Appendix F

Soils

QUEENSLAND
PACIFIC METALS

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QPM Energy Project

Soils Impact Assessment

Prepared for QPM Energy

October 2022

QPM Energy Project

Soils Impact Assessment

QPM Energy

E210671 RP1

October 2022

Version	Date	Prepared by	Approved by	Comments
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Abbreviations

Table 1 Abbreviations

Abbreviation	Term
ASC	Australian Soil Classification
ASPAC	Australasian Soil & Plant Analysis Council
ASS	Acid Sulfate Soils
Bgl	Below ground level
BoM	Bureau of Meteorology
Ca:Mg	Calcium:magnesium
CEC	Cation exchange capacity
EA	Environmental Authority
EMM	EMM Consulting Pty Ltd
EP Act	*Environmental Protection Act 1994*
ESCP	Erosion and sediment control plan
ESP	exchangeable sodium percentage
GCF	Gas Compression Facility
GPS	Global Positioning System
ha	hectare
km	Kilometres
m	metres
mAHD	Metres Australian Height Datum
Na	Sodium
NATA	National Association of Testing Authorities
NQGP	North Queensland Gas Pipeline
QPM Energy	Queensland Pacific Metals Energy
RUSLE	Revised Universal Soil Loss Equation
SLC	Soil loss classes
SMU	soil mapping units
SPC	soil profile classes
SSMP	Soil Stripping and Management Plan
t	tonnes
TECH	Townsville Energy Chemicals Hub Project

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1 Introduction

1.1 Project overview

The QPM Energy Project (the Project) involves the design, construction and operation of a gas compression facility (GCF) and a high-pressure pipeline that links the proposed GCF to the nearby existing and operational North Queensland Gas Pipeline (NQGP).

The Project proposes to collect waste coal mine gas at the proposed GCF via waste gathering lines from existing coal mines located adjacent to the proposed site. At the GCF, waste coal mine gas will be dehydrated and filtered, with the remaining clean gas then compressed and transported via high-pressure pipeline to the existing and operational NQGP. The NQGP will then transport the compressed gas north to Townsville, where in turn it will be depressurised and distributed, by a third party, to industrial users, including the QPM Townsville Energy Chemicals Hub (TECH) Project.

The Project is located approximately 43 kilometres (km) north of Moranbah.

1.2 Purpose of this report

This soils impact assessment has been prepared by EMM Consulting Limited (EMM) on behalf of QPM Energy in support of an application for a new Environmental Authority (EA) for a resource activity, as part of the Project.

The purpose of this document is to provide sufficient detail to support an application for a site-specific EA.

The aim of this report is to provide an assessment of the Project's impact on soils. The assessment includes an evaluation of the existing environment to identify and assess the risks arising from the disturbance and excavation of land and soil materials.

This report aims to inform likely soil and erosion hazards and constraints of the proposed project and propose appropriate management and mitigation measures. It includes an assessment of soil physical and chemical characteristics and their distribution.

Contaminated land and waste matters are addressed separately in Appendix G of the Environmental Assessment Report (EMM 2022a, EMM 2022b).

1.3 Project footprint and study area

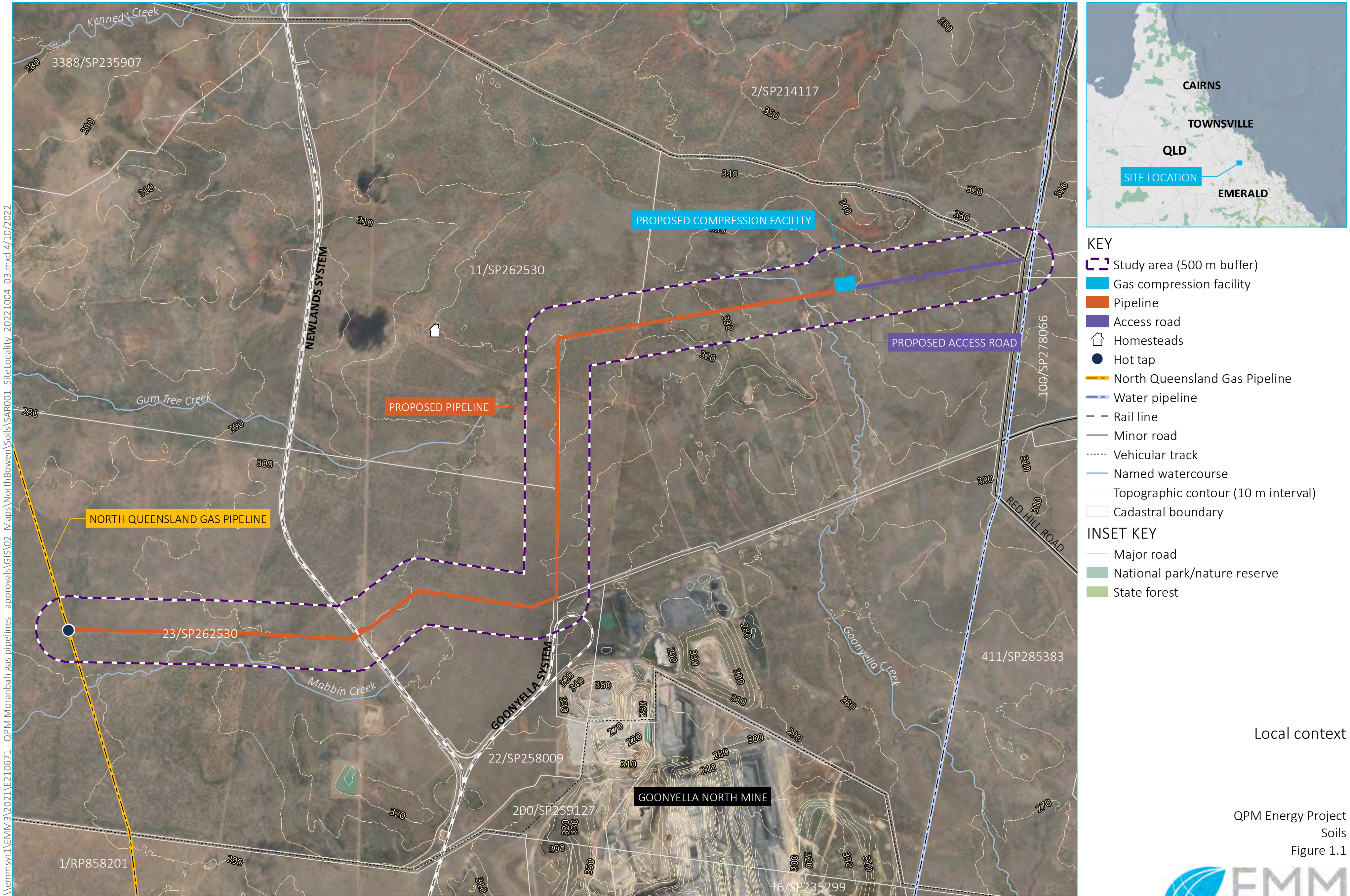
The Project footprint is comprised of the following components and land areas:

- GCF – 200 m by 300 m, an area of 6 ha;
- pipeline – easement initially a 30 m wide construction right of way (an area of 51 ha) which reduces to a 15 m wide operating easement (an area of 25 ha) after the first 3.2 km from the GCF;
- access road – 8 ha being a 30 m wide easement from Red Hill Road to the GCF – a distance of 2.8 km; and
- other incidental/ancillary activities, within the above footprint.

A detailed project description is provided in Section 3 of the Environment Assessment Report (EAR).

For the purposes of the soils impact assessment, the study area is defined as the area including permanent and temporary infrastructure, plus a 500 m buffer.

The local context is shown in Figure 1.1.



Source: EMM (2022); ABS (2021); DES (2019); DNRME (2022); GA (2011); ESRI (2022)

0 1 2 km
GDA 1994 MGA Zone 55

KEY
- Study area (500 m buffer)
- Gas compression facility
- Pipeline
- Access road
- Homesteads
- Hot tap
- North Queensland Gas Pipeline
- Water pipeline
- Rail line
- Minor road
- Vehicular track
- Named watercourse
- Topographic contour (10 m interval)
- Cadastral boundary

INSET KEY
- Major road
- National park/nature reserve
- State forest

Local context

QPM Energy Project
Soils
Figure 1.1

EMM creating opportunities

\\emmsvr1\EMM3\2021\E210671 - QPM Moranbah gas pipelines - approvals\GIS\02_Maps\NorthBowen\Soils\SAR001_SiteLocality_20221004_03.mxd 4/10/2022

2 Project description

2.1 Overview

The Project involves the design, construction, and operation of a GCF and a high-pressure pipeline that links the proposed GCF to the nearby existing and operational NQGP.

The Project proposes to collect waste coal mine gas at the proposed GCF via waste gathering lines located at adjacent coal mines. At the GCF, waste coal mine gas will be dehydrated and filtered, with the remaining clean gas then compressed and transported via high-pressure pipeline to the existing and operational NQGP. The NQGP will then transport the compressed gas north to Townsville, where in turn it will be depressurised and distributed, by a third party, to industrial users, including QPM's TECH Project.

Access to the GCF will be provided via the construction of a 2.8 km all-weather access road from Red Hill Road.

Ancillary activities will also occur within the defined Project footprint.

The Project is proposed 43 km north of Moranbah.

It should be noted that the Project involves capturing and converting methane in waste coal mine gas (a greenhouse gas) into carbon dioxide that would otherwise be released into the atmosphere by the relevant coal mining operator. The Project proposes to capture and convert waste coal mine gas through a process of filtration to remove water slugs and fine coal dust, compression, dehydration to remove water vapour, and flaring, in the event of a shutdown. It does not involve refining natural gas or coal seam methane gas.

For further detail on the Project description refer to Section 3 of the Environmental Assessment Report (EAR).

2.2 Key project components

Table 2.1 summarises the key components of the Project.

Table 2.1 Project components

Component	Description
GCF	• Captures and converts waste coal mine gas to clean gas which is then compressed to 15.3 megapascal for transport within the high pressure gas pipeline. • Proposed to be located at Dabin Station on the southern boundary of Lot 2 SP214117 and 2.8 km west of the Red Hill Road reserve. • Sited on a 200 m by 300 m pad. • 6 ha disturbance footprint.
High-pressure pipeline	• High-pressure pipeline to transport clean compressed gas from the GCF to the NQGP. • 16.8 km in length, running along fence lines and property boundaries. • During construction, a 30 m wide construction right of way (disturbance area of 51 ha). • During operations, a 15 m wide operating easement (disturbance area of 25 ha) after the first 3.2 km.
Access road	• Road to provide all-weather access to the GCF from Red Hill Road reserve. • 2.8 km long and 30 m wide. • 8 ha disturbance footprint.

A detailed project description is provided in Section 3 of the Environmental Assessment Report.

2.3 Project description influencing soils matters

The Project activities that may impact on soils matters include:

- clearing of vegetation;
- stripping, stockpiling and backfill of topsoil;
- trenching, stockpiling and backfill of subsoil;
- earthworks, including cut and fill and compaction to design levels, grading to establish a safe working construction area, trenching, and blasting in hard rock areas;
- disturbance activities within a watercourse (Goonyella Creek);
- progressive rehabilitation and restoration of temporary disturbance areas to ensure, as far as practicable:
    - land is returned as close as possible to its previous state;
    - stable landforms are re-established to original topographic contours; and
    - natural drainage patterns are reinstated; and
- implementation of erosion control measures.

3 Legislation, policies, standards and guidelines

The following legislation, policies, standards and guidelines in Table 3.1 are relevant to this soils assessment.

Table 3.1 Relevant legislation, policies, standards and guidelines to the soils assessment

Document	Relevance to the assessment
Legislation	
Environmental Protection Act 1994 (EP Act)	The *Environmental Protection Act 1994* lists obligations and duties to prevent environmental harm, nuisances and contamination. The *Environmental Protection Act 1994* also sets out enforcement tools that can be used when offences or acts of non-compliance are identified. Stormwater run-off from construction sites is regulated under s.440ZG and s.319 the EP Act. Under s.440ZG it is an offence to: • unlawfully deposit a prescribed water contaminants in waters or in a roadside gutter or stormwater drainage or at another place, in a way that the contaminant could reasonably be expected to wash, blow, fall or otherwise move into waters a roadside gutter or stormwater drainage; and • unlawfully release stormwater run-off into waters, a roadside gutter or stormwater drainage that results in the build-up of earth in waters, a roadside gutter or stormwater drainage. Under s.319, persons in Queensland carrying out activities which may cause environmental harm must comply with the general environmental duty. Demonstrating that all reasonable and practicable measures have been adopted to prevent and minimise environmental harm is a defence for offences such as release of prescribed water contaminants.
Environmental Protection Regulation 2019	The *Environmental Protection Regulation 2019* regulates prescribed activities that are classified on the base of the aggregate environmental scores worked out for the activities under the environmental emission profile. In addition, it aims at protecting environmental values, and meeting quality objectives, under relevant environmental protection policies and prescribes the regulatory requirements with which the administering authority is required to comply for making environmental management decisions and defines the matters relating to environmental management and environmental offences. The Regulation also gives effect to, and enforce compliance with, the 'National Environment Protection (National Pollutant Inventory) Measure 1998' (the NPI NEPM) made under the *National Environment Protection Council Act 1994* (Cwlth), Section 14.
Environmental Protection (Water and Wetland Biodiversity Policy) 2019	Schedule 1 EPP Water and Wetland Biodiversity provides a process for protecting Queensland waters by establishing environmental values and water quality objectives for many waters of the State For waters not included in Schedule 1, the EPP Water and Wetland Biodiversity provides a process for determining the environmental values and water quality objectives. Section 15 establishes a hierarchy of preferred management options for wastes, including water contaminants which, when applied, protects or enhances the environmental values of waters.
Policies, standards, guidelines	
Australian Soil and Land Survey Field Handbook (NCST 2009)	The *Australian Soil and Land Survey Field Handbook* provides specific methods and terminology for soil and land surveys. It is widely used throughout Australia to provide one reference set of definitions for the characterisation of landforms, vegetation, land surface, soil and substrate.
Soil Conservation Guidelines for Queensland	The *Soil Conservation Guidelines for Queensland* provide information on soil degradation and practical tools for its prevention from water-based erosion. They also provide tools and techniques to remediate degraded areas.
Australian Soil and Land Survey: *Guidelines for surveying soil and land resources*	The guidelines give information on the methods that can be utilised to obtain and utilise information for making decisions on land use and management. The guidelines aim to promote the development and implementation of consistent methods and standards for surveys of soil and land resources.

Table 3.1 Relevant legislation, policies, standards and guidelines to the soils assessment

Document	Relevance to the assessment
Guidelines for Soil Survey along Linear Features	*Guidelines for Soil Survey along linear features* addresses soil survey requirements for linear infrastructure features. The guideline identifies the varying scales of soil mapping and associated survey intensity required to collect suitable data for different projects.
The Australian Soil Classification 3rd Edition	The primary guide on soil classification in Australia, a multi-categoric scheme with classes defined on the basis of diagnostic attributes, *horizons* or materials (collectively called *diagnostic features*) and their arrangements in vertical sequence as seen in an exposed *soil profile*.
Queensland Acid Sulfate Soil (ASS) Technical Manual: *Soil Management Guidelines*	The management guidelines for ASS provide a risk based management measures with a variety of 'preferred' or 'high risk' strategies that can be used to manage documented ASS. If ASS is disturbed directly or indirectly during Project delivery, an ASS Management plan is required to be prepared.
Salinity Management Handbook, 2nd Edition	The *Salinity Management Handbook* provides a guide to salinity processes, investigating salinity risks within landscapes, and developing integrated management strategies should saline soils be encountered.
IECA Best Practice Erosion and Sediment Control Guidelines 2008	Developed to aid erosion and sediment control practitioners in the planning, design, installation and maintenance of erosion and sediment control on building sites to facilitate the minimisation of environmental harm through the identification of best practice.

4 Assessment methodology

4.1 Desktop assessment

A desktop assessment for the study area has been completed with a nominal search radius of 500 m around the proposed high-pressure pipeline and GCF. The desktop assessment has included:

- evaluation of relevant government databases and mapping datasets, including:
  - Queensland Globe (DNRME 2020a);
  - Atlas of Australian Soils (BRS 2009);
  - Land systems of the Nogoa-Belyando area (Gunn *et al* 1967);
  - Land Systems of the Isaac-Comet area, Central Queensland (Story *et al* 1967); and
  - Australian Soil Classification 3rd Edition ('ASC', Isbell & NCST 2021).
- review of available designs, proposed disturbance areas, construction plans and site layouts with respect to potential soils impacts (provided by QPM Energy and the design teams); and
- review the latest legislation and guidelines relating to soils.

4.2 Field survey

A soils survey was conducted between 31 May and 2 June 2022 to examine the soil and landform properties of the Project, with samples obtained for laboratory analysis.

The survey was conducted with reference to the following guidelines:

- *Australian Soil and Land Survey Field Handbook* (NCST 2009);
- *Australian Soil and Land Survey: Guidelines for surveying soil and land resources* (McKenzie *et al.* 2008);
- *Guidelines for Soil Survey along Linear Features* (SSA 2015); and
- *The Australian Soil Classification 3rd Edition* ('ASC', Isbell & NCST 2021).

4.2.1 Sample site selection and density

The survey consisted of the excavation of 27 soil profiles to a maximum depth of 1.0 m below ground level (BGL), resulting in a site intensity of 1 site per 1 km of alignment. This site intensity achieved a survey scale of 1:50,000 as per the *Guidelines for Soil Survey along Linear Features* (SSA 2015), suitable for major disturbances in non-urban areas and not close to (>500 m) sensitive receivers, or where there is a clear repetitive pattern of soil type changes with a general overall length of disturbance/corridor greater than 10 kms (SSA 2015). Per McKenzie *et al.* (2008) this is considered a "medium (semi-detailed)" survey intensity with an objective of moderately intensive uses at 'farm' level, semi-detailed project planning and district level planning.

The rationale for the location of the soil investigation sites was based on the desktop assessment of available regional mapping for the Project. The investigation sites were distributed according to variations in the available desktop aerial imagery, ASC, elevation and landform. The aim was to provide at least one detailed site description for each combination of these factors to assess their influence on soil distribution across the Project footprint.

The soil investigation site locations are detailed below in Table 4.1 and shown alongside the soil mapping units in Figure 6.1.

Table 4.1 Soil investigation sites

Site	Coordinates		Site	Coordinates	
	Latitude	Longitude		Latitude	Longitude
QPM01	-21.6671812	147.8757234	QPM15	-21.64677611	147.9977931
QPM02	-21.66725754	147.8854156	QPM16 - Depression	-21.64174162	148.0000908
QPM03	-21.66739775	147.8943829	QPM16 - Mound	-21.64174162	148.0000908
QPM04	-21.667504	147.9014928	QPM17	-21.65740576	147.950885
QPM05	-21.667398	147.894383	QPM18	-21.64913825	147.9509282
QPM06	-21.6677567	147.9199477	QPM19	-21.64033081	147.9511052
QPM07	-21.66073588	147.9293532	QPM20	-21.63175035	147.9508575
QPM08 – Depression	-21.66212187	147.938586	QPM21	-21.62420478	147.951068
QPM08 - Mound	-21.66205831	147.9386511	QPM22	-21.62301541	147.9591478
QPM09	-21.66330563	147.9481303	QPM23	-21.62196815	147.9661038
QPM10	-21.66004132	147.9566353	QPM24	-21.62094395	147.9721311
QPM11	-21.65673331	147.9657461	QPM25	-21.61984151	147.9791142
QPM12	-21.65375647	147.9748783	QPM26	-21.61858727	147.9864276
QPM13	-21.65180543	147.9837219	QPM27	-21.61809854	147.9943552
QPM14	-21.64870509	147.9923908			

4.2.2 Soil profile descriptions

Soil site descriptions to be undertaken in accordance with the *Australian Soil Survey and Land Survey Field Handbook, 3rd Edition* (NCST 2009) and classified using *The Australian Soil Classification* (Isbell & NCST 2021). Soil site descriptions include a soil profile description, site observation and photographs taken of the soil profile and landscape at each location.

Site observations include descriptions of:

- location;
- landform (including slope and morphology);
- geology;
- land use;
- disturbance;

- surface characteristics (eg gilgai and rockiness); and
- vegetation.

Soil profile descriptions include (where applicable) details of:

- horizon depths and designation;
- soil surface condition (crusting, cracking, self-mulching);
- boundary distinctness;
- field texture (ribboning technique as per NCST 2009);
- colour (hue and chroma using the Munsell colour chart);
- mottles;
- coarse fragments (visual assessment of shape, size and distribution);
- structure and pedality;
- segregations;
- hydrology (profile drainage and permeability); and
- field tests (eg pH).

Photographs of the excavated soil profiles were captured, along with photographs of the surrounding landscape of the site.

4.2.3 Soil samples

Composite surface soil samples consisted of a combination of at least 12 sub-samples collected randomly within a 10 m radius of the soil profile and on the same landform element. Generalised sampling depths were 0–0.1 m, 0.2–0.3 m, 0.5–0.6 m, 0.9–1.0 m with no sample interval exceeding 0.3 m in thickness. Allowances were made for horizon boundaries with samples collected from within major soil horizons (ie sampling did not cross A and B horizons).

Soil samples (approximately 250–500 g) were collected in bags and identified using the project name, the observation site number, and depth range.

The soil sampling activities undertaken are summarised in Table 4.2.

Table 4.2 Soil sampling activities

Activity	Description
Soil core locations (sites)	Observation locations were recorded with either: • a Garmin eTrex 20 handheld Global Positioning System (GPS) unit with an accuracy of generally +/-4 m; or • ArcCollector GPS location software used on a mobile phone. Where neither of the above are possible the estimated position coordinates are retrieved from online mapping georeferencing.
Soil coring	Hand auguring was undertaken with the use of a 75 mm Jarret auger or a shovel and crowbar where required. Soil cores were extended to a maximum of 1.0 metre BGL (mBGL).
Abandonment	Where hand augured, soil cores were backfilled to the existing natural ground level using soil retrieved during soil coring.
Decontamination	Prior to commencing each soil core, bulk soil material was removed from the auger head. The auger head, boots and vehicle wheels and mudflaps were washed down with disinfectant when moving between different properties in accordance with best practice management procedures.
Soil logging	Soil characteristics were described, and profiles classified in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST 2009) and the *Australian Soil Classification* (Isbell & NCST 2022) respectively. In addition to soil descriptions, the associated landscape features, including terrain, land use, areas of degradation, slopes and vegetation were recorded and photographed.
Soil sampling	Soil samples, approximately 500 g in weight, were obtained directly from the auger at nominal depths of 0–0.1 m, 0.2–0.3 m, 0.5–0.6 m and 0.9–1.0 m, depending on sample site depth. These depths sometimes varied to accommodate horizon boundaries. Discrete soil samples were collected and placed into resealable plastic bags for dispatch to the laboratory.
Labelling	Sample bags were labelled with the sample site number and depth. For instance, a sample collected at site QPM 01 at a depth of 0–10 centimetres (cm) BGL was labelled as follows: QPM01, 0–0.1 m.
Dispatch	Samples were stored out of direct sunlight and transported by road for analysis at East West EnviroAg Pty Ltd (Tamworth, NSW).

