removed from up-slope of all traps; (b) The filtration system is free from sediment blockage; and (c) Rock Filter Dam and spillway are free of damage.		

46	*Temporary Watercourse Crossings* (e.g. construction access) have been reduced to the minimum practical number.		
47	Instream structures are not located on, or adjacent to, unstable or highly mobile channel bends.		
48	Construction works are not unnecessarily disturbing instream or riparian vegetation.		
49	Erosion is not occurring because of stormwater passing down channel banks.		
50	Appropriate temporary erosion control measures are being applied to disturbed areas.		
51	Synthetic reinforced erosion control blankets/mats are not being used where there is a potential threat to wildlife.		
52	*Sediment Fences* have not been placed in areas of actual or potential concentrated flow.		
53	Appropriate material (spoil) de-watering procedures have been adopted.		
54	Site stabilisation/revegetation is occurring in accordance with approved Plans and/or programming.		
55	Exposed areas are adequately stabilised given the site conditions, environmental risk, and construction schedule		
56	Newly seeded areas are developing an appropriate grass cover (not just strike rate), density and grass type.		
57	No newly seeded areas require reseeding.		
58	Soil erosion within revegetated areas is being adequately controlled (i.e. mulching) during the plant establishment phase.		
59	Revegetation is controlling soil erosion as required.		
60	Newly seeded areas have been lightly mulched as specified.		
Note: Attach additional sheets if needed to identify plans for corrective actions, expected date of implantation, who is to perform the work and any other relevant specifics			

5.12 Conclusion

The Project will occupy land that is presently used for cattle grazing for both fattening and breeding of stock. There are no occupied homesteads within the proposed mining lease boundaries but there are various farm access tracks, two windmills, two dams, two vacant homesteads and farming infrastructure and fence lines along paddock boundaries. No other infrastructure such as water, power, telecommunications or gas pipelines are present within the Project disturbance area.

The only designated ESA predicted to be directly affected are areas of mapped endangered remnant vegetation. There are no National Parks, nature refuges or declared catchments within the Project area, or registered areas of existing contaminated land.

Soils within the Project area have a low erosion potential although some soils within parts of the transport corridor and TLF have a higher erosion risk. Soil types include clay soils with a relatively high fertility.

In terms of agriculture, the soils provide moderate quality grazing pastures with some areas of good quality grazing land over vertosols in the north of the Project area. No areas of mapped SCL will be disturbed by the Project.

Physical impacts to the land will include land clearing and topsoil removal for the open-cut pits, mineral waste rock stockpiles, water storage dams and other surface infrastructure including the haul road and TLF.

Measures to minimise these impacts include:

- Sensitive clearance, handling and storage of topsoils;
- Establishing appropriate soil erosion and sediment controls; and
- Progressive rehabilitation of disturbed land will occur in a manner which allows the land to be returned to land suitable for the continued natural regeneration of land undisturbed by mining activities or land that has been rehabilitated to meet conservation objectives.

An assessment of potential Project impacts against the Reef 2050 Water Quality Triggers (WQT) has been completed. The assessment takes into consideration the benefits associated with the installation of specifically designed and engineered erosion and sediment control measures, the removal of grazing from the majority of the Mamelon Property and the anticipated ongoing reduction in sediments reporting to the GBR associated with the change in land use.

The assessment concluded the Project would result in a positive contribution to the Reef 2050 WQT through:

- A reduction in nutrients because of the cessation of grazing activities and subsequent managed regeneration of native vegetation on the majority of the Mamelon Property;
- The expected reduction in sediment load reporting to Tooloombah Creek and Deep Creek associated with the cessation of grazing activities and subsequent managed regeneration of native vegetation on the majority of the Mamelon property;
- A reduction of grazing lands, either as disturbed land associated within mining activities, or land where cattle have been destocked. The destocked land will positively contribute to achieving WQTs associated with increasing late dry season groundcover and increasing the extent of riparian vegetation; and

An increase of the extent of riparian vegetation through the cessation of grazing on the vast majority of Mamelon property. The destocking of cattle and subsequent Project management of native revegetation will enable vegetation to regenerate within the riparian corridors associated with Deep and Tooloombah Creeks, both of which currently remain as narrow bands of vegetation within heavily cleared lands (as they occur adjacent to the ML).

5.13 Commitments

Central Queensland Coal's commitments, in relation to the land are provided in Table 5-63.

Table 5-63 Commitments – land

Commitments
Soils and landforms
Design and implement an ESCP to be certified by a suitably qualified person, prior to construction.
Schedule construction activities and dedicate specific work areas to minimise the impact to soils, landforms and any receiving waters.
Establish No Go Zones, prior to clearing / grubbing activities, and maintain throughout the life of the Project. This will be achieved by installing physical demarcation along work area perimeters to visibly delineate the maximum allowable area of disturbance.