4.2.4 Laboratory analysis

A National Association of Testing Authorities (NATA) and Australasian Soil & Plant Analysis Council (ASPAC) accredited laboratory, East West Enviro Ag Pty Ltd (NATA accreditation 12360 and 15708), was used to ensure that laboratory testing was undertaken using scientifically correct methods. The analyses undertaken on sampled soils is given in Table 4.3.

Table 4.3 Soil chemical analysis

Horizons	Indicative sampled depths[1]	Analysis performed
Topsoil	0.0–0.1 m	pH (1:5 water & $CaCl_2$); EC (1:5 water); Cl- (1:5); exchangeable cations (Ca, Mg, Na, K, Al) and cation exchange capacity (CEC) (NH_4Cl or Ammonium Acetate); OC and OM (Walkley and Black); PSA (Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 micrometres; µm), Clay (<2 µm); Colwell P; Sulfate Sulfur; Total P, Total N, nitrate N, Ammonium N, micro nutrients (Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn)); exchangeable sodium percentage (ESP): Emerson Aggregate Test (EAT).
Subsoil	0.2–0.3 m 0.5–0.6 m 0.9–1.0 m	pH (1:5 water & $CaCl_2$), EC (1:5 water); Cl- (1:5); exchangeable cations (Ca, Mg, Na, K, Al) and CEC (NH4Cl or Ammonium Acetate); nitrate N, Ammonium N; PSA (Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm); ESP, Emerson Aggregate Test (EAT).

1. These depths will vary to accommodate horizon boundaries.

Detailed laboratory results are provided in Annexure A. Soil 'fertility' is utilised to describe the assessment of topsoil Nitrogen (total), Potassium (exchangeable), Phosphorous (Colwell) and Organic Carbon. Interpretation of the laboratory analysis results is based predominantly on guidelines provided in:

- *Soil Chemical Methods* (Rayment & Lyons 2011);
- *Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982);
- *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and
- *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

4.3 Risk assessment method

The risk-based approach applied to hazard assessment and management (Section 10) involved the following key steps:

- Identification: This step identifies the areas of impact, potential hazards and their causes and potential consequences.
- Analysis of inherent risk: This involves developing an understanding of the risks, including the likelihood and consequences of particular events, without considering mitigation measures. The likelihood, consequence and risk scoring criteria are defined in Table 4.4, Table 4.5 and Table 4.6.
- Evaluation: Information from the risk analysis is combined to assess the overall level of risk of an event as demonstrated in Table 10.1. This helps to determine which hazards and risks need treatment or management. It also prioritises treatment.
- Mitigation: This involves identification of relevant and appropriate mitigation measures and how they will be implemented to reduce the risk.
- Analysis of residual risk: Risks are analysed again after the application of mitigation measures.

Likelihood criteria are given in Table 4.4.

Table 4.4 Likelihood criteria

Likelihood	Description	Frequency
A) Almost certain	Can be expected to occur in most circumstances	>85%
B) Likely	Will probably occur in most circumstances	40–85%
C) Possible	Might occur at some time	20–40%
D) Unlikely	Could occur at some time	5–20%
E) Rare	May only occur in exceptional circumstances	<5%

Consequence criteria are given in Table 4.5.

Table 4.5 Consequence criteria

Rating	Description
5. Severe: *Widespread serious permanent effect*	Incident is reportable to the regulator, serious permanent/persistent and irreversible damage is caused, significant public interest and media coverage and/or uncontained impacts.
4. Major: *Widespread, moderate to long-term effect*	Incident is reportable to the regulator and notable damage is caused to an area or asset from which it will take more than 10 years to recover with long-term evidence of the incident resulting, or incident is reportable to the regulator and public concern raised.
3. Moderate: *Localised, short-term to moderate effect*	Moderate but repairable damage that will take up to 10 years to recover, or incident is reportable to the regulator.
2. Minor: *Localised short-term effect*	Minor damage to the environment or heritage asset or area that is immediately contained on-site. It will take less than two years for the resource or asset to fully recover or it will only require minor repair, or disturbance to scarce or sensitive environmental or heritage resources.
1. Insignificant: *No impact or no lasting effect*	Negligible damage that is contained on-site, or the damage is fully recoverable with no permanent effects, taking less than three months to fully recover

The risk assessment matrix in Table 4.6 is used to combine the likelihood and consequence rating, to give a risk assessment score.

Table 4.6 Risk assessment matrix

Likelihood	Consequence				
	1) Insignificant	2) Minor	3) Moderate	4) Major	5) Severe
A) Almost certain	Medium A1	Medium A2	High A3	Extreme A4	Extreme A5
B) Likely	Low B1	Medium B2	High B3	Extreme B4	Extreme B5
C) Possible	Low C1	Low C2	Medium C3	High C4	High C5
D) Unlikely	Low D1	Low D2	Low D3	Medium D4	Medium D5
E) Rare	Low E1	Low E2	Low E3	Low E4	Medium E5

5 Desktop assessment results

5.1 Topography

The topography of the region is flat to rolling with varying elevation in the vicinity of the Project. Elevation ranges from approximately 290 metres Australian Height Datum (mAHD) at its western margins to 330 mAHD in the vicinity of the proposed GCF along Red Hill Ridge. Near the GCF the land surface slopes to the southwest towards Goonyella Creek.

5.2 Climate and hydrology

Rainfall is seasonal with a distinct wet season occurring during the summer months of December through February and an extended dry season occurring from April through to September. Monthly and annual rainfall data sourced from Moranbah Airport Bureau of Meteorology (BoM) (BoM 0434035) indicates that annual rainfall totals for the region range between 280 and 833 mm per year.

The nearest watercourses to the Project footprint include Mabbin Creek, Gum Tree Creek and Goonyella Creek, presented in Figure 2.1. The creeks are non-perennial and are strongly influenced by seasonal changes in rainfall.

The proposed high-pressure pipeline crosses the upper reach of Goonyella Creek, approximately 530 m to the west from the proposed GCF and is located within the Fitzroy Basin. Mabbin Creek is located approximately 100 m south of the proposed high-pressure pipeline and Gum Tree Creek is located approximately 960 m to the west of the proposed high-pressure pipeline, both creeks lie within the Burdekin Basin.

The study area hydrology is discussed in further detail in the surface water assessment (EMM, 2022c).

5.3 Atlas of Australian Soils

The digital Atlas of Australian Soils mapping (BRS 2009) in the Project footprint is presented at the 1:2,000,000 scale. Mapping was accessed through Queensland Globe (DNRME 2020a) and is summarised in Table 5.1 and illustrated in Figure 5.1. Due to the broad-scale nature of the available mapping and associated increased potential for variation, the mapping described includes those units proximal to the study area.

Table 5.1 Summary of Atlas of Australian Soils mapping units

AAS Soil landscape	Landscape description	Soil description	ASC type [1]
My28	Gently undulating lands with broad ridge crests & low rises	Gradational red, no A2 horizon, neutral massive earth whole col B horizon.	Kandosol
CC33	Level or very gently undulating clay plains	Uniform fine cracking, smooth faced peds, grey clay horizon underlain by grey/mottled clay.	Vertosol
Sl21	Gently undulating plains	Duplex yellow-grey, hard setting A horizon, A2 horizon conspicuously bleached, alkaline pedal whole col B horizon.	Sodosol
Ke19	Gently to broadly undulating plains	Uniform fine cracking, smooth faced peds, dark clay horizon underlain by weathered rock before 1.5m.	Vertosol
Va52	Undulating or gently undulating lands	Duplex yellow-grey, hard setting A horizon, A2 horizon conspicuously bleached, alkaline pedal mottled B horizon.	Sodosol

1. per Ashton & McKenzie (2001).

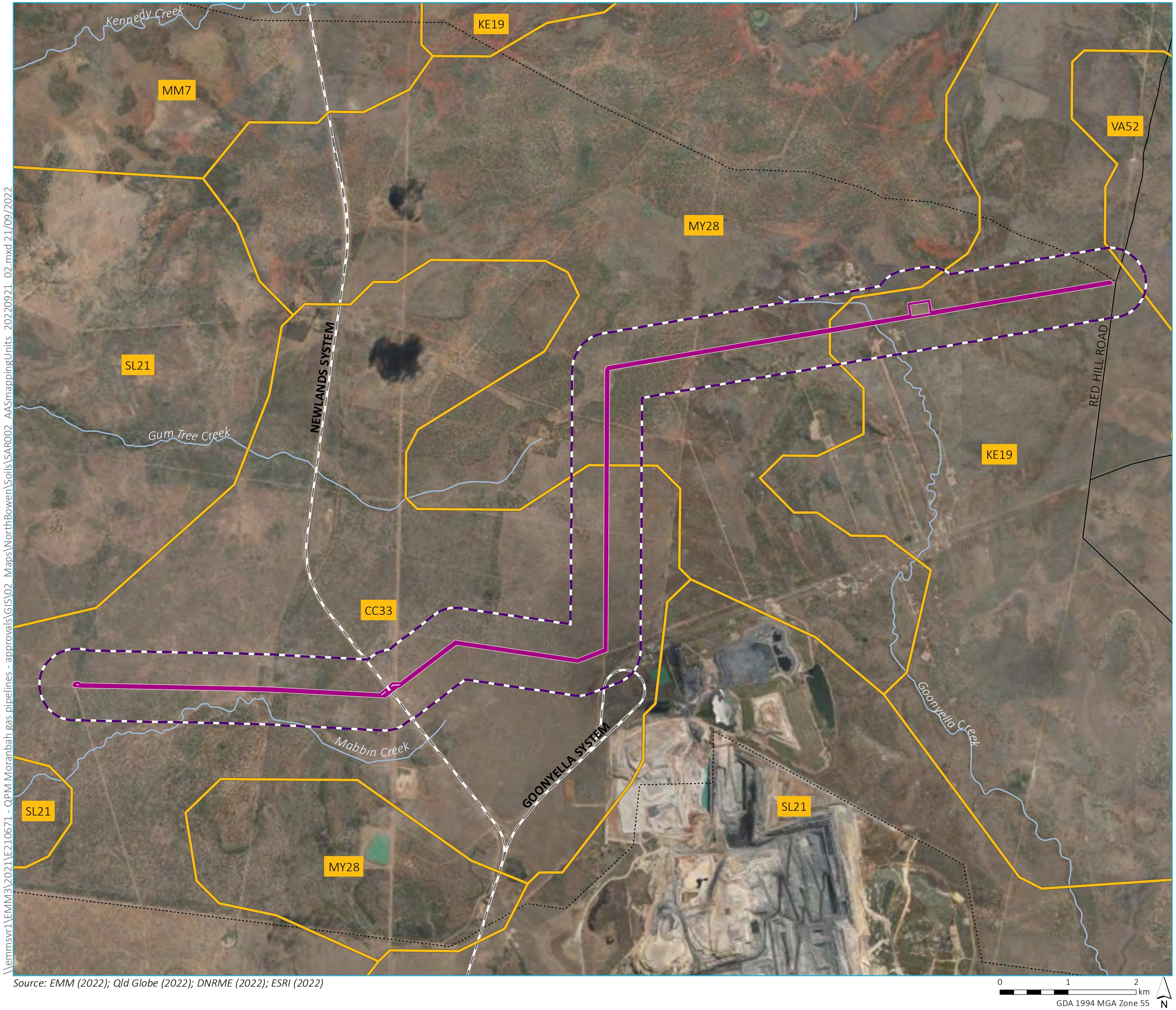
5.4 Australian Soil Classification

The Australian Soil Classification scheme ('ASC', Isbell & NCST 2021) is a multi-category scheme with soil classes defined on the basis of diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed profile. State-wide mapping of ASC was derived from the Atlas of Australian Soils (BRS 2009) by Ashton and McKenzie (2001) and identifies that the study area encompasses three soil orders; Vertosols, Kandosols and Sodosols described in Table 5.2 and illustrated in Figure 5.2. Vertosols and Kandosols were identified as the dominant soils type.

Table 5.2 Summary of desktop ASC mapping

Soil Type	ASC description [1]	Agricultural potential [2]	AAS Soil landscape
Vertosols	• Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates. • Soils which have all the following: – a clay field texture of 35% or more clay throughout the solum except for thin, surface crusty horizons 0.03 m or less thick; – when dry, open cracks occur at some time in most years[3]. These are at least 5 mm wide and extend upward to the surface or to the base of any plough layer, peaty horizon self-mulching horizon, or thin, surface crusty horizon; and – slickensides and/or lenticular peds occur at some depth in the solum.	• Generally high agricultural potential. • High chemical fertility and water holding capacity but require significant amounts of rain before water is available to plants). • Gypsum and/or lime may be required to improve the structure. • Heavy plastic clays can be difficult to respread and cultivate, especially when wet. • Shrink-swell phenomena creates foundation problems for buildings and infrastructure.	• CC33 • Ke19
Kandosols	• Soils that lack strong texture contrast, have massive or only weakly structured B horizons and are not calcareous throughout. • Soils other than Hydrosols which have all the following: – B2 horizons in which the major part has a grade of pedality that is massive or weak; – a maximum clay content in some part of the B2 horizon that exceeds 15%; – do not have a clear or abrupt textural B horizon; and – are not calcareous throughout the solum, or below the A1 or Ap horizon or to a depth of 0.2 m if the A1 horizon is only weakly developed.	• Generally low to moderate agricultural potential. • Moderate chemical fertility and water holding capacity.	• My28
Sodosols	• Soils with strong texture contrast between A and *sodic B horizons* which are not strongly acid. • Soils other than Hydrosols with: – with a *clear or abrupt textural B horizon* and in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is *sodic* and *not strongly acid;* and – soils with strongly sub-plastic upper B2t horizons are excluded.	• Typically have very low agricultural potential with high sodicity leading to high erodibility, poor structure and low permeability. • Subsoils are often dispersive and prone to gully and tunnel erosion. • Often hard- setting when dry and prone to crust formation. • Low to moderate chemical fertility and can be associated with soil salinity.	• Sl21 • Va52

1. per Isbell & NCST (2021)
2. per Gray and Murphy (2002)
3. Note that there is no crack frequency criterion as in the Factual Key (Isbell & NCST 2021)



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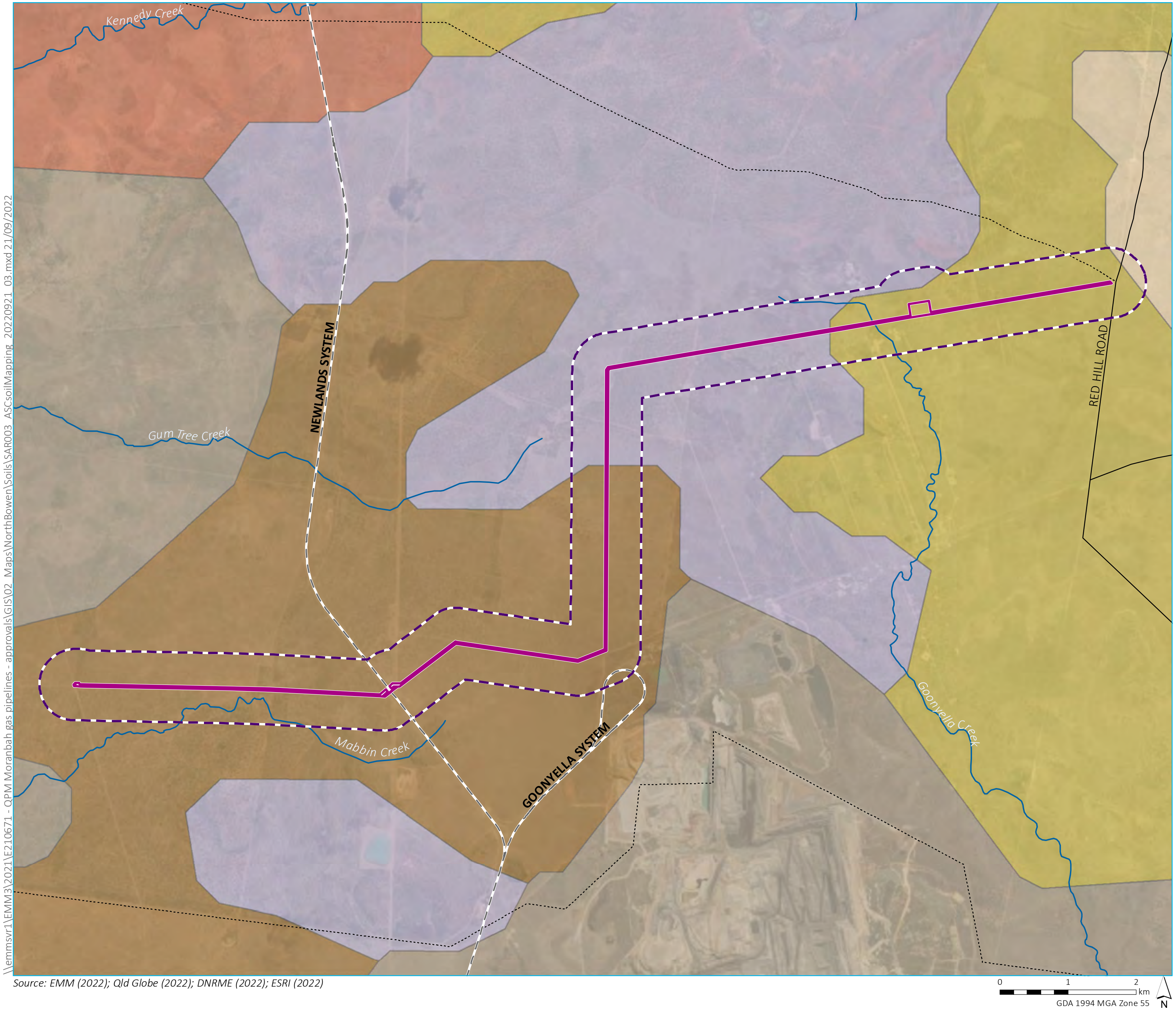
Source: EMM (2022); Qld Globe (2022); DNRME (2022); ESRI (2022)

Atlas of soils mapping

QPM Energy Project
Soils
Figure 5.1

EMM creating opportunities



Source: EMM (2022); Qld Globe (2022); DNRME (2022); ESRI (2022)

KEY
Proposed disturbance footprint
Study area (500 m buffer)
Rail line
Minor road
Vehicular track
Named watercourse
ASC soil mapping
CC33 - Vertosol
Ke19 - Vertosol
MM7 - Vertosol
My28 - Kandosol
Sl21 - Sodosol
Va52 - Sodosol

ASC soil mapping

QPM Energy Project
Soils
Figure 5.2

EMM
creating opportunities

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5.5 Land systems mapping

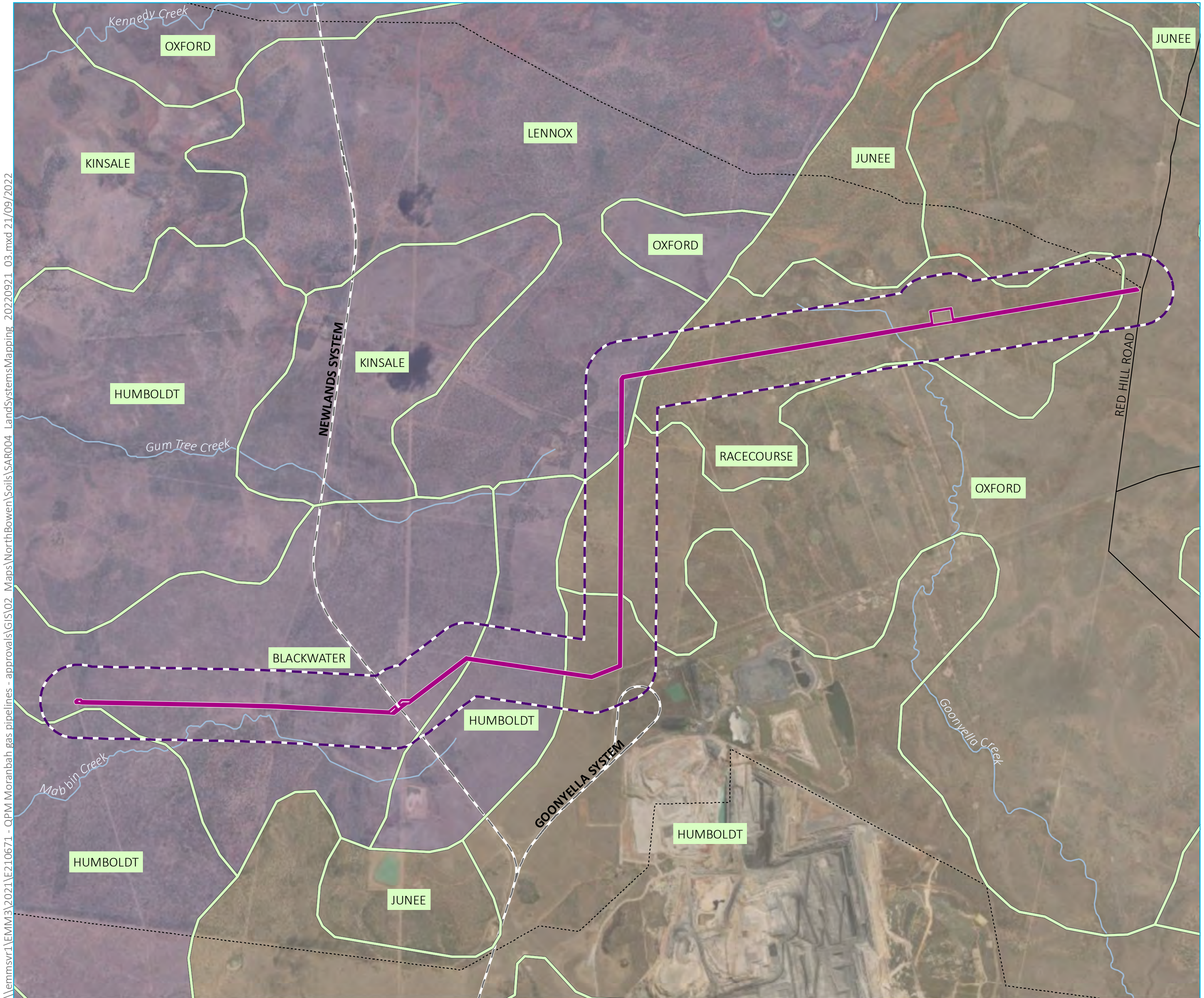
Numerous soil and land assessments have been completed for Queensland, predominantly in the form of land systems mapping based on patterns of geology, topography, soils and vegetation over large areas. The study area lies on the boundary of two such surveys:

- land systems of the Nogoa-Belyando area (Gunn *et al* 1967); and
- land systems of the Isaac-Comet area, Central Queensland (Story *et al* 1967).

Table 5.3 describes the land mapping systems that are intercepted by the study area and also illustrated in Figure 5.3.

Table 5.3 Land systems

Land system	Map unit	Description	Land system survey
Humboldt	Hu	Blackbutt (*Eucalyptus pilularis*) and Brigalow (*Acacia harpophylla*) on weathered clay plains occurring in most parts of the area; texture contrast and cracking clay soils.	Nogoa-Belyando and Isaac-Comet
Blackwater	Bl	Brigalow (*A. harpophylla*) plains and cracking clay soils on weathered Tertiary clay and older rocks along the central axis of the area.	Nogoa-Belyando
Oxford	O	Downs and cracking clay soils on slightly weathered or unweathered basalt widespread throughout the area.	Isaac-Comet
Lennox	Le	Gently undulating uplands and plains with silver-leaved ironbark woodland and yellow and red earths on intact Tertiary land surface.	Nogoa-Belyando
Racecourse	R	Softwood scrub and brigalow lowlands with cracking clay soils on weathered basalt, mainly in the south.	Isaac-Comet



Source: EMM (2022); Qld Globe (2022); DNRME (2022); ESRI (2022)

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KEY

- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse
- Land systems mapping units

Land systems mapping

- Nogoa-Belyando (ZCQ2)
- Isaac-Comet (ZDK3)

Land systems mapping

QPM Energy Project
Soils
Figure 5.3

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5.6 Geology

Based on detailed 1:100,000 scale surface geological mapping available on QLD Globe[1] (DNRME 2020a), the study area is characterized predominantly by Late Tertiary and Quaternary unconsolidated sediments (colluvium and alluvium). Key geological units include:

- Late Tertiary and Quaternary alluvium (Tqa) comprising red-brown mottled, poorly consolidated sand, silt, clay and minor gravels are dominant surface unit in the western half of the study area;
- Late Tertiary and Quaternary colluvium and residual deposits (TQr>Tb) is the dominant surface unit in the eastern portion of the study area (including the GCF) and consists of clay, silt, sand, gravel and soil;
- Tertiary Basalt (Tb) is mapped along a section of the proposed high-pressure pipeline to the west of the GCF; and
- underlaying much of the Project footprint (but of limited relevance due to the depth of disturbance) is the sedimentary units of the Permo-Triassic aged Bowen Basin.

While there are no registered bores located in the study area, drillers logs from four registered bores approximately 900 m to the east of the proposed high-pressure pipeline centreline (bores 81152, 162179, 81093 and 81151) indicate that the base of the alluvium occurs at depths from 60 m below ground level (mBGL) to 80 mBGL. Near the eastern portion of the proposed high-pressure pipeline and GCF, registered bores 162630, 162631 and 162632 approximately 900 m to 1,700 m to the south indicated compacted fill/topsoil and alluvium to approximately 1.0 to 4.5 mBGL depth. Basalt and mudstone were then encountered underlying this thin alluvium layer.

Local geology is shown in Figure 5.4.

Table 5.4 Regional geology

Geological unit	Map unit	Geological description	Age
TQr-QLD	TQr	Clay, silt, sand, gravel and soil; colluvial and residual deposits (generally on older land surfaces).	Late Tertiary to Quaternary
TQr\f-QLD	TQr\f	Older residual soils, colluvium (ferruginous).	Late Tertiary to Quaternary
TQr\f-QLD> Back Creek Group	TQr\f>Pb	Older residual soils, colluvium (ferruginous).	Late Tertiary to Quaternary
TQr\f-QLD>Tb-QLD	TQr\f>Tb	Clay, silt, sand, gravel and soil; colluvial and residual deposits (generally on older land surfaces).	Late Tertiary to Quaternary
TQa-QLD	TQa	Locally red-brown mottled, poorly consolidated sand, silt, clay, minor gravel; high-level alluvial deposits (generally related to present stream valleys but commonly dissected).	Late Tertiary to Quaternary
Suttor Formation	Tu	Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt.	Paleocene to Eocene
Tb-QLD	Tb	Mostly olivine basalt flows and some plugs; some areas of nephelinite, basanite etc.	Tertiary

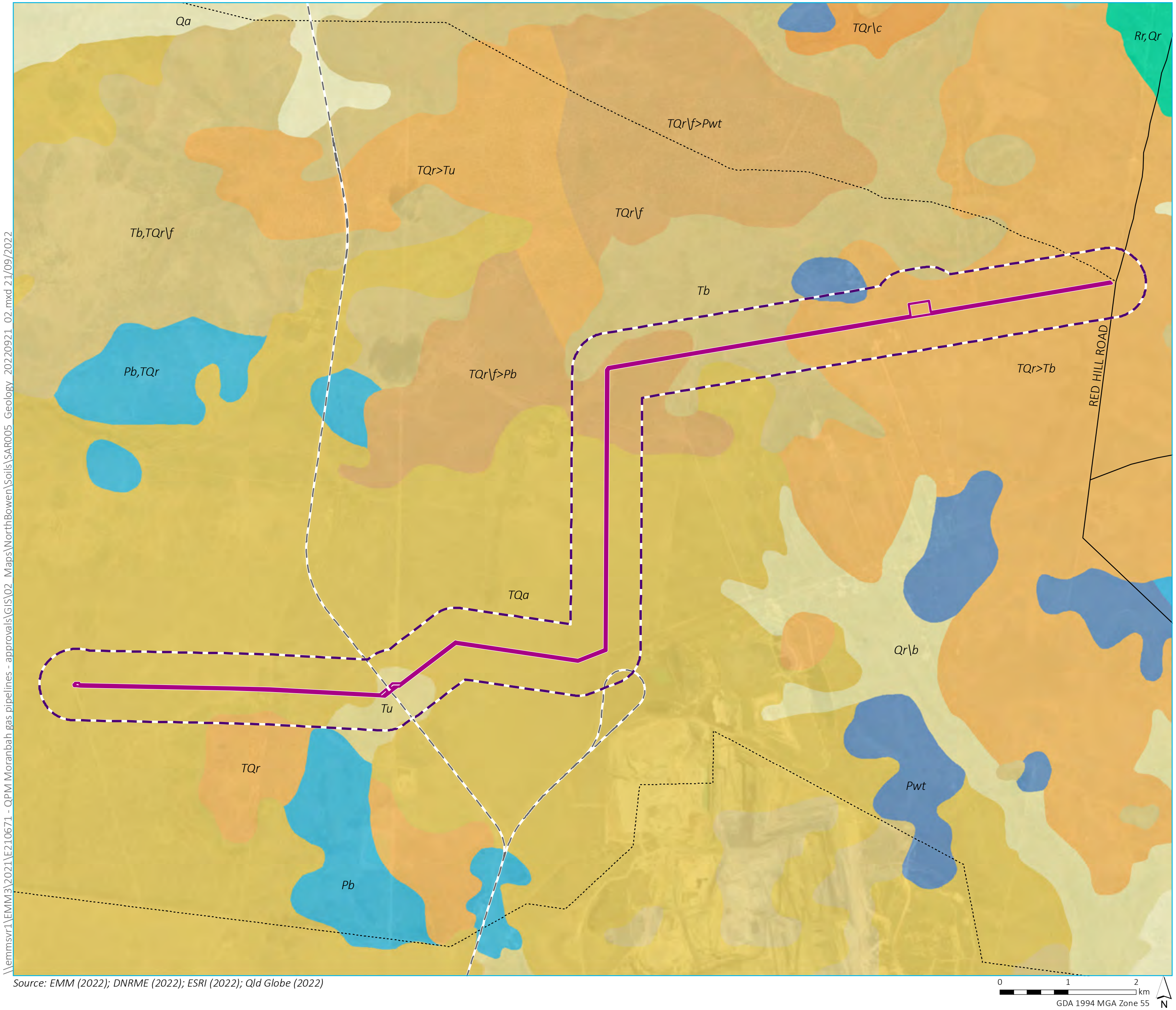
[1] Accessed on 12 July 2022 at https://qldglobe.information.qld.gov.au/

Table 5.4 Regional geology

Geological unit	Map unit	Geological description	Age
Fort Cooper Coal Measures	Pwt	Lithic sandstone, conglomerate, mudstone, carbonaceous shale, coal, tuff, tuffaceous (cherty) mudstone.	Late Permian
Back Creek Group	Pb	Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite.	Early to late Permian

5.7 Acid sulfate soils

There are no ASS mapped in the study area, as per the *Guidelines for the Use of Acid Sulfate Soil Risk Maps* (DLWC 1998). The Australian Soil Resource Information System (ASRIS) ASS mapping (Fitzpatrick *et al*. 2011) has mapped the study area as Cq (p4), Extremely Low Probability of Occurrence, the lowest probability allocation. Inland (ASS) theoretically has the potential to occur within the study area in association with any waterway where suitable conditions prevail (such as sulfate salinised areas in inland regions with anoxic conditions and abundant organic matter). Such conditions are generally rare and associated predominantly with sustained anoxic aquatic environments, like inland lakes, not minor ephemeral waterways which characterise the study area, and therefore was not considered within scope.



Source: EMM (2022); DNRME (2022); ESRI (2022); Qld Globe (2022)

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Geology

QPM Energy Project
Soils
Figure 5.4

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6 Field survey results

6.1 Soil profile classes

Soil profiles were described at 27 locations. The soil at each detailed site was classified using the Australian Soil Classification ('ASC', Isbell & NCST 2021). Soils with comparable profiles determined by similar morphological properties, physico-chemical properties, parent material, representative landforms and geomorphological position in the landscape were grouped into soil profile classes (McKenzie *et al*. 2008).

Soils across the Project footprint were grouped into three soil profile classes (SPC), with one soil phase subdivision, based primarily on classification under the ASC, with the site consisting predominantly of cracking clay Vertosols and smaller areas of deep, apedal Kandosols, and non-cracking clay Dermosols, generally consistent with regional soil mapping described in Section 2.

Table 6.1 Soil profile classes

SPC	Brief description	Typical ASC	Landform	Sites
1	Deep cracking clays with cracks and self-mulching surfaces of light medium clays to subsoils of medium clay.	Vertosol	Level or very gently undulating clay plains	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 21, 26, 27
1a	Deep cracking clays with gilgai microrelief on cracking and self-mulching surfaces of light medium clays to subsoils of medium clay.	Vertosol	Level or very gently undulating clay plains	8, 16
2	Deep non-cracking clay loams with common sandy textures.	Dermosol	Level or very gently undulating clay plains	6
3	Deep, weakly structured red soils with soft surfaces of sandy clay loams over subsoils of clay loams with sandy textures.	Kandosol	Gently undulating lands with broad ridge crests and low rises	20, 22, 23, 24, 25

6.1.1 SPC01: Deep cracking clays

Typically, the SPC01 soils have soft to firm, commonly self-mulching and cracking, topsoils of black, light medium clays over moderately to strongly structured black subsoils of medium clays. Coarse fragments are common throughout the profile consisting of few, subangular fine gravelly fragments on the surface and topsoils becoming common to many subangular coarse gravel in the subsoils.

Site QPM01 is classified as a Black Vertosol and is a representative profile of a deep cracking clay. The profile description of QPM01 and typical landform characteristics of SPC01 are described in Table 6.2.

Table 6.2 SPC01 typical landform and representative profile description

Landform			
Slope:	0%	**Runoff:**	Very slow
Morphological type:	Flat	**Permeability:**	Slowly permeable
Landform element:	Plain	**Drainage:**	Imperfectly drained
Landform pattern:	Plain	**Surface condition:**	Firm, cracking (5–10 mm)

Table 6.2 SPC01 typical landform and representative profile description

Landform			
Relief modal class:	Level plain	**Disturbance:**	Complete clearing; pasture
Surface coarse fragments:	<2% subangular coarse fragments of 2–6 mm	**Rock outcrop:**	–
Vegetation:	Pasture grass species and Brigalow (*Acacia harpophylla*). Groundcover of 80–100%.		

QPM01 – Soil profile (surface left)

QPM01 – landscape

Profile description:			
Easting:	-21.6671812	Northing:	147.8757234
ASC Soil Order:	Black Vertosol	Site ID:	QPM01

Horizon	Depths (m)	Description
A1 – topsoil	0.00–0.10	Very dark greyish brown (10YR 3/2); light medium clay; 2–10% subangular coarse fragments of 2–6 mm; weak 2–5 mm subangular blocky structure; pH 7.5; gradual change to –
B21 – subsoil	0.10–0.35	Very dark brown (10YR 2/2); medium clay; 10–20% subangular coarse fragments of 6–20 mm; moderate 5–10 mm polyhedral structure; pH 8.5; gradual change to –
B22 – subsoil	0.35–0.60	Very dark brown (10YR 2/2); medium clay; 10–20% subangular coarse fragments of 20–60 mm; strong 10–20 mm polyhedral structure; pH 8.5; gradual change to –
B23 – subsoil	0.60–1.0	Very dark brown (10YR 2/2); medium heavy clay; 10–20% subangular coarse fragments of 20–60 mm; strong 10–20 mm polyhedral structure; pH 9.0.

i SPC01: Soil chemistry

Chemically, the SPC01 topsoils are moderately to highly fertile, with low to moderate total nitrogen and organic carbon, and moderate to very high levels of phosphorous and exchangeable potassium.

The topsoils are consistently non-sodic (exchangeable sodium percentage (ESP) <6%) with very low to low salinity. Topsoil pH is slightly alkaline becoming generally strongly alkaline throughout the subsoil. The subsoils show increased salinity and sodicity constraints with depth, becoming generally moderately saline and sodic (ESP >6% but <15%) by 0.6 mBGL and reaching very highly saline and strongly sodic (ESP >15%) by 1.0 mBGL.

Cation exchange capacity (CEC) is high (>15 cmol(+)/kg) throughout the profiles though increases with depth. CEC balance is poor, with consistently deficient calcium and elevated magnesium, resulting in poor calcium:magnesium (Ca:Mg) ratio. Sodium levels are consistently elevated (>1%) but are non-sodic in the topsoils, whilst potassium is variable, being elevated in some topsoils and deficient in others.

The topsoils are calcium (Ca) low. Ca:Mg ratio decreases with depth to Ca deficient by 0.6 mBGL whilst Emerson Class is 3a (severe dispersion of remoulded soil) in the topsoil and 3b (moderate dispersion of remoulded soil) and 4 (no dispersion, presence of carbonate or gypsum) throughout the subsoils, indicating the potential for soil dispersion and the presence of carbonate or gypsum respectively.

Table 6.3 SPC01 soil chemistry summary

Depths (m)	pH	Texture	Cation balance and Ca:Mg	Salinity	Sodicity
0.00–0.10	Slightly alkaline	Light medium clay	Poor and Ca low	Low	Non-sodic, non-dispersive
0.10–0.60	Moderately to strongly alkaline	Medium clay	Poor and Ca low to deficient	Moderate	Non-sodic to sodic, potentially dispersive
0.60–1.0	Strongly alkaline	Medium clay	Poor and Ca deficient	Very high	Strongly sodic, dispersive

ii SPC01: key features

The key features of SPC01 include;

- cracking or self-mulching topsoils;
- uniform textured soil profiles of well-structured light medium clays or heavier; and
- moderate to high soil fertility and typically highly constrained saline and sodic subsoils at depth.

6.1.2 SPC01a: Deep cracking clays with gilgai microrelief

Typically, the SPC01a soils have soft, commonly self-mulching and cracking, topsoils of black, light medium clays over moderately to strongly structured black subsoils of medium clays. Coarse fragments are common on the surface, consisting of few, subangular fine gravelly fragments and are occasionally present in the subsoils becoming common to many subangular coarse gravel in the subsoils.

The varying characteristic of this SPC *phase* is the presence of gilgai microrelief, repeated mounds and depressions formed from the wetting and drying cycles of the shrink well nature of cracking clay soils. The variation of drying and wetting between the mounds and depressions often results in varying soil characteristics at a very fine scale (<10 m) due to different soil drainage within the gilgai.

Site QPM08 is classified as a Black Vertosol and is a representative profile of a deep cracking clay with gilgai microrelief. The profile description of QPM08, for both a mound and a depression, and typical landform characteristics of SPC01a are described in Table 6.4.

Table 6.4 SPC01a typical landform and profile description

Landform			
Slope:	0%	**Runoff:**	Very slow
Morphological type:	Flat, Gilgai microrelief	**Permeability:**	Slowly permeable
Landform element:	Plain	**Drainage:**	Imperfectly drained
Landform pattern:	Plain	**Surface condition:**	Firm, cracking (5–10 mm)
Relief modal class:	Level plain	**Disturbance:**	Complete clearing; pasture
Surface coarse fragments:	2–10% coarse fragments of 2–6 mm	**Rock outcrop:**	–
Vegetation:	Pasture grass species and Brigalow (*Acacia harpophylla*). Groundcover of 80–100%.		

QPM08 depression – Soil profile (surface left)

QPM08 – landscape

Profile description:			
Easting:	-21.66212187	**Northing:**	147.938586
ASC Soil Order:	Black Vertosol	**Site ID:**	QPM08 - depression

Horizon	Depths (m)	Description
A1 – topsoil	0.00–0.10	Very dark brown (10YR 2/2); light medium clay; 10–20% coarse fragments of 2–6 mm; moderate 2–5 mm subangular blocky structure; pH 7.0; gradual change to –
B21 – subsoil	0.10–0.50	Very dark brown (10YR 2/2); light medium clay; moderate 5–10 mm subangular blocky structure; pH 7.0; gradual change to –
B22 – subsoil	0.50–0.80	Very dark brown (10YR 2/2); medium clay; moderate 5–10 mm subangular blocky structure; pH 7.0; gradual change to –
B23 – subsoil	0.80–1.0	Very dark brown (10YR 2/2); medium clay; moderate 10–20 mm polyhedral structure; pH 7.0.

Table 6.4 SPC01a typical landform and profile description

Landform	
	
QPM08 mound – Soil profile (surface left)	**QPM08 – landscape**

Profile description:

Easting:	-21.66205831	**Northing:**	147.9386511
ASC Soil Order:	Black Vertosol	**Site ID:**	QPM08 - mound

Horizon	Depths (m)	Description
A1 – topsoil	0.00–0.10	Very dark brown (10YR 2/2); clay loam sandy; 2–10% coarse fragments of 2–6 mm; strong 2–5 mm subangular blocky structure; pH 7.0; gradual change to –
B21 – subsoil	0.10–0.45	Very dark brown (10YR 2/2); light medium clay; strong 5–10 mm subangular blocky structure; pH 8.0; gradual change to –
B22 – subsoil	0.45–0.60	Very dark brown (10YR 2/2); medium clay; strong 10–20 mm polyhedral structure; pH 8.5; gradual change to –
B23 – subsoil	0.60–0.80	Very dark brown (10YR 2/2); medium clay; strong 10–20 mm polyhedral structure; pH 8.0.

i SPC01a: Soil chemistry

Due to the variable soil drainage associated with gilgai microrelief, soil chemistry is often particularly variable between the mounds and depressions and as such has been described separately below.

a Mounds

Chemically, the SPC01a mound topsoils have moderate fertility, with very low to low phosphorous, moderate total nitrogen and organic carbon, and moderate to high levels of exchangeable potassium.

The topsoils are non-sodic to sodic with very low to low salinity. Topsoil pH is slightly alkaline becoming moderately alkaline throughout the subsoil. The subsoils show increased salinity and sodicity constraints with depth though this is variable in its intensity. QPM08 is strongly sodic with very high to extreme salinity throughout the subsoil whilst QPM16 was moderately saline and sodic by 0.6 mBGL, reaching highly saline by 0.8 mBGL.

CEC is high throughout the profiles. CEC balance is poor, with generally deficient calcium and elevated magnesium, resulting in poor Ca:Mg ratio. Sodium levels are consistently elevated (>1%) but are non-sodic in the topsoils and some subsoils, whilst potassium is deficient.

Ca:Mg ratio is predominantly Ca low and decreases with depth to Ca deficient by 0.7 mBGL in QPM08 whilst Emerson Class is commonly 3a and 3b with some class 5 in the QPM16 topsoils, indicating the potential for soil dispersion.

b Depressions

Chemically, the SPC01a depression topsoils have low fertility, with very low to low phosphorous, low total nitrogen and organic carbon, and high to very high levels of exchangeable potassium.

The topsoils are non-sodic to sodic with very low salinity. Soil pH is slightly to moderately alkaline throughout, being most alkaline between 0.2–0.6 mBGL and becoming slightly acid at depth (0.9–1.0 mBGL) at QPM08. The subsoils show increased salinity and sodicity constraints with depth though the increase is variable in its intensity. QPM08 upper subsoil (02–0.3 mBGL) is sodic with moderate salinity, becoming strongly sodic and highly to very highly saline below 0.5 mBGL, whilst QPM16 was low to moderately saline and sodic to 0.6 mBGL, reaching very highly saline and strongly sodic 0.9 mBGL.

CEC is high (>15 cmol(+)/kg) throughout the profiles. CEC balance is poor, with predominantly deficient calcium, especially in the subsoils, and elevated magnesium throughout, resulting in poor Ca:Mg ratio. Sodium levels are consistently elevated (>1%) but are non-sodic in some topsoils, whilst potassium is deficient.

Ca:Mg ratio is consistently Ca low, near Ca deficient, and decreases with depth whilst Emerson Class is commonly 3b with some class 3a and 5, indicating the potential for soil dispersion.

c Summary

Clear variations in soil chemistry between the mounds and depressions present on site are obscured by the variation in soil constraints seen between the sites of QPM08 and QPM16, with QPM08 typically showing more intense constraints of salinity and sodicity. QPM16 has less variation between mounds and depression than QPM08.