Commitments
Restrict vehicle movements to stabilised access locations. Stabilised access points and nominated construction and haul roads will prevent excessive ground disturbance from the movement of vehicles and machinery across the Project site.
No surfaces will be left open if they are not being worked on and all areas will have topsoil pulled back over and be suitably compacted once construction work in the area has finished. Grassed areas cleared for construction of any mine-related infrastructure will be re-contoured and landscaped once construction is complete to minimise erosion impacts.
Where significant excavation is required, excavated material will be deposited up-slope of the work and diversion measures to control soil and water flows will be installed (including banks and berms). Any diversion measures will discharge to a stabilised control or sedimentation trap.
Excavations shall be kept open for the shortest period of time possible and this will be achieved by incorporating a more detailed construction schedule into the Project planning phase.
Topsoil management
Topsoil and subsoil stripping during construction to be carried out under an approved Permit to Work and supervision of Environmental staff.
Prior to stripping, all vegetation will be cleared progressively to the minimum extent required for the impending future works.
Supervisors and earthmoving plant operators will be trained to visually identify the topsoil layers to ensure that stripping operations are conducted in accordance with stripping plans and in-situ soil conditions.
Care will be taken to ensure soil moisture conditions are appropriate for stripping and stockpiling, for example the moisture content of the topsoil material is not too dry or too wet.
All soils to be appropriately stockpiled away from mining operations for future rehabilitation use.
Soil that has been stockpiled until it is reused will be protected from excessive disturbance or traffic, and stockpiled and kept away from drainage lines.
Drainage will be constructed to manage or divert surface water flows around soil stockpiles and maintained to ensure proper functioning.
Weed and pests will be monitored and controlled as required on soil stockpiles.
Contamination
Provision of appropriate spill control materials including booms and absorbent materials at refuelling facilities to contain spills.
Ensure all refuelling facilities and the storage and handling of oil and chemicals to comply with relevant Australian Standards.
Ensure all staff to be made aware of the potential for groundwater quality to be impacted and the requirement to report any spills.
Establish procedures to ensure safe and effective fuel, oil and chemical storage and handling. This includes storing these materials within roofed, bunded areas to contain spills and prevent uncontrolled discharge to the environment.
Returning the land to a stable landform (i.e. no major erosion) with no greater soil management inputs than those required for the change from the current land use of livestock grazing to conservation purposes.
Night lighting
Lighting to be used at the Mine Infrastructure Area will be designed to minimise upwards light spill.
Towers designed to a minimum height, positioning of towers to adequately illuminate working areas and directional shields attached to lamps to minimise horizontal and upwards spill.

5.14 ToR Cross-reference Table

Table 5-64 ToR cross-reference

Terms of Reference	Section of the EIS
8.2 Land	
Conduct the impact assessment in accordance with the EHP's *EIS information guideline—Land*, and, if any quarry material is needed for construction of project works including related infrastructure, use EHP's *EIS information guideline—Quarry material*.	Noted
Describe potential impacts of the proposed land uses taking into consideration the proposed measures that would be used to avoid or minimise impacts. The impact prediction must address the following matters:	Sections 5.8

Terms of Reference	Section of the EIS
▪ Any changes to the landscape and its associated visual amenity in and around the project area.	
▪ Any existing or proposed mining tenement under the *Mineral Resources Act 1989*, petroleum authority under the *Petroleum and Gas (Production and Safety) Act 2004*, petroleum tenure under the *Petroleum Act 1923*, geothermal tenure under the *Geothermal Energy Act 2010* and greenhouse gas tenure under the *Greenhouse Gas Storage Act 2009* overlying or adjacent to the project site.	Chapter 3 – Project Description
▪ Temporary and permanent changes to land uses of the project site and adjacent areas, considering actual and potential agricultural uses, regional plans and local government planning schemes, and any key resource areas that were identified as containing important extractive resources of state or regional significance which the state considers worthy of protection.	Sections 5.2, 5.5 and 5.8
▪ Identify any existing or proposed incompatible land uses within and adjacent to the site, including the impacts on economic resources and the future availability and viability of the resource including extraction, processing and transport location to markets.	Section 5.5.5
▪ Identify any infrastructure proposed to be located within, or which may have impacts on, the Stock Route Network[1],[2] and the *Stock Route Management Act 2002*.	Section 5.2.3
▪ Propose suitable measures to avoid or minimise impacts related to land use.	Sections 5.5.2, 5.8 and 5.9
Assess the project against the requirements of the *Regional Planning Interests Act 2014*[3], including any relevant Regional Plan. Further advice is provided in the '*DILGP Companion guide – A guide for state agencies and proponents on the requirements of the Regional Planning Interests Act 2014 in the planning and development process'* (Department of Infrastructure, Local Government and Planning, July 2016[4]) and the *DAFF Environmental Impact Assessment Companion Guide*' (Department of Agriculture, Fisheries and Forestry, August 2014[5]).	Chapter 1 – Introduction and Sections 5.2 and 5.5.5.3
Describe how the project will avoid or minimise impacts on any land identified as Strategic Cropping Land on the Trigger Map for Strategic Cropping Land[6].	Section 5.5.5.3
Show how the land form during and after disturbance will be stable over time and will meet any requirements of project or property plans under the *Soil Conservation Act 1986*.	Chapter 11 – Rehabilitation and Decommissioning
Detail any known or potential sources of contaminated land that could be impacted by the project. Describe how any proposed land use may result in land becoming contaminated.	Sections 5.5.6, 5.8 and 5.9
Identify existing or potential native title rights and interests possibly impacted by the project and the potential for managing those impacts by an Indigenous Land Use Agreement or other measure in accordance with the *Native Title (Queensland) Act 1993* and consistent with the Queensland Government *Native Title Work Procedures*[7].	Chapters 3 – Description of the Project and 18 – Cultural Heritage

[1] https://www.qld.gov.au/environment/land/stock-routes/about/

[2] https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0010/99622/stock-route-management-strategy.pdf

[3] http://www.dilgp.qld.gov.au/planning/regional-planning/regional-planning-interests-act.html

[4] http://www.dilgp.qld.gov.au/planning/regional-planning/rpi-act-forms-guidelines-and-fact-sheets.html

[5] https://publications.qld.gov.au/dataset/daff-environmental-impact-assessment-companion-guide/resource/7b1825c4-5e42-4cf8-aa2d-7fa55c2f5e4c

[6] https://www.dnrm.qld.gov.au/land/accessing-using-land/strategic-cropping-land

[7] https://www.dnrm.qld.gov.au/land/indigenous-land/queensland-government-native-title-work-procedures