Soil fertility levels are seen to be typically lower in the depressions than the mounds, predominantly due to low levels of total nitrogen and organic carbon compared to moderate levels in the mounds.

The variation seen between the mounds and depression of QPM08 is typical of that expected in gilgai, with lower pH, salinity and soil fertility due to periodic waterlogging and higher drainage, whilst the mounds comparatively exhibit higher pH, sodicity and extremely high salinity and chloride levels even at shallow depths (0.2–0.3 mBGL) where levels are comparable to those seen at depth in the depressions (0.9–1.0 mBGL).

Table 6.5 SPC01a soil chemistry summary - mounds

Depths (m)	pH	Texture	Cation balance and Ca:Mg	Salinity	Sodicity
0.00–0.10	Slightly alkaline	Light medium clay	Poor and Ca low	Very low to low	Non-sodic to sodic, potentially dispersive
0.10–0.50	Moderately alkaline	Medium clay	Poor and Ca low to deficient	Low to very high	Non-sodic to strongly sodic, potentially dispersive
0.50–1.0	Moderately alkaline	Medium clay	Very poor and Ca deficient	Very high to extreme	Sodic to strongly sodic, dispersive

Table 6.6 SPC01a soil chemistry summary - depressions

Depths (m)	pH	Texture	Cation balance and Ca:Mg	Salinity	Sodicity
0.00–0.10	Slightly to moderately alkaline	Clay loam to light medium clay	Poor and Ca low	Very low	Non-sodic to sodic, potentially dispersive
0.10–0.50	Slightly to moderately alkaline	Medium clay	Poor and Ca low	Low to moderate	Sodic, potentially dispersive
0.50–1.0	Slightly acid to moderately alkaline	Medium clay	Poor and Ca low	Moderate to very high	Strongly sodic, dispersive

ii SPC01a: key features

They key features of SPC01a include;

- cracking or self-mulching topsoils;
- uniform textured soil profiles of light medium clays or heavier;
- presence of gilgai microrelief;
- variable soil chemistry between gilgai mounds and depressions; and
- low to moderate soil fertility and typically highly constrained saline and sodic subsoils.

6.1.3 SPC02: Deep non-cracking clay loams

The soils of SPC02 have a soft surface consisting of brown, massive to weakly structured sandy clay loams over weakly to moderately structured red subsoil of clay loams with sandy textures. Coarse fragments are common on the surface and in the topsoil, consisting of very few, rounded fine gravelly fragments and are present in the subsoils as very slightly, rounded fine gravel.

Site QPM06 is classified as a Red Dermosol and is a representative profile of a deep non-cracking clay. The profile description of QPM06 and typical landform characteristics of SPC02 are described in Table 6.7.

Table 6.7 SPC02 typical landform and profile description

Landform			
Slope:	0%	**Runoff:**	Very slow
Morphological type:	Flat	**Permeability:**	Slowly permeable
Landform element:	Plain	**Drainage:**	Moderately well drained
Landform pattern:	Plain	**Surface condition:**	Soft
Relief modal class:	Level plain	**Disturbance:**	Complete clearing; pasture
Surface coarse fragments:	<2% coarse fragments of 2–60 mm	**Rock outcrop:**	–

Table 6.7 SPC02 typical landform and profile description

Landform			
Vegetation:	Pasture grass species and Brigalow (*Acacia harpophylla*). Groundcover of 80–100%.		

QPM06 – Soil profile (surface left) **QPM06 - landscape**

Profile description:			
Easting:	-21.6677567	**Northing:**	147.9199477
ASC Soil Order:	Red Dermosol	**Site ID:**	QPM06

Horizon	**Depths (m)**	**Description**
A1 – topsoil	0.00–0.10	Strong brown (7.5YR 4/6); sandy clay loam; <2% rounded coarse fragments of 2–6 mm; massive to weak <2 mm subangular blocky structure; pH 7.0; gradual change to –
B21 – subsoil	0.10–0.30	Yellowish red (5YR 4/6); clay loam sandy; 2–10% rounded coarse fragments of 2–6 mm; weak 2–5 mm subangular blocky structure; pH 8.0; gradual change to –
B22 – subsoil	0.30–0.80	Yellowish red (5YR 4/6); clay loam sandy; 2–10% rounded coarse fragments of 2–6 mm; weak to moderate 2–5 mm subangular blocky structure pH 8.5–9.0.

i SPC02: Soil chemistry

Chemically the SPC02 topsoils have moderate fertility, with moderate levels of total nitrogen, phosphorous and organic carbon and high levels of exchangeable potassium.

The topsoils are non-sodic with low salinity. Topsoil pH is slightly acid becoming slightly to strongly alkaline throughout the subsoil. The subsoils show increased salinity and sodicity constraints with depth, being strongly sodic throughout and becoming moderately saline by 0.6 mBGL.

CEC is moderate (5–15 cmol(+)/kg) in the topsoil and subsoil though increases with depth to high at depths of 0.7 mBGL. CEC balance is poor, with consistently deficient calcium and highly elevated magnesium (35–50% of CEC), resulting in poor Ca:Mg ratio. Sodium levels are consistently elevated (>1%) but are non-sodic in the topsoils and highly sodic (20–37%) in the subsoils, whilst potassium is sufficient in topsoil and deficient in the subsoil.

The topsoils are calcium (Ca) low Ca:Mg ratio and Ca:Mg ratio decreases with depth to be Ca deficient throughout the subsoil. Emerson Class is 8 in the topsoil and 1 throughout the subsoils, indicating the high potential for soil dispersion in the subsoil.

Table 6.8 SPC02 soil chemistry summary

Depths (m)	pH	Texture	Cation balance and Ca:Mg	Salinity	Sodicity
0.00–0.10	Slightly acid	Sandy clay loam	Poor and Ca low	Low	Non-sodic, non-dispersive
0.10–0.50	Slightly alkaline	Clay loam sandy	Very poor and Ca deficient	Low	Strongly sodic, strongly dispersive
0.50–1.0	Moderately alkaline	Clay loam sandy	Very poor and Ca deficient	Moderate	Strongly sodic, strongly dispersive

ii SPC02: key features

They key features of SPC02 include;

- non-cracking topsoils;
- uniform textured soil profiles of clay loams with sandy textures;
- weak to moderate subsoil structure; and
- moderately soil fertility and high constrained sodic subsoils.

6.1.4 SPC03: Deep, weakly structured red clay soils

Typically, the SPC03 soils have soft to firm, topsoils of brown, massive, sandy clay loams to light clays over weakly structured brown to red subsoils of clay loams with sandy textures. Coarse fragments are common on the soil surface consisting of very, fine to medium gravelly fragments and are occasionally present throughout the soil profile, becoming very few subangular fine gravel.

Site QPM20 is classified as a Red Kandosol and is a representative profile of a deep, weakly structured red clay. The profile description of QPM20 and typical landform characteristics of SPC03 are described in Table 6.9.

Table 6.9 SPC03 typical landform and profile description

Landform			
Slope:	1–2%	**Runoff:**	Slow
Morphological type:	Simple slope	**Permeability:**	Moderately permeable
Landform element:	Plain	**Drainage:**	Moderately well drained
Landform pattern:	Plain	**Surface condition:**	Soft to firm
Relief modal class:	Gently undulating plain	**Disturbance:**	Complete clearing; pasture
Surface coarse fragments:	50–90% coarse fragments of 2–6 mm	**Rock outcrop:**	–
Vegetation:	Clarkson's Bloodwood (*Corymbia clarksoniana*), Narrow-leaved Bottle Tree (*Brachychiton rupestris*), False Sandalwood (*Eremophila mitchellii*). Groundcover of 60–80%.		

Table 6.9 SPC03 typical landform and profile description

Landform

	
QPM20 – Soil profile (surface left)	**QPM20 – landscape**

Profile description:

Easting:	-21.63175035	**Northing:**	147.9508575
ASC Soil Order:	Red Kandosol	**Site ID:**	QPM20

Horizon	Depths (m)	Description
A1 – topsoil	0.00–0.10	Strong brown (7.5YR 4/6); sandy clay loam; massive; pH 6.0; gradual change to –
B21 – subsoil	0.10–0.50	Yellowish red (5YR 4/6); sandy clay loam; massive; pH 6.0; gradual change to –
B22 – subsoil	0.50–1.0	Yellowish red (5YR 4/6); clay loam sandy; weak 5–10 mm subangular block structure; pH 6.0.

i SPC03: Soil chemistry

Chemically the SPC03 topsoils have moderate fertility, with low levels of phosphorous and organic carbon, moderate total nitrogen and high levels of exchangeable potassium.

The soil chemistry reflects their uniform physical characteristics, being consistent throughout the profile. The soils are consistently slightly acid, non-sodic with very low salinity.

CEC is moderate (5–15 cmol(+)/kg) through the profile though decreases with depth to be near low levels (<5 cmol(+)/kg). CEC balance is generally good, with consistently sufficient calcium and some elevated magnesium increasing with depth, resulting in decreasing Ca:Mg ratio. Sodium levels are consistently elevated (>1%) but are non-sodic, whilst potassium is sufficient until depths of 0.9 mBGL.

The topsoils are Mg low Ca:Mg ratio and Ca:Mg ratio decreases with depth to be balanced by 0.2 mBGL and Ca low below 0.5 mBGL. Emerson Class is 3a in the topsoil and 5 throughout the subsoils, indicating the potential for limited soil dispersion.

Table 6.10 SPC03 soil chemistry summary

Depths (m)	pH	Texture	Cation balance and Ca:Mg	Salinity	Sodicity
0.00–0.10	Slightly acid	Sandy clay loam	Good and Mg low	Very low	Non-sodic, non-dispersive
0.10–0.50	Slightly acid	Sandy clay loam	Good and balanced	Very low	Non-sodic, non-dispersive
0.50–1.0	Slightly acid	Clay loam sandy	Moderate and Ca low	Very low	Non-sodic, non-dispersive

ii SPC03: key features

They key features of SPC03 include;

- deep red profile;
- massive to weak soil structure;
- uniform textured soil profiles of clay loams with sandy textures; and
- moderate soil fertility and benign soil chemistry, with no salinity or sodicity.

6.2 Soil mapping units

Soils across the Project footprint, grouped into SPCs, were subsequently mapped into two soil mapping units (SMU) reflecting the variation in soil type and landforms present and the ability to delineate the distribution of SPCs based on soil survey intensity (1:50,000 scale).

Of the two SMUs, one is a '*simple*' SMU, with one predominant soil type present and one is a '*complex*' SMU with (two or more SPCs present within these units that cannot be separated at the surveyed mapping scale).

Soil mapping across the Project footprint was extrapolated according to the results of the surveyed areas. It is important to note that boundaries between soil units are based on field observations at an intensity of 1 site per 1 km, and desktop digital aerial photographs/LiDAR DEM interpretation. Boundaries between soil units can be abrupt (within 10 m) or diffuse (>50 m) or somewhere in between. Owing to the natural variability between soil types, boundaries and landforms, the confidence levels of the mapped SMUs decreases with distance from the originally proposed and surveyed sites. Any conclusions or interpretations of the data collected from this survey and presented in this report can only serve as an indication of the type and distribution of soils and SMUs potentially present and should not be relied upon as a comprehensive (exhaustive) assessment across the Project footprint.

SMUs and the corresponding ASCs (after Isbell & NCST 2021) are summarised in Table 6.11 and presented in Figure 6.1.

Table 6.11 Soil mapping units

SMU	Soils	Landform and vegetation	Associations
A	Complex SMU consisting of *deep cracking clays* (SPC01), *deep cracking clays with gilgai microrelief* (SPC01a) and *deep non-cracking clay loams* (SPC02).	Level plains with predominantly flat (0–1%), occasionally gentle (1–3%), slopes associated with land cleared for pasture. Brigalow (*Acacia harpophylla*) regrowth.	Land systems – Humboldt, Blackwater, Oxford, Racecourse. Geology - alluvial surficial geology (TQr and TQa).
B	Simple SMU of *deep, weakly structured red clay soils* (SPC03).	Gently undulating plains with grades of between 1–3%.	Land systems – Lennox. Geology - basaltic surficial geology (Tb-QLD).

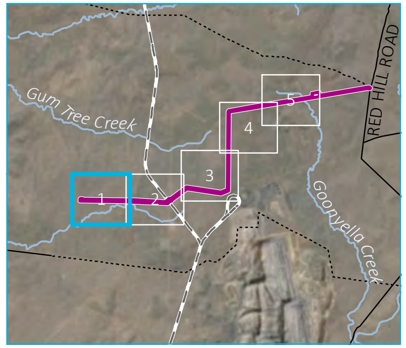
6.3 Project soil hazards

The soils present on site present a range of potential hazards, primarily due to subsoil constraints of salinity or sodicity. These constraints mean soil management, particularly around stripping, handling and backfill of subsoils, will need to be carefully managed to prevent any soil mixing or erosion.

SPC01 and SPC01a soils are both sodic and saline with poor cation balance, which results in the potential to disperse that will be temporarily limited by the high salinity, but consistent exposure to non-saline water will result in soil dispersion and subsequent erosion. The heavy clay textures and gilgai depressions will also result in limitations from poor soil drainage and waterlogging.

The SPC02 soils are less constrained by salinity but are strongly sodic and have poor cation balance and the lack of salinity results in subsoils highly prone to dispersion.

The SPC03 soils have no constraints relating to salinity or sodicity and pose much lower risk.



KEY

- Soil survey site
- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Soil mapping unit

- SMU A

Source: EMM (2022); Qld Globe (2022); DNRME (2022); ESRI (2022)

0 0.5 1 km

GDA 1994 MGA Zone 55

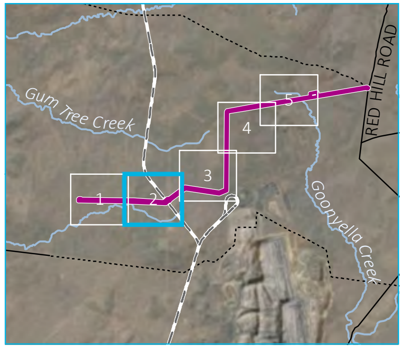
N

Soil mapping units
Map 1 of 5

QPM Energy Project
Soils
Figure 6.1

EMM
creating opportunities

Source: EMM (2022); Qld Globe (2022); DNRME (2022); ESRI (2022)



KEY

- Soil survey site
- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Soil mapping unit

- SMU A

Soil mapping units
Map 2 of 5

QPM Energy Project
Soils
Figure 6.1

EMM creating opportunities

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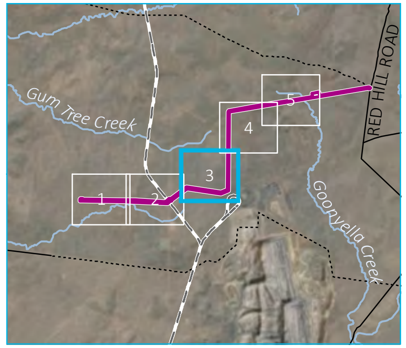
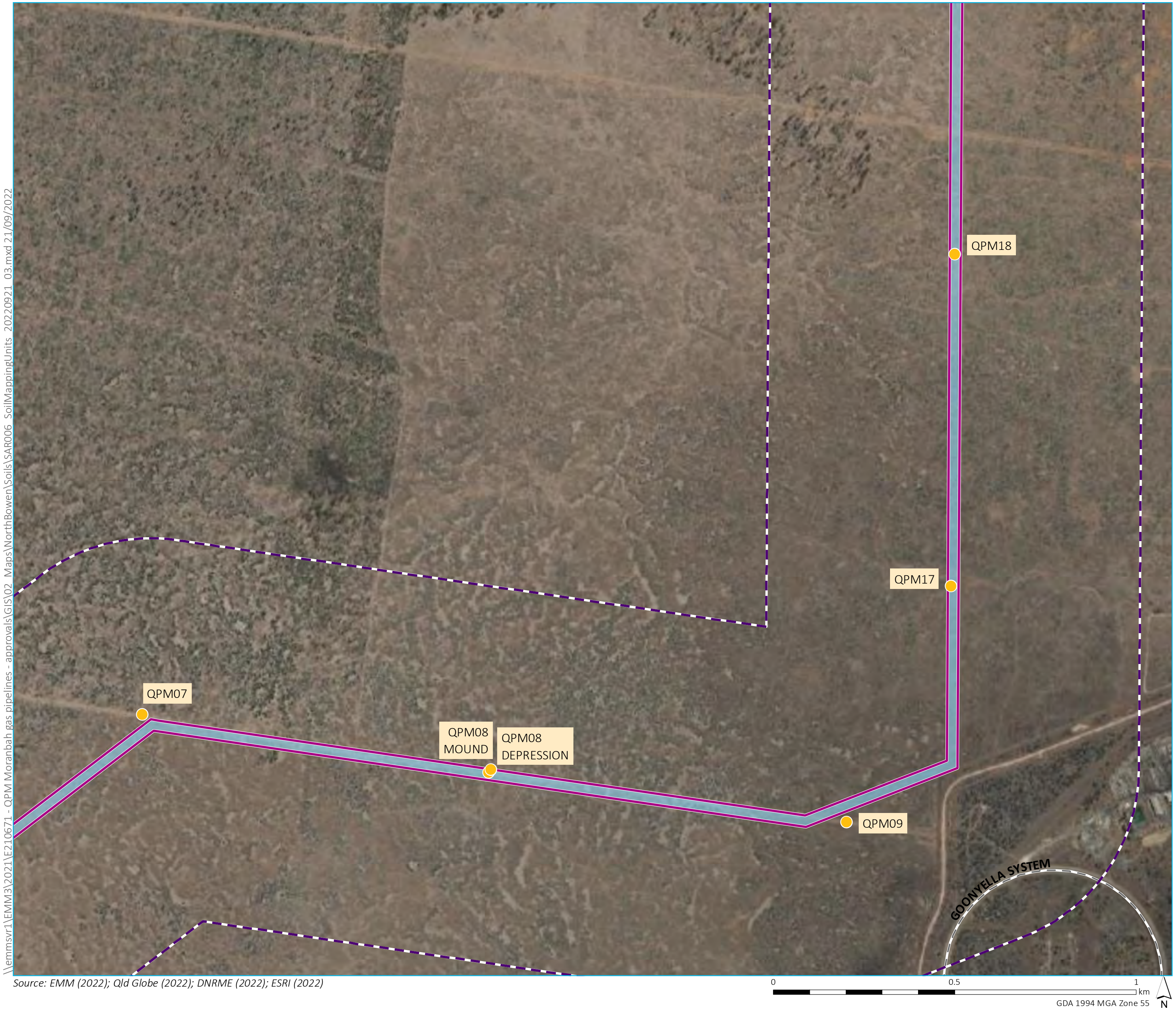


KEY

- Soil survey site
- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Soil mapping unit

- SMU A



Source: EMM (2022); Qld Globe (2022); DNRME (2022); ESRI (2022)

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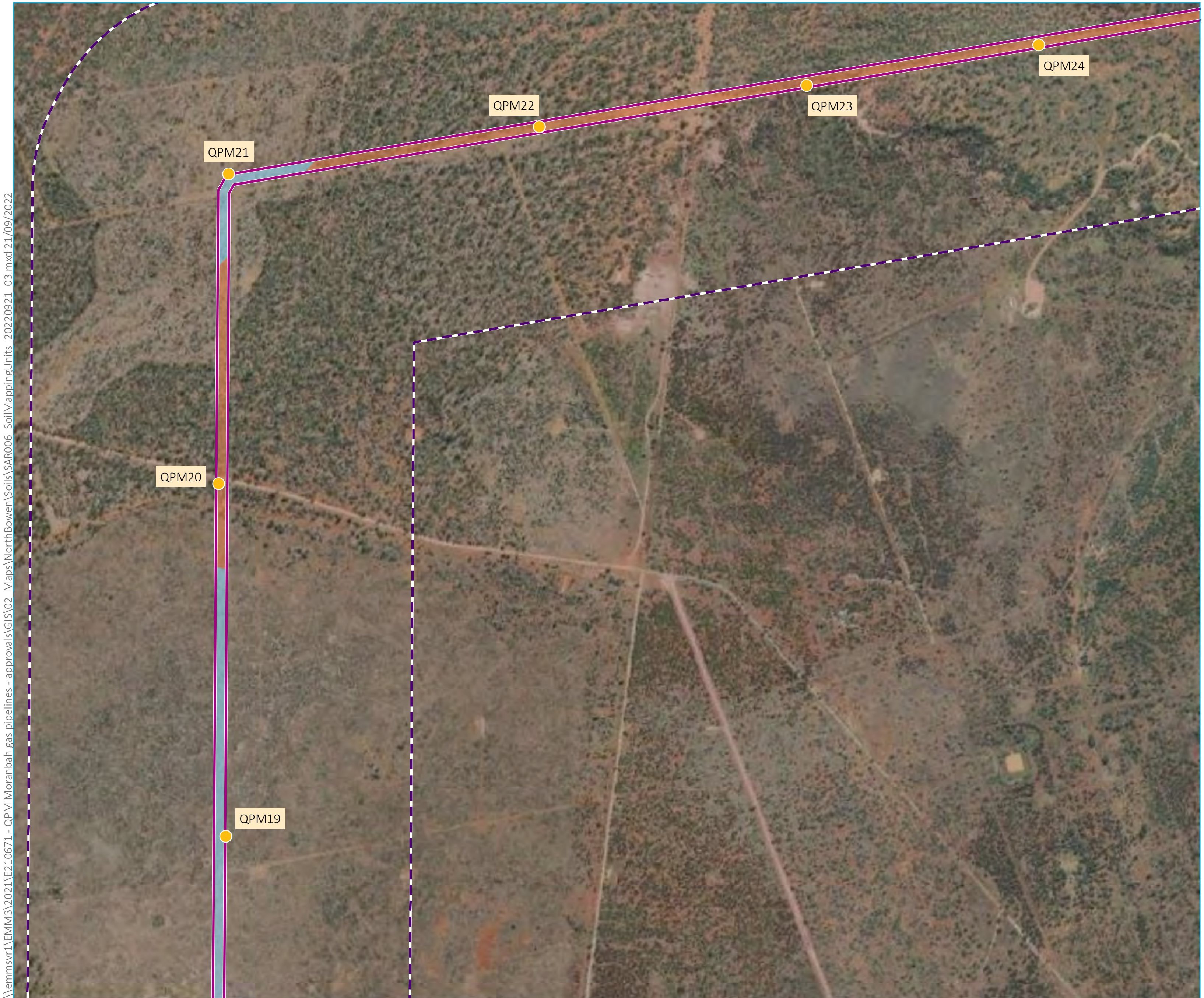
Soil mapping units
Map 3 of 5

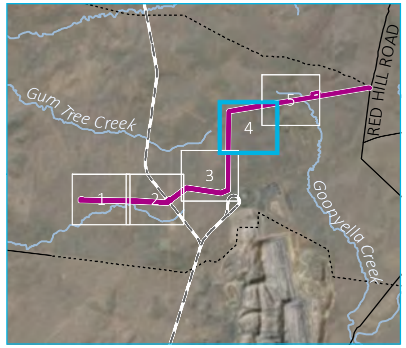
QPM Energy Project
Soils
Figure 6.1

creating opportunities



Source: EMM (2022); Qld Globe (2022); DNRME (2022); ESRI (2022)

0 0.5 1 km
GDA 1994 MGA Zone 55
N



KEY

- Soil survey site
- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Soil mapping unit

- SMU A
- SMU B

Soil mapping units
Map 4 of 5

QPM Energy Project
Soils
Figure 6.1

EMM creating opportunities

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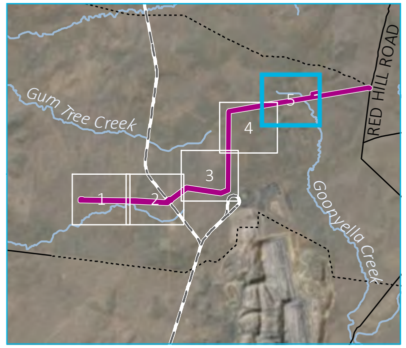
Source: EMM (2022); Qld Globe (2022); DNRME (2022); ESRI (2022)



KEY

- Soil survey site
- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Soil mapping unit

- SMU A
- SMU B

Soil mapping units
Map 5 of 5

QPM Energy Project
Soils
Figure 6.1

creating opportunities

7 Erosion risk assessment

An erosion risk assessment has been undertaken for the Project footprint in accordance with IECA, 2008 and IECA, 2015, to establish the baseline conditions relevant to erosion risk and provide guidance on the need and type of erosion and sediment control measures required and the design standards for control measures.

7.1 Erosion risk assessment methodology

An erosion risk assessment has been undertaken using the following parameters (refer Table 7.1):

- slope steepness;
- soil dispersion;
- duration of disturbance;
- estimated soil loss;
- rainfall erosivity; and
- the sensitivity of receiving waters to turbidity levels.

Table 7.1 shows each of the erosion risk parameters and their respective ratings. The specifics ratings for the Project footprint are described in Sections 7.1.1 to 7.1.5.

Table 7.1 Project erosion risk parameters

Erosion Risk Rating	Average slope of disturbance area (%)	Soil Emerson class number	Duration of soil disturbance	Soil loss classes (t/ha/yr)	Rainfall R-factor (monthly)
Very low	≤3	N/A	N/A	0–150	0–60
Low	>3 but ≤5	Class 4, 6, 7 or 8	≤1 month	151–225	60–100
Moderate	>5 but ≤10	Class 5	>1 month but ≤4 months	226–500	100–285
High	>10 but ≤15	Class 3	>4 months but ≤6 month	501–1,500	285–1,500
Extreme	>15	Class 1 or 2	>6 months	>1,500	>1,500

Adopted from Tables 3.1, F4, 4.4.1 and 4.4.3 from IECA (2008)

7.1.1 Slope

As described in Section 6.1 and displayed in Figure 7.2, the Project slopes are generally low, with 98.8% (approximate 17,784 m) of the disturbance footprint sloping 0–3% and 1.2% (approximately 216 m) sloping 3–5%. This indicates a very low erosion risk as per Table 7.1.

7.1.2 Rainfall erosivity

The rainfall erosivity (R-Factor) is calculated using the formula:

$$R = 164.74\ (1.1177)^S\ S^{0.6444}$$

Where S is the 0.5EY, 6-hour event in mm/h (Rosewell & Turner 1992). For the Project S equals 10.5 mm/h (BoM 2022a). The calculated R-Factor for the Project is 2,411 $MJmmha^{-1}h^{-1}$, indicating an extreme erosion risk as per Table 7.1.

i Monthly R-factor

Monthly rainfall data for site from Bureau of Meteorology (BoM) Moranbah Water Treatment Plant Station (No. 034038), where monitoring commenced in 1972 and ceased in 2012 (BoM 2022b), was correlated with Tables 4.4.1 and 4.4.2 of IECA (2008) to determine the erosion risk from monthly mean rainfall and to estimate monthly R-factors shown in Table 7.2.

Table 7.2 Monthly R-factor

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean monthly rainfall (mm)	103.8	100.7	55.4	36.4	34.5	22.1	18.0	25.0	9.1	35.7	69.3	103.9
Erosion risk[1]	High	High	Mod	Low	Low	V.low	V.low	V.low	V.low	Low	Mod	High
R-factor[2]	>285–1,500	>285–1,500	>100–285	>60–100	>60–100	0–60	0–60	0–60	0–60	>60–100	>100–285	>285–1,500
Erosion risk[3]	High	High	Mod	Low	Low	Low	V.low	V.low	V.low	Low	Mod	High

1. As per IECA (2008) Table 4.4.2.
2. As per IECA (2008) Table 4.4.1.
3. As per IECA (2008) 4.4.4 for Emerald, QLD.

7.1.3 Soil Emerson class

As described in Section 6.1, the Emerson class results are commonly class 3a and 3b, with occasionally class 1, 4 and 5, resulting in predominantly high erosion risk as per Table 7.1.

7.1.4 Soil K-factor

The erosion potential of a soil is determined by its physical and chemical properties and is expressed as its K-Factor (t.ha.h)/(ha.MJ.mm).

Rosewell (1993) provides an estimate of soil erosion risk based on the physical properties of the soil (Table 7.3) but not the chemical properties, even though the K-Factor is increased by 20% (IECA, 2008) when a dispersive soil in encountered. Soils where the dominant cations are sodium or magnesium tend to be dispersive when wet.

Table 7.3 Rosewell (1993) soil erosion ranking

K-Factor (t ha h $ha^{-1}MJ^{-1}mm^{-1}$)	Erosion potential
<0.02	Low
>0.02 to <0.04	Moderate
>0.04	High

A K-Factor of 0.036 t ha h $ha^{-1}MJ^{-1}mm^{-1}$ has been calculated for Project SMU A soils, and K-factor of 0.01 for SMU B, indicating moderate and low erosion hazard respectively as per Table 7.3. The K-factor calculation is based on Foster *et al* (1981), which uses soil index (SI) units and is derived from soil sand percentage, organic matter percentage (equivalent to percent soil organic carbon content x 1.72 (Pringle *et al* 2013), structure grade and permeability class (Rosewell 1993). However, this does not account for soil sodicity or dispersion.

As described in Section 6.1, much of the Project soils (SMU A) are likely to have dispersive subsoils. IECA (2008) recommends increasing the K-Factor for dispersive soils by 20% but provides no scientific justification for this. Loch *et al.* (1998) measured and range of various sodic soils across NSW and QLD with K-Factors ranging from 0.056–0.106 t ha h $ha^{-1}MJ^{-1}mm^{-1}$. A K-Factor of 0.06 t ha h $ha^{-1}MJ^{-1}mm^{-1}$ has been adopted for SMU A subsoils to account for the sodic and dispersive soil properties, indicating a high erosion potential.

7.1.5 Soil loss classes

Soil loss classes (SLC) are calculated using the Revised Universal Soil Loss Equation (RUSLE) with site specific slopes, soil conditions and a nominal slope length of 80 m.

Calculated indicative soil loss in t/ha/yr for slopes ranges from 1–40% for the Project are provided in Table 7.4.

Table 7.4 Annual average soil loss t/ha/yr

Slope	1%	3%	5%	10%	12%	16%	20%	30%	40%
Rainfall erosivity (calculated R-Factor)	2411	2411	2411	2411	2411	2411	2411	2411	2411
Soil erodibility (K-Factor) - SMU A(Landcom 2004)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Soil erodibility (K-Factor) - SMU B (Landcom 2004)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Topographic factor (LS-factor), (Table A1 Landcom 2004 and USDA 1997)	0.19	0.65	1.19	2.81	3.70	7.32	9.51	11.6	15.67
Erosion control practice factor (P-factor) (Table A2 Landcom 2004)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Cover and management factor (C-factor) (Figure A5 Landcom 2004)	1	1	1	1	1	1	1	1	1
SMU A – Soil loss t/ha/y	**35.7**	**122.3**	**223.8**	**528.5**	**695.9**	**1038.3**	**1376.8**	**2181.8**	**2947.4**
SMU B – Soil loss t/ha/y	**6.0**	**20.4**	**37.3**	**88.1**	**116.0**	**173.0**	**229.5**	**363.6**	**491.2**

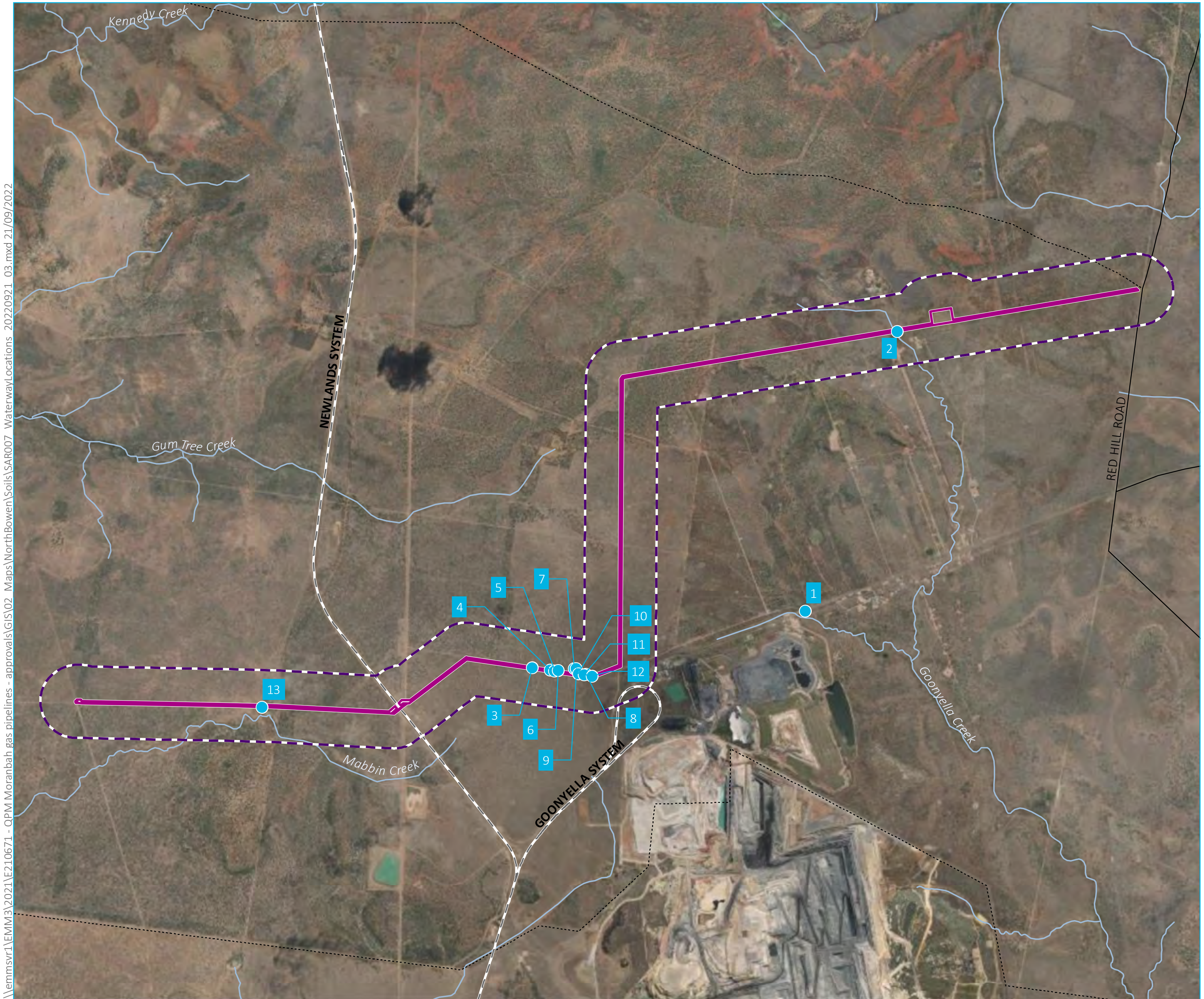
As indicated in Table 7.4, for SMU A slopes of 5% can result in moderate erosion risk whilst around 9% erosion risk becomes high as per Table 7.1. For SMU B erosion risk does not reach moderate until slopes of around 20% and does not reach high until slopes have exceeded 40%.

7.2 Project waterway crossings

Waterways present along the alignment were photographed and described as part of the soils field survey, with one crossing identified. The crossing is displayed in Figure 7.1 and described in Table 7.5 along with the coordinates of other minor creek lines and depressions identified.

Table 7.5 Site waterways

Waterway ID	Description	Soils	Latitude	Longitude
1	**Crossing of Goonyella Creek.** North east: • low gradient banks; • high percentage grass cover on bank; • small wattle and trees further upstream; and • drainage channel either side observed; Southerly: • low gradient banks; • medium tree coverage; and • vegetation to right of water column. Further upstream high embodied banks	SMU A	-21.6182154	147.9891378
2	Localised depression	SMU A	-21.6621095	147.9387723
3	Localised depression	SMU A	-21.6624754	147.9423769



Source: EMM (2022); Qld Globe (2022); DNRME (2022); ESRI (2022)

KEY
- Waterway crossing
- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Watercourse/draingage line

Waterway locations

QPM Energy Project
Soils
Figure 7.1

EMM
creating opportunities

\\emmsvr1\EMM3\2021\E210671 - QPM Moranbah gas pipelines - approvals\GIS\02 Maps\NorthBowen\Soils\SAR007 WaterwayLocations 20220921 03.mxd 21/09/2022

Based on assessment of the waterway against Table 5.1 of IECA (2008), as a *creek with permanent pools and naturally clear base flow but turbid storm flows*, and a clay base, is likely to be moderately to highly sensitive to turbidity.

Further discussion on impacts to surface water quality are in the Surface Water Assessment (EMM, 2022c).

7.3 Erosion risk

The erosion risk assessment is highly variable but ranges from very low (slope) to extreme (R-factor) erosion risk, predominantly high, due to the potential for site soils to disperse and total predicted soil loss due to sheet and rill erosion and rainfall erosivity of the Project footprint. Although not applicable for the Project footprint, for lands steeper than 9%, the erosion risk ranges from high to extreme.

Dispersive soils tend to have high Na content, are structurally unstable and tend to be highly erodible when in contact with non saline water. These soils disperse in water into basic particles due to the hydration of Na ions pushing the clay particles apart. In Australia soils are classified as sodic (prone to dispersion) when Na >6% of the CEC. Dispersive soils present problems for successfully managing earth works and rehabilitation.

The majority of soils have subsoil sodicity, reaching very high ESP values of up to 37%. In some cases soils with high salinity as well as sodicity are more stable due to the influence of other cations on the soil structure. In slightly saline water, or water with a moderate electrolyte concentration, sodic soils swell but generally do not disperse. The presence of salts within the soil pore water reduces the osmotic gradient between the ouside and inside of the clay platelets preventing the ultimate stage of swelling leading to dispersion (Nelson and Ham, 2000).

When these soils are excavated and exposed to fresh water such as rainfall, the saline pore water will be flushed from the soil and dispersion is likely to occur. Such soils when exposed generate highly turbid runoff.

The Project footprint is intersected by several minor un-named ephemeral drainage lines. Minor ephemeral creeks such as these are very sensitive to turbid water discharges. This is because the turbidity released during light rainfall is unlikely to be flushed from the drainage lines' permanent water bodies (pools) by spring flows entering the drainage line following rainfall. It is therefore important both sediment and turbidity are controlled either side of the drainage lines and discharge of run-off from disturbed areas during light rainfall is minimised. Where turbid run-off cannot be captured it is essential to provide a corresponding increase in erosion control to minimise the generation of turbid water.

7.4 Sediment basin triggers

The two key triggers for sediment basins in IECA 2008 include:

- a disturbed area greater than 2,500 m^2; and
- an annual average soil loss calculated using RUSLE greater than 150 t/y off a disturbed area.

Sediment basins are also required for turbidity sensitive environments as conventional Type 2 and Type 3 sediment controls are unable to reduce turbidity. RUSLE parameters and the calculated annual average soil loss for the GCF is provided in Table 7.6.

Table 7.6 GCF annual average soil loss

Factor	GCF
Slope	1%
Rainfall erosivity (calculated R-Factor)	2411 MJ mm ha^{-1} h^{-1} yr^{-1}
Soil erodibility (K-factor) (Landcom 2004) (SMU A)	0.06
Topographic factor (LS-factor), average slope gradient of 1%, 300m slope length (Table A1 Landcom 2004 and USDA 1997)	0.27
Cover and management factor (C-factor) (IECA 2008)	1 (totally disturbed)
Erosion control practice factor (P-factor) (IECA 2008)	1.3 (compacted and smooth)
Area (m^2)	60,000
GCF – Soil loss t/ha/y	**50.8**
GCF – Total soil loss t/y	**304.7**

A sediment basin is triggered for the GCF on both disturbed area and annual average soil loss calculations. This would be a Type D (dispersive soil) basin due to the presence of dispersive soils within the Project footprint.

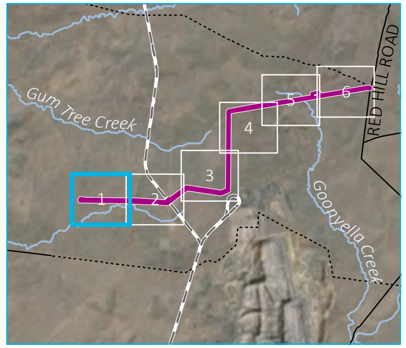
7.5 Application of the erosion risk assessment

The erosion risk assessment generally demonstrates a high to extreme risk due to:

- the erodibility of soils;
- calculated soil loss from site;
- duration of construction; and
- rainfall erosivity in the wet season (December to February).

The ephemeral creeks that drain the Project footprint are sensitive to turbidity during low flows.

QPM will need to adopt drainage, erosion and sediment control management strategies in Section 9 to address the Project erosion risk. Implementation of these measures, along with suitable soil management, construction and remediation, could result in reduced sediment loss compared to the existing land use of cleared grazing land.



KEY

- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Slope (%)

- 0 - 3

Project slopes
Map 1 of 6

QPM Energy Project
Soils
Figure 7.2

EMM
creating opportunities

Source: EMM (2022); DNRME (2022); ESRI (2022)

0 0.5 1 km
GDA 1994 MGA Zone 55
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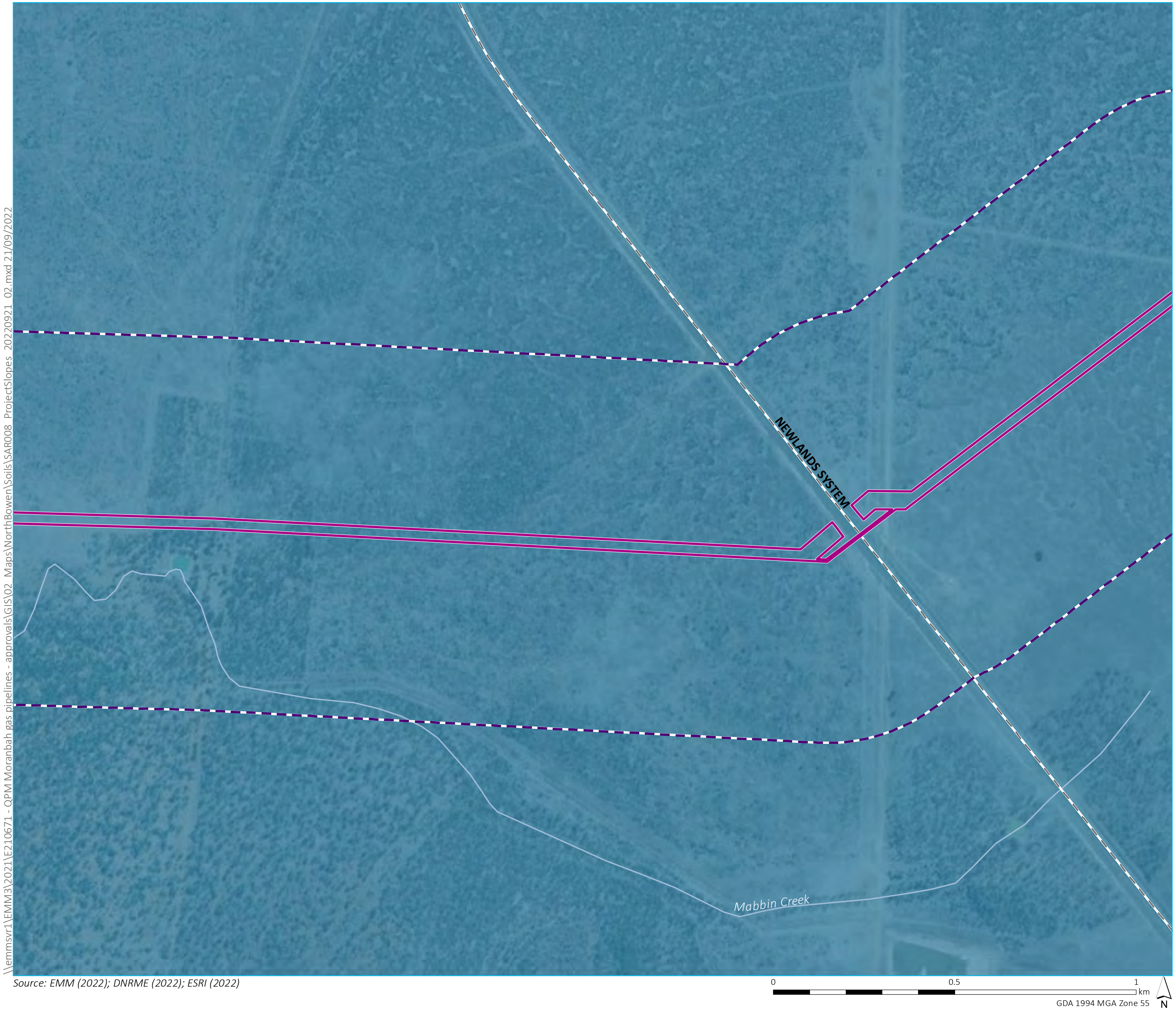

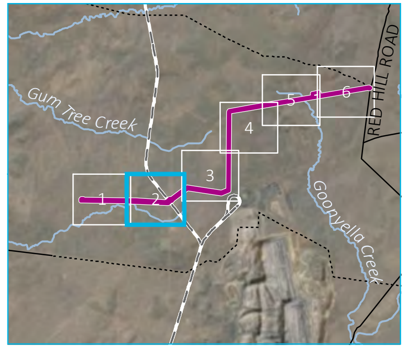

KEY

- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Slope (%)

- 0 - 3

Source: EMM (2022); DNRME (2022); ESRI (2022)

Project slopes
Map 2 of 6

QPM Energy Project
Soils
Figure 7.2

EMM
creating opportunities

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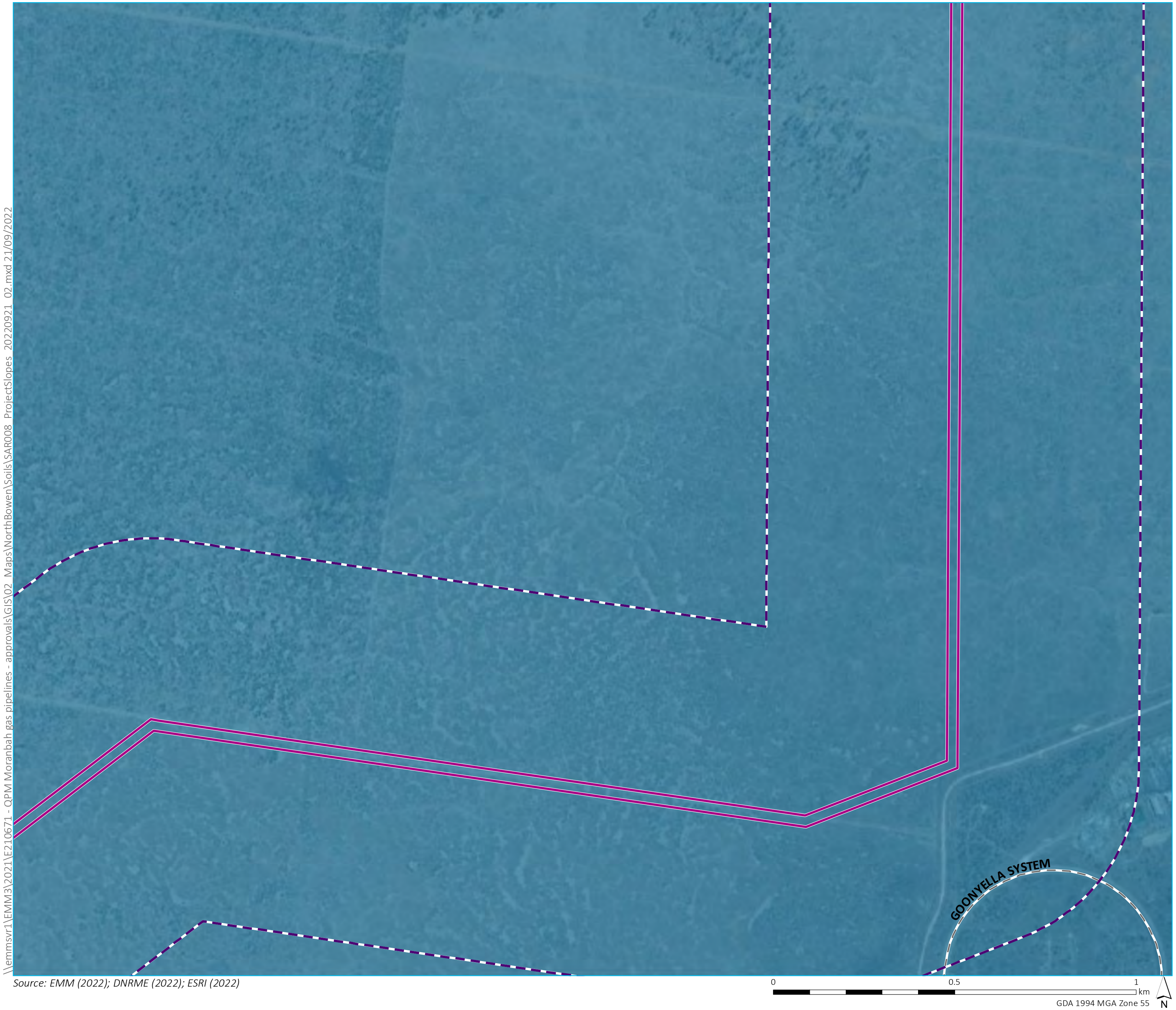

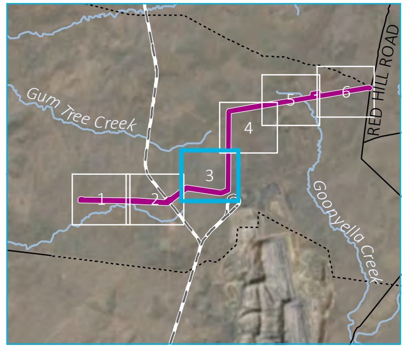

KEY
- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Slope (%)
- 0 - 3

Project slopes
Map 3 of 6

QPM Energy Project
Soils
Figure 7.2

EMM creating opportunities

Source: EMM (2022); DNRME (2022); ESRI (2022)

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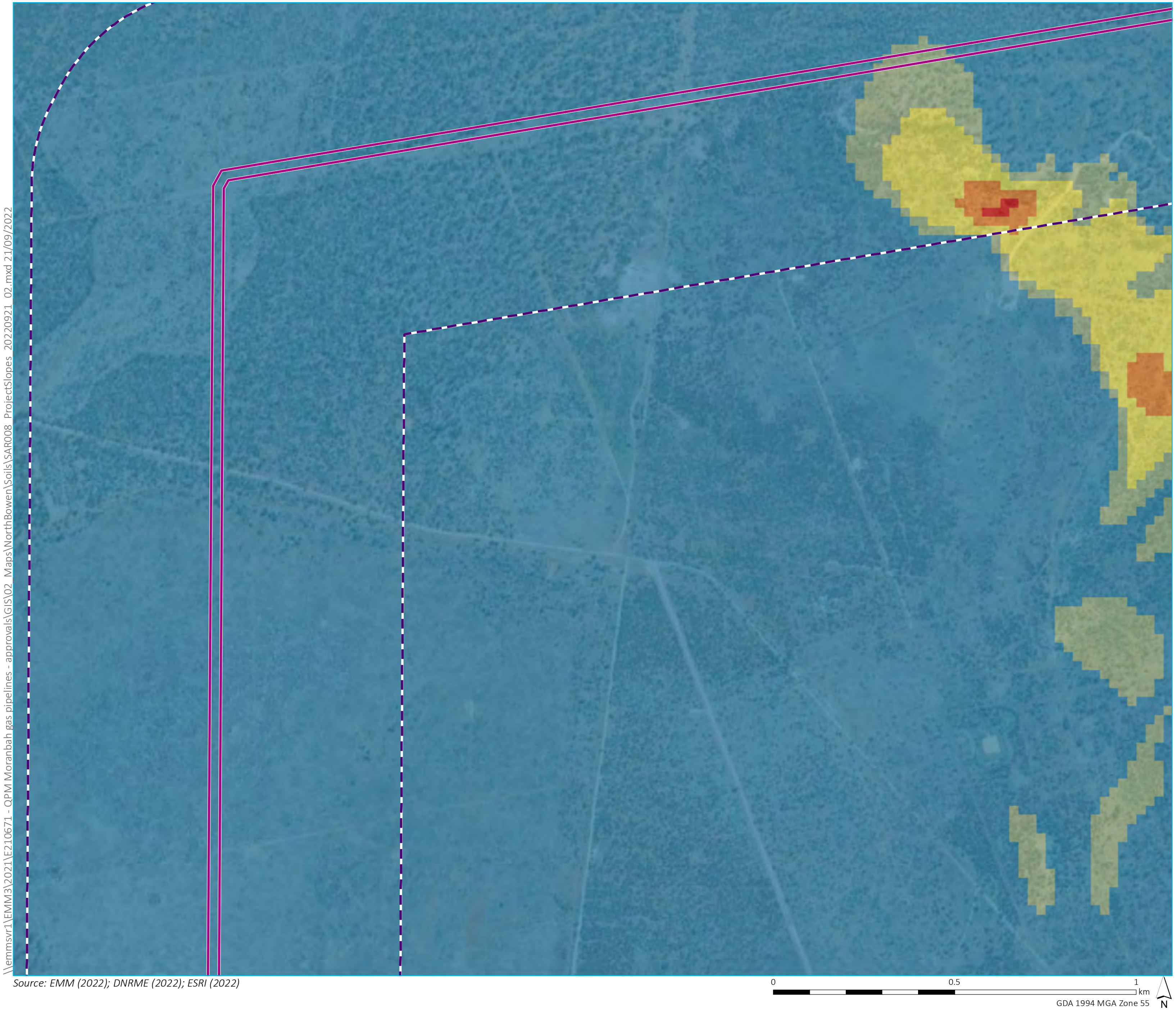

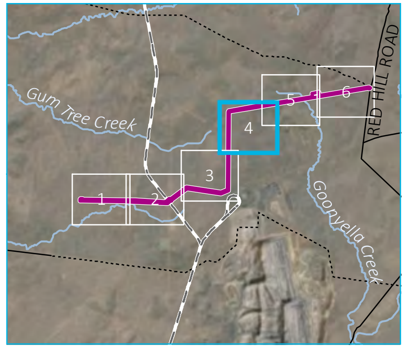

KEY

Proposed disturbance footprint
Study area (500 m buffer)
Rail line
Minor road
Vehicular track
Named watercourse

Slope (%)

0 - 3
3 - 5
5 - 10
10 - 15
> 15

Source: EMM (2022); DNRME (2022); ESRI (2022)

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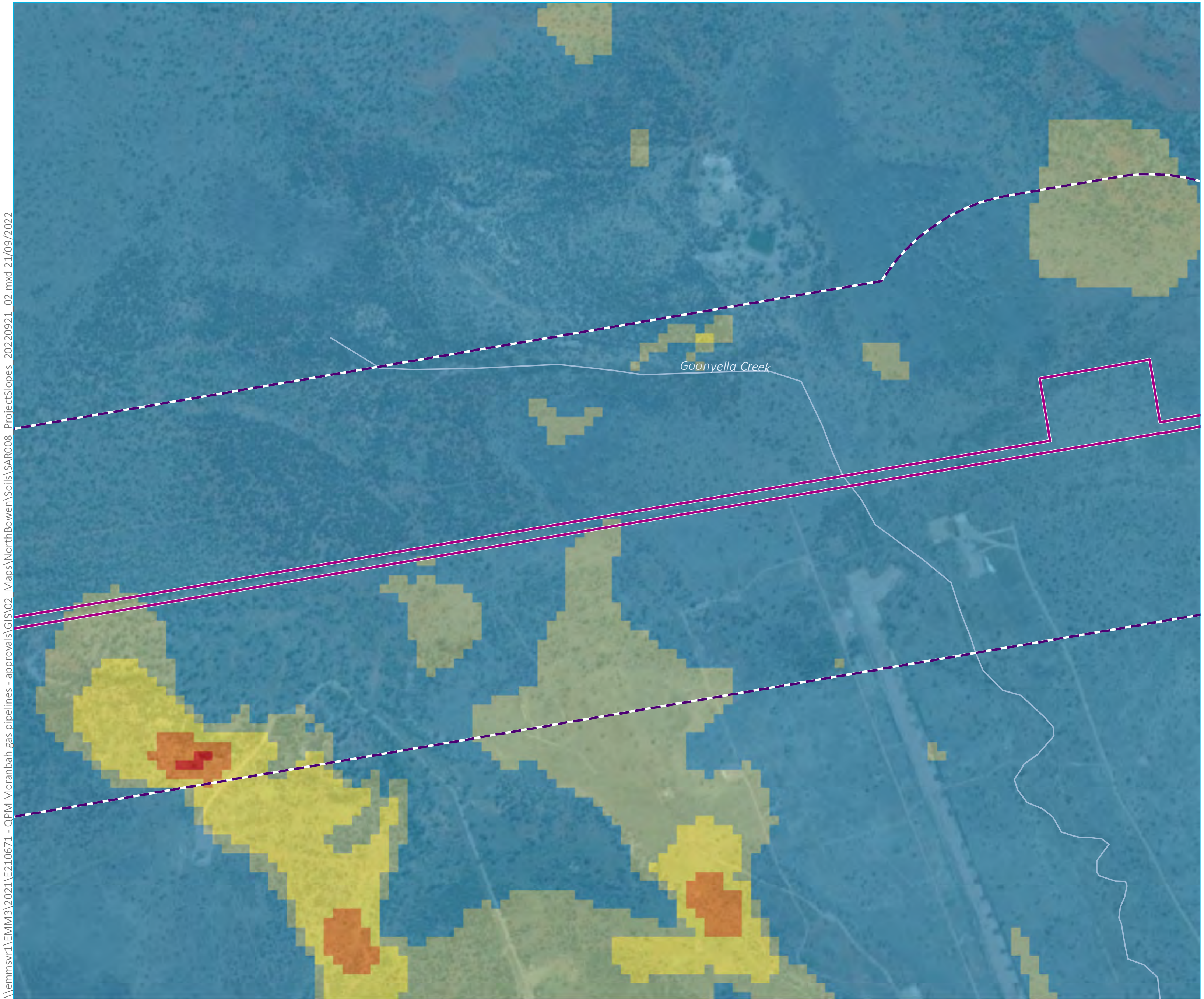
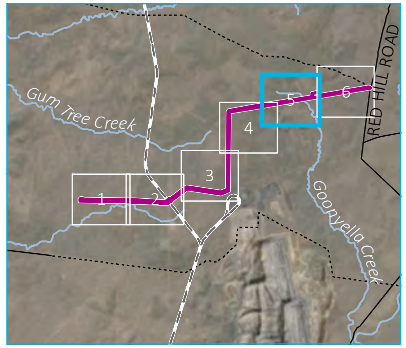
Project slopes
Map 4 of 6

QPM Energy Project
Soils
Figure 7.2

EMM creating opportunities





KEY

- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Slope (%)

- 0 - 3
- 3 - 5
- 5 - 10
- 10 - 15
- > 15

Source: EMM (2022); DNRME (2022); ESRI (2022)

0 0.5 1 km

GDA 1994 MGA Zone 55

N

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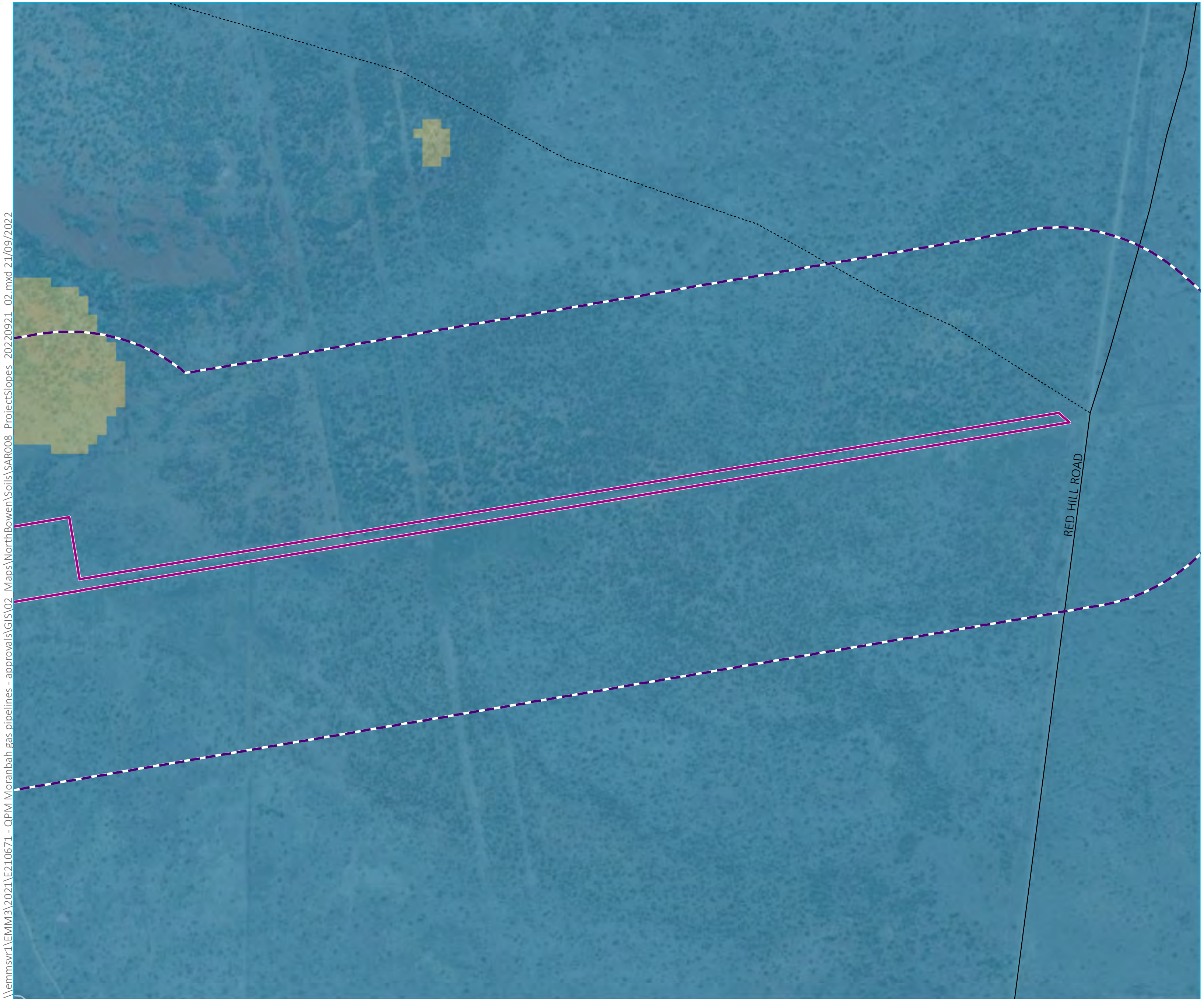
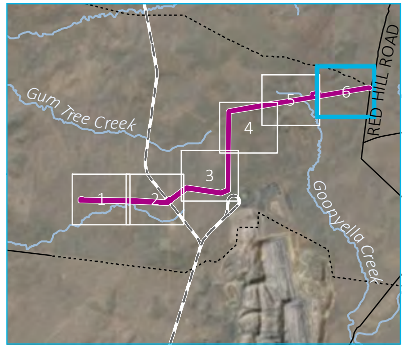
Project slopes
Map 5 of 6

QPM Energy Project
Soils
Figure 7.2

EMM creating opportunities





KEY

- Proposed disturbance footprint
- Study area (500 m buffer)
- Rail line
- Minor road
- Vehicular track
- Named watercourse

Slope (%)

- 0 - 3
- 3 - 5

Project slopes
Map 6 of 6

QPM Energy Project
Soils
Figure 7.2

EMM creating opportunities

Source: EMM (2022); DNRME (2022); ESRI (2022)

0 0.5 1 km
GDA 1994 MGA Zone 55
N

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8 Potential impacts

Impacts to soil quality and land and soil capability can occur through various pathways and mechanisms, which are outlined below. Any activity that could result in harm to soil characteristics or volumes will present a risk of harm to land and soil capability, erosion potential, productivity and rehabilitation success.

8.1 Impact 1 – reduced soil quality and land capability

The soil disturbance during construction has the potential to result in the following impacts:

- Reduce soil stability and increase susceptibility to erosion due to vegetation removal, soil exposure or soil mixing, especially if the subsoil is saline, sodic and dispersive.
- Loss or degradation of topsoil material viable for use in rehabilitation.
- Introduce subsoil constraints such as salinity or sodicity into the topsoil material and root zone if soil is inadequately managed.
- Introduce constraints of deeper 'overburden' material into the topsoil and subsoil if material is inadequately managed and potentially reduce the depth of root zone if sufficient depth of soil material is not reinstated above this material.
- Risk of exposing buried contaminants (hydrocarbons from farm fuel storage, agricultural pesticides and herbicides, wastes disposed in informal farm landfill).
- Introduction of contaminants into soil material during Project operations (eg weeds, hydrocarbons from plant and equipment, mineral processing reagents).

Due to the nature of the study area land use of agriculture, the inherent soil quality of the land is a directly relevant factor in maintaining the existing levels of agricultural productivity. The potential impact to soils that could occur due to Project activities are detailed above, but any of these could result in reduction of soil quality that could be deleterious to agricultural productivity and land use after rehabilitation if not suitably managed or mitigated.

Given high subsoil constraints and the presence of valuable agricultural land across most of the Project footprint, soil management should be prioritised to avoid pathways that present a risk of harm to soil and land resources, such as soil mixing and compaction, as discussed below.

8.1.1 Soil mixing

Impacts on soils and land capability are typically a function of topsoil loss or degradation during construction and/or soil inversion due to poor soil management. Topsoil typically has the highest biological activity, organic matter, and plant nutrients which are all key components of a productive soil, as well as fewer constraints. The potential loss of this upper layer of soil impacts the ability of the soil to provide nutrients, regulate water flow, and resist pests and disease.

Inappropriate separation of topsoil and subsoils during stripping and stockpiling can result is less fertile topsoils due to introduced constraints or potentially constrained subsoils forming the upper of the soil profile. Given the predominantly constrained nature of the subsoils encountered in the study area there are likely to be limitations relating to any introduced constraints because of any inappropriate soil handling practices, should they occur. Mixing of the soil profile can also result in increased stoniness of surface soils impacting the ability to cultivate the soil.

Loss of nutrients and nutrient holding capacity results in a less fertile environment for crop and pasture production. The organic matter and finer soil particles, primarily clays, responsible for soil fertility can be readily eroded when exposed leaving larger, less reactive particles such as sand and gravel.

8.1.2 Compaction

Topsoil degradation can result in organic matter reduction which can lead to soil density increases and subsequent compaction. Compaction lowers the infiltration rate of water into the soil profile and reduces the available water holding capacity. Lower organic matter levels are also associated with weaker soil aggregates and therefore greater risk of further erosion and soil crusting.

Construction equipment, such as plant movement, can also compact the soil resulting in reduced water holding capacity, increased runoff and therefore erosion potential and reduced plant root and shoot penetration. This is of particular concern on soils with high clay content and sodicity limitations (SMU A).

8.1.3 Soil stockpiling

Due to the short-term nature of the Project (staged pipeline construction, ie from clear and grade to reinstatement, is anticipated to take less than two months) many of the topsoils will be stockpiled for short periods of time and will likely only suffer minimal degradation of organic matter and nutrients.

Topsoil will be stripped at the GCF and stockpiled as wind rows around the perimeter of the GCF. This will in turn act as a clean surface water diversion bund. It is recommended the top soil wind rows are vegetated (no greater than 3 months) and should be vegetated with suitable vegetative cover or applied with a soil binder agent to ensure minimal loss of top soil.

8.1.4 Soil biology

The mechanical handling of soil during stripping, stockpiling and placement can significantly degrade the soil biology. Disturbed soils can become devoid of symbiotic microbes, which assist plants in accessing soil nutrients, water and help protect them from disease. Symbiotic microbes provide a self-sustaining, long term nutrient supply system leading to greater ecosystem resilience.

Mycorrhizal fungi are instrumental in soil aggregation, which leads to better soil structure resulting increased water infiltration and water holding capacity, seedling emergence, root penetration and gaseous exchange.

Soil biology of areas that have been cleared and subject to agricultural practice, such as spraying, will have been affected, however, likely to a lesser extent than that resulting from construction and rehabilitation

8.1.5 Spread of weeds and pathogens

Construction and other earthworks activities proposed as part of the Project have the potential to spread weeds or pathogens between properties in the Project footprint or to introduce weeds or pathogens into the area (for example on machinery or equipment). Introduction or spread of weeds pose a risk of harm through contaminating rehabilitation soil resources, adversely impacting crop production on re-established landforms and/or threatening the persistence or quality of native re-vegetation.

8.2 Impact 2 – Increased erosion and sedimentation

Potential erosion and sedimentation impacts include but are not limited to:

- erosion of rehabilitated right of way and topsoil/subsoil stockpiles, requiring rework to repair during the construction, in the event of rain;
- operational hazards associated with erosion gullies and tunnelling (due to dispersive subsoils and non-cohesive sands in areas) leading to accumulated sediments, uncontrolled water and dust;
- construction downtime and delays due to access restrictions and the time taken to repair and de-silt the site after rainfall;
- cost and rework to replace soil lost to tunnel erosion within the pipe trench; and
- changes in rehabilitated land capability due to rill, gully and tunnel erosion.

Potential off-site erosion and sedimentation impacts include:

- eutrophication of downstream waters due to the release of fine clays materials from site;
- increases in downstream sediment deposition and turbidity due to release of untreated runoff;
- dust emissions; and
- change in land and soil capability due to gully and tunnel erosion.

Some types of soils are more prone to erosion than others. The soil survey identified significant sections of the pipeline with sodic dispersive subsoils (SMU A). These soils have a high erosion potential when disturbed and exposed to rainfall and runoff. The erosion risk assessment in accordance with Appendix P (IECA) has identified extreme erosion risk in areas with highly sodic soils.

8.2.1 Surface erosion

Construction of the proposed pipeline and GCF would require vegetation clearing which destabilises soils and leaves them exposed to erosion. Follow-on effects can include undermining of structures such as fences and gates, pipeline exposure, stream bank erosion, downstream sedimentation, decline in fertility through loss of soil material and structure, and increased dust generation.

Due to the working surface of the pipeline alignment being lower than the surrounding landscape following stripping of topsoil, the alignment can become a drainage channel, collecting rainfall and concentrating water flow at increasing quantity and velocity down the alignment.

Increased slope can also contribute to the erosion potential of the soil, especially when disturbed. The majority of the pipeline alignment occurs in areas with very low gradient with subsequent low likelihood of erosion potential.

Cut and fill slopes associated with the construction of the GCF must have suitable design, such as slope lengths and gradients appropriate to the site constraints (such as sodic soils) and be suitably stabilised to minimise erosion.

8.2.2 Pipeline tunnel erosion

Tunnel erosion can occur post rehabilitation, with water infiltrating into the subsoil and flowing preferentially along the disturbed alignment within the backfilled trench, resulting in significant tunnelling and collapse of the backfilled surface especially where sodic and dispersive subsoils are present. This commonly requires re-excavation of the remaining backfill material, importation and treatment of suitable backfill material, backfilling the trench, importation and spreading of suitable topsoil and additional revegetation works.

8.2.3 Waterway erosion

Due to the nature of the works with ground disturbance and plant activity in proximity to a watercourse, the potential for erosion and sedimentation during construction is high, in the event of rain.

Watercourse crossings pose a high level of erosion and sediment control risk because:

- the erosive energy of flow is greater;
- the potential for water pollution is higher;
- steeper slopes are often present; and
- riparian vegetation is disturbed or removed, particularly tree roots which are a primary mechanism for bank stability.

Open trenching of creeks is high risk and often has long term impact on bed and bank stability.

8.2.4 Dust generation

Wind erosion and dust generation is dependent on the type and state of the soil and subsoil as well as the prevailing weather conditions. Dust can be a nuisance if generated in significant quantities near sensitive receptors such as homes and sensitive crops.

Compaction through trafficking and construction activities can result in pulverisation of the soil structure and potentially creating finer particles that become a dust nuisance and complicate pipe cleaning, as the pipe must be devoid of dust.

The particle size distribution of soil types can also contribute to dust generation. Dispersive clay soils have a high potential to generate dust when disturbed in dry conditions.

9 Mitigation measures

To manage and minimise potential land and soil impacts, relevant mitigation measures will be implemented during the construction and operational phases of the Project. Table 9.3 outlines mitigation measures with respect to Project phase (construction or operation) and the potential impacts which are to be managed. A Soil Stripping and Management Plan (SSMP) and Erosion and Sediment Control Plans (ESCPs) will be in place during construction and an EMP will be in place during operations, all of which will detail relevant mitigation measures.

9.1 Soils

The soil disturbance during construction has the potential to result in the following impacts:

- reduce soil stability and increase susceptibility to erosion due to vegetation removal or soil exposure, especially where the subsoil is sodic and dispersive;
- loss or degradation of topsoil material viable for use in rehabilitation; and
- introduce constraints, such as salinity or sodicity, into the topsoil material if soil is inadequately managed.

Proposed management and mitigation measures focus on implementing suitable soil management measures around soil stripping, handling, stockpiling, amelioration and backfill contained within a SSMP. The primary objective of the soil management approach is to reinstate disturbed areas to as near as practical to pre-existing environmental conditions by:

- avoiding, minimising or mitigating impacts to soils;
- maintaining soil quantity and quality;
- restoring land to its pre-activity use but that it is also returned to its pre-activity productive capacity or potential productive capacity as soon as possible following completion of the activity; and
- returning the land to a stable landform (ie no subsidence or major erosion) with no greater management inputs than those required prior to land disturbance.

9.1.1 Soil stripping

Segregation of topsoil from subsoil is key in maintaining viable growth material and preserving soil resources. The stripping depths have been designed to minimise the introduction of constraints into the topsoils and segregate the subsoils to reduce mixing of layers with distinctly separate constraints whilst maximising the amount of topsoil preserved for rehabilitation.

Due to the extremely high chemical constraints of salinity and sodicity in SPC01, SPC01a and SPC02, especially at shallow depths in some of the mounds of SPC01a, it is recommended that the segregation and management of topsoils and subsoils of these SPC's be prioritised. Mixing of the full subsoil profiles of SMU A will result in overall increased salinity and sodicity constraints at shallow depths.

Due to the benign nature of the SMU B subsoils, the topsoil stripping depth has been designed primarily to ensure recovery of viable topsoil material.

Table 9.1 Soil management layers

SMU	Topsoil stripping depths (mBGL)	Subsoil stripping depth (mBGL)
A	0–0.10	0.10–1.0
B	0–0.15	0.15–1.0

It is important to note that boundaries between soil units are based on field observations at approximately 1 km intervals, desktop digital aerial photographs and landform interpretation. Boundaries between soil units can be abrupt (within 10 m) or diffuse (> 50 m) or somewhere in between. Due to this natural variability between soil type boundaries and variability of topsoil depth within the soil types, stripping depths should be adjusted as necessary depending on actual topsoil depths encountered.

9.1.2 Soil management

i Topsoil management

The objective of topsoil management is to:

- preserve as much of the topsoil as possible;
- ensure topsoil is not degraded during construction and following reinstatement; and
- ensure topsoil is not contaminated with other soil and spoil materials.

Recommended topsoil management measures are contained in Table 9.3.

ii Subsoil management

The objective of subsoil management is to:

- prevent contamination of topsoil;
- Prevent degradation of the subsoil structure;
- avoid or ameliorate subsoil constraints immediately below topsoils;
- ensure reinstatement of soil horizons in the correct order and depths; and
- reduce the tunnel erosion risk along the pipeline trench.

Recommended subsoil management measures are contained in Table 9.3.

9.1.3 Soil amelioration

This section contains specific soil type management recommendations for soils located in the Project footprint based on the soil stripping depths proposed in Section 9.1.1. Soil amelioration recommendations for consideration are included in Table 9.2.

Table 9.2 Recommended soil amelioration rates

SMU	SPC	Topsoil amelioration	Recommended rate (t/ha/0.1 m)	Subsoil amelioration	Recommended rate (t/ha/0.1 m)
A	01, 01a, 02	Gypsum	0.5	Gypsum	7
B	03	Nil	-	Nil	-

i Gypsum amelioration

As an example of a soil ameliorant, gypsum can be used to ameliorate sodic soil material (ie high sodium (Na) concentration) by increasing soil calcium levels, acting to promote sodium displacement to reduce ESP, improve soil structure and assist in increasing soil permeability (ie chloride and salt leaching). However, similar limitations can occur due to excessive magnesium, which in sufficient amounts (ie below Ca:Mg ratio of 2 (DPI 2021)) can behave similarly to sodium and result in dispersive soil behaviour.

The high levels of sodium and magnesium found commonly in subsoils within the Project footprint necessitated calculations for amelioration of both sodic soil and soil material with elevated magnesium in the cation balance. To inform this assessment and detailed design, gypsum amelioration rates are calculated for the presence of sodium and reducing magnesium concentration based on treating a soil depth of 0.1 m. The method used to determine the subsoil gypsum rate involves the calculation of the individual gypsum treatment rate for each sampled depth down the subsoil profile for a particular sample site for both sodium and magnesium, then averaging these rates to determine an overall treatment rate for the soil at a site (this assumes the mixing of the full relevant soil stripping layer).

The recommended gypsum rate to ameliorate soil magnesium is based on a trigger threshold of soil Ca:Mg ratio at <1. The calculated rate for the Project uses a target ESP of 5%, target exchangeable magnesium percentage of 25%, with 75% gypsum purity, and an 80% efficiency factor (note, these values are toward the low end of recommended ranges). The target ESP of 5% aims to result in the soil being classified "non-sodic" (<6%) according to Northcote and Skene (1972).

9.2 Erosion and sediment control

The erosion and sediment control management and mitigation measures contained in Table 9.3.

A key measure will be to undertake civil work, especially the construction of the pipeline, during the dry season (April to October) to reduce the likelihood of rain.

Table 9.3 Mitigation measures for land and soils

Project phase	Potential impact or activity	Mitigation measures
Construction	Impact 1 – Soil management	**Soil Stripping and Management Plan (SSMP)** Prepare a soil stripping and management plan (SSMP) to ensure the preservation of soil resources, including quantity and quality to be managed, through the implementation of soil management measures detailed below. Overarching principles within the SSMP are to include or consider: • preserve as much of the topsoil and subsoil materials as possible; • ensure soil materials, especially topsoil, are not degraded during construction and following reinstatement; • ensure soil is not contaminated with other soil and spoil materials; • during soil handling ensure that structural degradation/compaction of the soil is minimised for example by designating access routes and minimising trafficking and compaction of stockpiles; • management of weeds and biosecurity; • effort should be made to reduce the time between excavation and backfill to minimise soil exposure; and • monitor for dispersion and erosion, particularly of exposed sodic subsoils. Any evidence of erosion may require the addition of ameliorants such as gypsum or lime.
Construction	Impact 1 – Clearing and grubbing	Measures to be contained in the SSMP relating to clearing and grubbing include: • remove groundcover vegetative material from the alignment prior to construction and reinstate following construction to provide seed stock and/or organic matter to assist revegetation; and • if suitable, vegetation that is cleared and mulched may be used to provide a thin surface mulch to protect the topsoil and mitigate erosion hazards.
Construction	Impact 1 – Soil stripping	Measures to be contained in the SSMP relating to soil stripping include: • an inventory of soils to be stripped, including soil types, stripping areas, depths and volumes; • a topsoil and subsoil stripping and excavation procedure; • Contractor Site Environmental Advisor (or relevant person) to identify, record and indicate (to plant operators) the stripping depth during stripping operations; • where available, strip topsoil to a minimum recommended depth as per Table 9.1 or a minimum of 0.1 m; • remove and stockpile subsoil separately from topsoil (Table 9.1) to prevent mixing; and • avoid soil stripping activities when the soil structure is saturated.

Table 9.3 Mitigation measures for land and soils

<table>
<tr><th>Project phase</th><th>Potential impact or activity</th><th>Mitigation measures</th></tr>
<tr><td>Construction</td><td>Impact 1 – Soil stockpiling</td><td>Measures to be contained in the SSMP relating to soil stockpiling include:
• topsoil stockpiles not to exceed 2 m in height to minimise degradation of topsoil, maintain biological capital and maintain fertility;
• stockpiles preferably not be stored for periods greater than 3 months and should be vegetated with suitable vegetative cover if so;
• topsoil stockpiles (particularly silty or dispersive soil materials) should be sprayed with a soil binding agent to stabilise the surface against rain (when forecast) or wind erosion whilst protective vegetative cover is absent;
• leave gaps between stockpiles at appropriate intervals to allow for drainage, and permit the movement of vehicles and fauna;
• place stockpiles away from water discharge zones where they are not disturbed by other activities;
• topsoil should not be stockpiled against fences or vegetation and should be retained separately from mulch (apart from a surface layer);
• monitor and control weeds on the stockpiles to prevent establishment and spread. Control should not reduce vegetative cover such that the stockpile erodes due to exposure of the soil; and
• stockpile excess subsoil (if present) separately for disposal by burial in borrow pits or quarries, or as fill on the property owner's land if requested by the property owner, or for other infrastructure uses. However, prior to the use as fill or for other infrastructure uses that may expose the material to erosion, the material should be analysed to assess its suitability for the purpose.</td></tr>
<tr><td>Construction</td><td>Impact 1 – Soil amelioration</td><td>Recommended measures to be considered in the SSMP relating to soil amelioration include:
• all ameliorants sufficiently mixed with the soil to be effective;
• soil ameliorants are applied with a suitable purpose and rate, to ameliorate sodic or dispersive soils, at indicative rates proposed in Table 9.2; and
• proposed rates aim to improve soils with an ESP of >5% and/or a Ca:Mg ratio at <1.
Gypsum application should be considered for:
• surface topsoil either prior to surface topsoil stripping, or following surface topsoil re-spreading and incorporated to approximately 0.1 m (topsoil stripped area);
• trench areas during subsoil reinstatement before compaction. Application on the subsoil stockpile following trenching allows for mixing during trench filling. Ensure thoroughly incorporated prior to compaction and surface topsoil placement; areas where topsoil has been stripped and subsoil with a required gypsum application rate is disturbed or where runoff with high turbidity needs to be controlled. Apply at 1 t/ha; and
• any areas of disturbed subsoil.</td></tr>
</table>

Table 9.3 Mitigation measures for land and soils

Project phase	Potential impact or activity	Mitigation measures
Construction	Impact 1 – Soil reinstatement	Measures to be contained in the SSMP relating to soil backfill and rehabilitation include: • reinstate soil profiles in sequence order according to their soil management layers as per Table 9.1 (ie subsoil then topsoil); • following subsoil reinstatement place topsoil and re-spread to the topsoil strip depth so that there is no exposed sub-surface material; • respread topsoil to a minimum depth of 0.1 m of cover over the entire disturbed area to be reinstated; • compact reinstated subsoil material adequately with a trench roller within the trench to ensure minimal subsidence or potential for tunnel erosion; • ripping or cultivation of the reinstated subsoil may be required to overcome any compaction that occurs during stockpiling and the reinstatement procedure; • remove soil compaction in upper subsoil by cultivation prior to spreading topsoil, if required; and • remove soil compaction in topsoil following respreading.
Construction	Impact 2 – Increased erosion and sedimentation	**Erosion and Sediment Control Plans (ESCP's)** Prepare Erosion and Sediment Control Plans (ESCP's) for all project disturbances in accordance with *Appendix P – Land-based pipeline construction* (IECA 2015). The ESCP's shall be prepared by a certified by a Certified Professional in Erosion and Sediment Control with appropriate professional experience. Overarching principles of ESC are to include or consider: • prevention or minimisation or erosion where possible; • minimising extent and duration of soil disturbance and avoiding land disturbance and construction during the wet season; • suitable sediment control measures; • where sediment basins are required (eg where dispersive soil is stockpiled) but where it is not practical to install (local management areas), ensure a compensatory level of erosion and temporary sediment controls are implemented to achieve an equivalent level of turbid water treatment; and • install stabilised construction exits where there is a risk of mud tracking onto public roads.

Table 9.3 Mitigation measures for land and soils

Project phase	Potential impact or activity	Mitigation measures
Construction/ Operation	Impact 2 – Surface erosion	Measures to be contained in the ESCP relating to surface ESC to include; • Erosion controls, including but not limited to: – minimise forward clearing; – maintain soil surface cover where possible; – progressively rehabilitate the right of way to minimise the extent and duration of disturbance; – maintain sheet flow conditions to the maximum possible extent; – control water movement through the site; – safely divert 'clean' run-on water away from active construction areas or soil disturbance through the construction areas without mixing with 'dirty' water; – provide erosion protection where the velocity of flow exceeds the maximum permissible velocity of the soil; – use temporary back-push diversion banks on sloping areas to minimise erosion along the pipeline trench; – suitably designed, constructed and stabilised cut and fill batters; – use trench breakers on sloping sections of the pipeline, a waterway crossings and where dispersive soils are present to minimise tunnel erosion along the trench; – inspect the right of way and GCF following rainfall to identify to areas of erosion, subsidence and/or tunnelling and repair as required; – overfill the trench during reinstatement to allow for subsidence and minimise the potential for water ponding and flow concentration particularly where dispersive soils are present; and – apply soil management measures such as amelioration and revegetation identified previously. • Sediment controls, including but not limited to: – locate travel roads on the downslope side of the right of way, where possible, to facilitate wet weather access to sediment controls; – install sediment control measures and prepare site proactively for wet weather and shutdown periods; – collect 'dirty' runoff generated from the site and deliver to a suitable sediment trap; – treat 'dirty' water on site to a suitable level before discharging; – calculations contained in Section 7.4 show that a Type-D sediment basin will be required. This should be designed to the 5-day, 85th percentile rainfall depth design level; and – coagulant and flocculant bench testing will need to be undertaken to determine the most appropriate coagulant and/or flocculant to treat the sediment basin and to determine dosing rates.

Table 9.3 Mitigation measures for land and soils

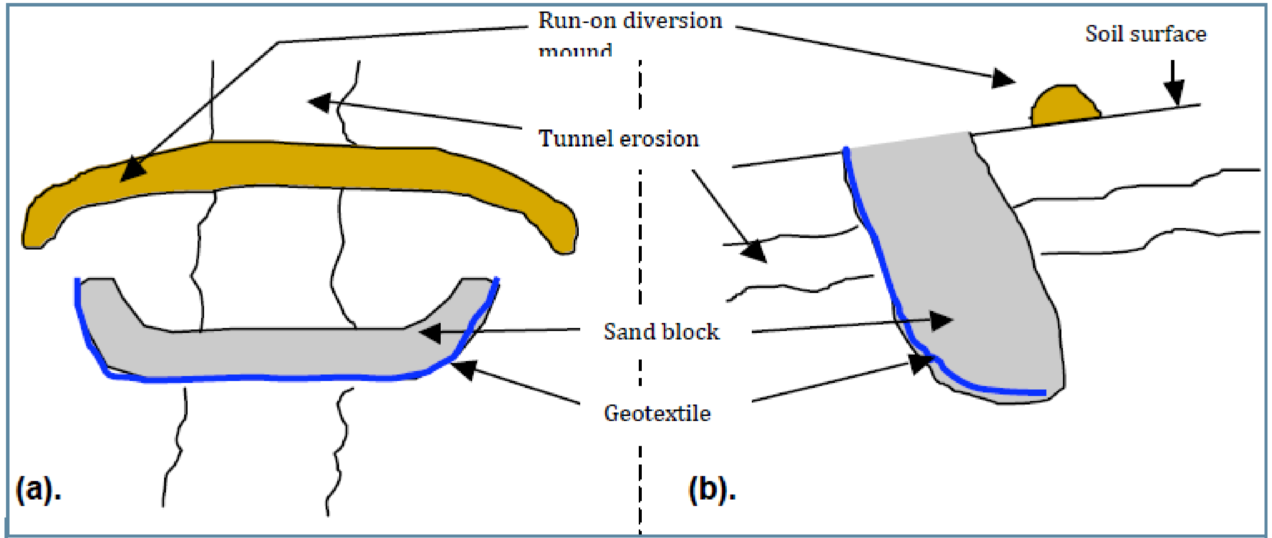
Project phase	Potential impact or activity	Mitigation measures
Construction/ Operation	Impact 2 – Pipeline tunnel erosion	Measures to be contained in the ESCP relating to subsurface tunnel ESC to include: • use trench breakers on sloping sections of the pipeline, waterway crossings and where dispersive soils are present to minimise tunnel erosion along the trench. Where dispersive soils are present, the trench breakers shall be laterally excavated into the in-situ soils either side of the trench to minimise the potential for flanking in accordance with Figure 9.1;  Figure 14. Modified sand block design. (a) plan view, (b) cross section view. The depth of the sand block is determined by the depth of dispersive soils or tunnel erosion. The span length of the structure is determined by the width of the tunnelling. Figure 9.1 Dispersive soil trench breaker (Figure 1.4 DPIW 2009) • apply soil management measures such as amelioration and subsoil compaction identified previously; and • inspect the right of way following rain to identify to areas of erosion, subsidence and/or tunnelling and repair as required.

Table 9.3 Mitigation measures for land and soils

Project phase	Potential impact or activity	Mitigation measures
Construction/ Operation	Impact 2 – Increased erosion at waterways	Measures to be contained in the ESCP relating to waterway ESC to include: • prepare individual ESCP's for each drainage line crossing; • minimise the extent and duration of disturbance across watercourses and on flood prone land; • install sediment controls to protect sensitive waterways and lands; and • where open trenching methods are used in waters and flow in existing or anticipated, place water filled coffer dams either side of the disturbed area and pump clean flows around the disturbed construction area in accordance with arrangement details in *Appendix P – Land-based pipeline construction* (IECA 2015).
Construction/ Operation	Impact 2 – Dust generation	Measures to be contained in the ESCP relating to dust ESC to include: • stabilise topsoil and subsoil stockpiles with soil stabilising polymer to minimise dust generation; and • water and/or apply trafficable soil stabilising polymers to the alignment and unsealed access tracks and roads to reduce dust emissions.

10 Risk assessment

A preliminary risk assessment has been undertaken in accordance with the likelihood, consequence and risk matrices in Section 4.3. Mitigation measures presented in Table 9.3 have been incorporated into the residual risk assessment, demonstrating the risk level to be as low as is reasonably practicable.

Table 10.1 Soils and erosion risk assessment

Risk	Description	Phase	Before mitigation measures are applied			After mitigation measures are applied (refer to Section 9)		
			L	C	R	L	C	R
Soil mixing	Increased constraints and loss of soil quality, volume and subsequent land capability and productivity due to mixing of different soil materials.	Construction	Likely	Major	Extreme B4	Possible	Moderate	Medium C3
Soil compaction	Loss of soil quality and land capability due to soil compaction.	Construction	Almost certain	Minor	Medium A2	Unlikely	Minor	Low D2
Soil stockpiling	Reduced soil quality due to loss of biological activity, organic matter and nutrients during stockpiling.	Construction	Likely	Moderate	High B3	Unlikely	Minor	Low D2
Spread of weeds and pathogens	Introduction of weed species and pathogens due to lack of biosecurity protocols.	Construction	Possible	Major	High C4	Unlikely	Moderate	Low D3
Pipeline surface erosion	Increased surface erosion due to loss of vegetative cover and exposure of soil surface.	Construction	Almost certain	Moderate	High A3	Unlikely	Minor	Low D2
		Operation	Almost certain	Minor	Medium A2	Unlikely	Minor	Low D2

Table 10.1 Soils and erosion risk assessment

Risk	Description	Phase	Before mitigation measures are applied			After mitigation measures are applied (refer to Section 9)		
			L	C	R	L	C	R
Pipeline tunnel erosion	Tunnel erosion and subsequent collapse of backfilled trench.	Construction	Almost certain	Major	Extreme A4	Possible	Moderate	Medium C3
		Operation	Almost certain	Major	Extreme A4	Possible	Moderate	Medium C3
Waterway erosion	Erosion around waterways due to construction activity and disturbance post-construction.	Construction	Almost certain	Moderate	High A3	Possible	Moderate	Medium C3
		Operation	Likely	Moderate	High B3	Rare	Moderate	Low E3
Dust generation	Increased dust due to compaction, construction and traffic on exposed soils.	Construction	Almost certain	Minor	Medium A2	Unlikely	Minor	Low D2
		Operation	Likely	Minor	Medium B2	Rare	Minor	Low E2

11 Conclusion

The Project involves the design, construction and operation of a GCF and a high-pressure pipeline that links a proposed GCF to the nearby existing NQGP.

The Project proposes to collect waste coal mine gas at the proposed GCF via third party coal mine waste gas gathering lines located on adjacent coal mines. At the GCF, waste coal mine gas will be dehydrated and filtered, with the remaining clean gas then compressed and transported via high-pressure pipeline to the existing and operational NQGP. The NQGP will then transport the compressed gas north to Townsville, where in turn it will be depressurised and distributed, by a third party, to industrial users, including the QPM TECH Project.

Project activities have the potential to impact on land values owning to soil disturbance activities during the construction phase.

Key results of the assessment include:

- Soil survey results are generally consistent with regionally available soil mapping, with the identification of four SPCs, grouped into two SMUs, consisting primarily of deep, well-structured clay soils (SMU A), predominantly cracking clay Vertosols, and deep red, weakly structured loamy soils (SMU B), typically Kandosols.
- SMU A (SPC01, SPC01a and SPC02) subsoils are commonly sodic (increasing with depth), highly saline at depth with poor cation balance in the subsoils, which results in the subsoils having high potential to disperse. The heavy clay textures and gilgai depressions will also result in limitations from poor soil drainage and waterlogging.
- SMU B (SPC03) soils have no constraints relating to salinity or sodicity and pose much lower risk.
- The erosion risk assessment is highly variable but ranges from very low (slope) to extreme (R-factor) erosion risk. It is high during construction, due to soil exposure and the potential for site soils to disperse in the event of rainf in SMU A areas.
- The erosion risk assessment generally demonstrates a high unmitigated risk due to:
  - the erodibility of soils;
  - calculated soil loss from site;
  - duration of construction; and
  - rainfall erosivity in the wet season (December to February).
- The ephemeral creeks that drain the Project footprint are sensitive to turbidity during low flows.
- Any activity that could result in harm to soil characteristics or volumes will present a risk of harm to land and soil capability, erosion potential, productivity and rehabilitation success.

Key avoidance and mitigation measures to be implemented include:

- Implementing suitable soil management measures around soil stripping, handling, stockpiling, amelioration and backfill contained within a SSMP. The primary objective of the soil management approach is to reinstate disturbed areas to as near as practical to pre-existing environmental conditions by:
  - avoiding, minimising or mitigating impacts to soils;
  - maintaining soil quantity and quality;
  - selective management and handling of saline and/or dispersive soils;
  - restoring land to its pre-activity use but that it is also returned to its pre-activity productive capacity or potential productive capacity as soon as possible following completion of the activity; and
  - returning the land to a stable landform (i.e. no subsidence or major erosion) with no greater management inputs than those required prior to land disturbance.
- Implementation of best practice erosion and sediment control, contained in Erosion and Sediment Control Plans (ESCP's) for all project disturbances in accordance with *Appendix P – Land-based pipeline construction* (IECA 2015). The ESCP's shall be prepared by a certified by a Certified Professional in Erosion and Sediment Control with appropriate professional experience.
- This impact assessment generally demonstrates a low (SMU B) to medium (SMU A) risk after mitigation measures.

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Annexure A
Soil chemistry data

creating opportunities

A.1 Soil chemistry data – SMU A: SPC01

A.1.1 Site QPM04

Table A.1 Site QPM04 – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1 m	7.69	20.7	0.25	M	143.0	VH	1.71	M	3.92	VH	2.94	1.42	8.6	1.3	2.6	14.1	25.8

1. Ratings as per *Soil Chemical Methods* (Rayment & Lyons 2011*); Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982); *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

Table A.2 Site QPM04 – soil profile chemistry data

Depth (m)	Particle size (%) [1]					pH (H_2O)	EC (dS/m)	EC rating[2]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1 m	22.8	5.8	30.4	38.7	2.3	7.69	0.17	L	28.4	-	8.3	7.0	3.92	0.56	19.8	2.8	NS	3a	1.2
0.2–0.3 m	40.4	5.8	20.6	32.6	0.6	8.97	0.23	L	45.9	-	13.7	11.0	3.92	1.60	30.2	5.3	NS	3b	1.2
0.5–0.6 m	36.0	3.8	22.3	35.8	2.0	9.04	0.36	M	109	-	12.7	15.3	1.59	3.60	33.2	10.8	S	4	0.8
0.9–1 m	34.3	3.9	19.3	41.0	1.5	9.01	0.91	VH	265	-	10.7	14.7	0.47	6.38	32.2	19.8	SS	4	0.7

1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)

Table A.3 Site QPM04 – images

Soil profile[1]	Landscape
	
Photograph A.1 QPM04 soil profile[1]	**Photograph A.2** QPM04 landscape

1. Surface left.

A.1.2 Site QPM05

Table A.4 Site QPM05 – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1 m	7.26	4.2	0.11	L	20.2	M	0.87	L	0.41	M	1.50	<0.20	3.37	1.4	0.6	33.9	39.8

1. Ratings as per *Soil Chemical Methods* (Rayment & Lyons 2011*); Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982); *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

Table A.5 Site QPM05 – soil profile chemistry data

Depth (m)	Particle size (%) [1]					pH (H_2O)	EC (dS/m)	EC rating[2]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1 m	33.4	5.6	36.5	24.4	<0.1	7.26	0.04	VL	10.5	-	11.3	6.9	0.41	0.83	19.4	4.3	NS	3a	1.6
0.5–0.6 m	42.7	1.7	26.9	28.3	0.3	9.18	0.44	M	518	-	9.3	4.2	0.80	0.64	14.9	4.3	NS	4	2.2

1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)

Table A.6 Site QPM05 – images

Soil profile[1]	Landscape
	
Photograph A.3 QPM05 soil profile[1]	Photograph A.4 QPM05 landscape

1. Surface left.

A.1.3 Site QPM01

Table A.7 Site QPM01 – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1 m	7.17	24.1	0.23	M	88.6	H	2.12	M	3.92	VH	3.65	1.47	11.1	1.8	2.2	28.9	79.8

1. Ratings as per *Soil Chemical Methods* (Rayment & Lyons 2011*); Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982); *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

Table A.8 Site QPM01 – soil profile chemistry data

Depth (m)	Particle size (%) [1]					pH (H_2O)	EC (dS/m)	EC rating[2]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1 m	40.8	5.9	24.7	28.3	0.3	7.17	0.13	L	32.8	-	10.7	7.5	3.92	0.56	22.7	2.5	NS	3a	1.4

1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)

Table A.9 Site QPM01 – images

Soil profile[1]	Landscape
	
Photograph A.5 QPM01 soil profile[1]	Photograph A.6 QPM01 landscape

1. Surface left.

A.2 Soil chemistry data – SMU A: SPC01a

A.2.1 Site QPM08 - depression

Table A.10 Site QPM08 - depression – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1 m	7.48	3.1	0.10	L	11.2	L	1.08	L	0.51	H	1.86	0.84	4.24	1.7	0.4	23.9	37.8

1. Ratings as per *Soil Chemical Methods* (Rayment & Lyons 2011*); Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982); *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

Table A.11 Site QPM08 - depression – soil profile chemistry data

Depth (m)	Particle size (%) [1]					pH (H_2O)	EC (dS/m)	EC rating[2]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1 m	50.3	11.3	20.9	17.5	0.1	7.48	0.09	VL	76.4	-	14.7	10.8	0.51	2.47	28.5	8.7	S	3a	1.4
0.2–0.3 m	56.3	13.2	13.4	17.0	0.2	7.94	0.42	M	608	-	18.7	10.7	0.27	4.82	34.5	14.0	S	3b	1.7
0.5–0.6 m	47.2	14.7	20.8	17.2	<0.1	7.80	0.69	H	1120	-	15.7	10.2	0.23	5.60	31.7	17.7	SS	3b	1.5
0.9–1 m	48.8	11.4	21.8	18.1	<0.1	6.89	0.99	VH	1540	-	11.7	9.2	0.20	6.47	27.5	23.5	SS	3a	1.3

1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)

Table A.12 Site QPM08 - depression – images

Soil profile[1]	Landscape
	
Photograph A.7 QPM08 - depression soil profile[1]	Photograph A.8 QPM08 - depression landscape

1. Surface left.

A.2.2 Site QPM08 - mound

Table A.13 Site QPM08 - mound – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1 m	7.50	3.1	0.17	M	15.4	L	1.54	M	0.32	M	2.65	0.4	11.5	1.2	0.4	21.9	37.8

2. Ratings as per *Soil Chemical Methods* (Rayment & Lyons 2011*); Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982); *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

Table A.14 Site QPM08 - mound – soil profile chemistry data

Depth (m)	Particle size (%) [1]					pH (H_2O)	EC (dS/m)	EC rating[2]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1 m	42.6	11.2	23.4	22.7	0.1	7.50	0.13	L	95.8	-	18.7	8.0	0.32	1.95	29.0	6.7	S	3b	2.3
0.2–0.3 m	46.6	9.4	20.5	23.4	0.1	8.77	1.21	VH	1640	-	12.7	9.5	0.18	6.73	29.1	23.1	SS	3b	1.3
0.5–0.6 m	52.5	9.4	19.4	18.7	<0.1	8.54	1.61	E	2300	-	10.7	10.3	0.16	8.12	29.3	27.7	SS	3b	1.0
0.7–0.8 m	55.6	9.0	18.3	17.0	<0.1	8.15	1.26	VH	2165	-	8.5	9.7	0.15	7.51	25.8	29.1	SS	3a	0.9

1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)

Table A.15 Site QPM08 - mound – images

Soil profile[1]	Landscape
	
Photograph A.9 QPM08 - mound soil profile[1]	Photograph A.10 QPM08 - mound landscape

1. Surface left.

A.2.3 Site QPM16 - depression

Table A.16 Site QPM16 - depression – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1 m	8.11	2.2	0.14	L	9.7	VL	1.47	L	1.30	VH	2.53	<0.20	8.56	0.9	0.5	13.5	23.8

1. Ratings as per *Soil Chemical Methods* (Rayment & Lyons 2011*); Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982); *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

Table A.17 Site QPM16 - depression – soil profile chemistry data

Depth (m)	Particle size (%) [1]					pH (H_2O)	EC (dS/m)	EC rating[2]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1 m	53.3	17.3	16.9	12.4	0.2	8.11	0.07	VL	31.1	-	26.7	10.5	1.30	0.73	39.2	1.9	NS	5	2.5
0.2–0.3 m	42.9	11.3	19.0	26.2	0.6	8.72	0.22	L	66.6	-	25.7	13.0	0.80	3.86	43.4	8.9	S	3b	2.0
0.5–0.6 m	39.3	11.3	19.8	29.7	<0.1	8.82	0.29	M	220	-	18.7	10.2	0.62	3.86	33.3	11.6	S	3b	1.8
0.8–0.9 m	45.3	11.4	16.4	26.2	0.7	8.28	0.99	VH	1810	-	16.7	11.3	0.65	6.21	34.9	17.8	SS	3b	1.5

1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)

Table A.18 Site QPM16 - depression – images

Soil profile[1]	Landscape
	
Photograph A.11 QPM16 - depression soil profile[1]	Photograph A.12 QPM16 - depression landscape

1. Surface left.

A.2.4 Site QPM16- mound

Table A.19 Site QPM16 - mound – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1 m	7.92	6.2	0.19	M	8.2	VL	1.98	M	0.94	H	3.41	<0.20	7.97	1.1	0.5	21.9	29.8

1. Ratings as per *Soil Chemical Methods* (Rayment & Lyons 2011*); Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982); *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

Table A.20 Site QPM16 - mound – soil profile chemistry data

Depth (m)	Particle size (%) [1]					pH (H_2O)	EC (dS/m)	EC rating[2]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1 m	36.1	15.4	21.8	25.8	0.9	7.92	0.08	VL	32.2	-	28.7	10.0	0.94	0.99	40.6	2.4	NS	5	2.9
0.2–0.3 m	43.0	9.9	18.3	28.7	0.2	8.57	0.14	L	47.8	-	25.7	11.2	0.69	2.03	39.6	5.1	NS	5	2.3
0.5–0.6 m	35.5	5.7	14.1	43.9	0.8	8.69	0.37	M	335	-	18.7	11.3	0.58	3.86	34.5	11.2	S	3b	1.7
0.8–0.9 m	37.0	7.9	15.1	38.8	1.3	8.38	0.7	H	895	-	16.7	12.0	0.55	4.90	34.2	14.3	S	3b	1.4

1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)

Table A.21 Site QPM16- mound – images

Soil profile[1]	Landscape
	
Photograph A.13 QPM16 - mound soil profile[1]	Photograph A.14 QPM16 - mound landscape

1. Surface left.

A.3 Soil chemistry data – SMU A: SPC02

A.3.1 Site QPM06

Table A.22 Site QPM06 – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1 m	6.87	5.7	0.17	M	23.6	M	1.76	M	0.65	H	3.03	0.4	8.9	0.7	1.5	18.1	79.8

1. Ratings as per *Soil Chemical Methods* (Rayment & Lyons 2011*); Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982); *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

Table A.23 Site QPM06 – soil profile chemistry data

Depth (m)	Particle size (%) [1]					pH (H_2O)	EC (dS/m)	EC rating[2]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1 m	19.2	7.8	26.6	45.4	0.9	6.87	0.1	L	79.3	-	4.6	2.8	0.65	0.09	8.2	1.1	NS	8	1.6
0.2–0.3 m	21.9	3.7	32.5	41.6	0.2	7.82	0.11	L	78.2	-	2.2	3.7	0.16	1.95	8.0	24.4	SS	1	0.6
0.5–0.6 m	27.8	3.5	31.0	37.3	0.4	8.88	0.31	M	345	-	1.8	7.2	0.08	5.34	14.4	37.1	SS	1	0.3
0.7–0.8 m [3]	21.8	7.4	32.3	38.5	0.2	8.59	0.28	M	348	-	6.5	5.6	0.38	3.30	15.8	20.9	SS	1	1.2

1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Exchangeable cations, ESP, Sodicity and Ca:Mg ratio results may be subject to uncertainty due to laboratory prewashing testing based on an erroneous acidic field pH result.

Table A.24 Site QPM06 – images

Soil profile[1]	Landscape
	
Photograph A.15 QPM06 soil profile[1]	Photograph A.16 QPM06 landscape

1. Surface left.

A.4 Soil chemistry data – SMU B: SPC03

A.4.1 Site QPM20

Table A.25 Site QPM20 – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1 m	6.87	5.7	0.17	M	23.6	M	1.76	M	0.65	H	3.03	0.4	8.9	0.7	1.5	18.1	79.8

1. Ratings as per *Soil Chemical Methods* (Rayment & Lyons 2011*); Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982); *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

Table A.26 Site QPM20 – soil profile chemistry data

Depth (m)	Particle size (%) [1]					pH (H_2O)	EC (dS/m)	EC rating[2]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1 m	19.2	7.8	26.6	45.4	0.9	6.87	0.1	L	79.3	-	4.6	2.8	0.65	0.09	8.2	1.1	NS	8	1.6
0.2–0.3 m	21.9	3.7	32.5	41.6	0.2	7.82	0.11	L	78.2	-	2.2	3.7	0.16	1.95	8.0	24.4	SS	1	0.6
0.5–0.6 m	27.8	3.5	31.0	37.3	0.4	8.88	0.31	M	345	-	1.8	7.2	0.08	5.34	14.4	37.1	SS	1	0.3
0.7–0.8 m	21.8	7.4	32.3	38.5	0.2	8.59	0.28	M	348	-	6.5	5.6	0.38	3.30	15.8	20.9	SS	1	1.2

1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)

Table A.27 Site QPM20 – images

Soil profile[1]	Landscape
	
Photograph A.17 QPM20 soil profile[1]	**Photograph A.18 QPM20 landscape**

1. Surface left.

Annexure B

Soil survey surface conditions

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B.1 Soil survey surface conditions

Table B.1 Soil surface condition

Site	Observation	Morphology	Slope (%)	Soil Land system	SPC	ASC	Groundcover (% veg)	Veg/litter	Cracks (width mm)	Cracks (depth mm)	Coarse fragment abundance	Coarse fragment size (mm)	Surface condition
QPM01	Detailed	Flat	0	CC33	1	Vertosol	60–80%		5–10 mm		<2%	2–6 mm	Firm
QPM02	Detailed	Flat	0	CC33	1	Vertosol	80–100%	50/50	5–10 mm	<10 mm	20–50%	2–6 mm	Firm
QPM03	Check	Flat	0	CC33	1	Vertosol	80–100%	40/60	<5 mm	<10 mm	10–20%	<60 mm	Firm
QPM04	Detailed	Flat	0	CC33	1	Vertosol	80–100%		5–10 mm		2–10%	<20 mm	Soft
QPM05	Detailed	Flat	0	CC33	1	Vertosol	80–100%	100% grass	none observed	none observed	-	-	Soft
QPM06	Detailed	Flat	0	CC33	2	Dermosol	80–100%	40/60	<5 mm	<10 mm	<2%	<2,000 mm	Soft
QPM07	Detailed	Flat	0	CC33	1	Vertosol	80–100%	80/20	<5 mm	<10 mm	<2%	2–6 mm	Firm
QPM08 depres sion	Detailed	Flat	0	CC33	1a	Vertosol	80–100%		5–10 mm		2–10%	2–6 mm	Soft
QPM08 mound	Detailed	Flat	0	CC33	1a	Vertosol	80–100%	80/20	5–10 mm		2-10%	2–6 mm	Soft
QPM09	Check	Flat	0	CC33	1	Vertosol	80–100%	80/20	<5 mm	<10 mm	<2%	2–6 mm	Firm
QPM10	Detailed	Flat	0	CC33	1	Vertosol	80–100%	80/20	none observed	none observed	<2%	2–6 mm	Soft
QPM11	Detailed	Flat	0	Sl21	1	Vertosol	60–80%		5–10 mm		20–50%	<60 mm	Firm
QPM12	Detailed	Flat	0	My28	1	Vertosol	40–60%	40/60	5–10 mm	<10 mm	10–20%	<60 mm	Firm
QPM13	Check	Flat	0	My28	1	Vertosol	80–100%	80/20	5–10 mm	10-20 mm	-	-	Soft

Table B.1 Soil surface condition

Site	Observation	Morphology	Slope (%)	Soil Land system	SPC	ASC	Groundcover (% veg)	Veg/litter	Cracks (width mm)	Cracks (depth mm)	Coarse fragment abundance	Coarse fragment size (mm)	Surface condition
QPM14	Detailed	Flat	0	My28	1	Vertosol	80–100%		5–10 mm		<2%	<60 mm	Firm
QPM15	Check	Flat	0	Ke19	1	Vertosol	80–100%	50/50	none observed	none observed	-	-	Soft
QPM16 depres sion	Detailed	Flat	0	Ke19	1a	Vertosol	80–100%	-	<5 mm	<10 mm	<2%	2–6 mm	Soft
QPM16 mound	Detailed	Flat	0	Ke19	1a	Vertosol	80–100%	-	<5 mm	<10 mm	<2%	2–6 mm	Soft
QPM17	Check	Flat	0	CC33	1	Vertosol	80–100%	80/20	<5 mm	<10 mm	2–10%	2–6 mm	Soft
QPM18	Check	Flat	0	CC33	1	Vertosol	80–100%	100 % grass	5–10 mm		2–10%	2–6 mm	Soft
QPM19	Check	Flat	0	CC33	1	Vertosol	80–100%	80/20	5–10 mm	<10 mm	2–10%	2–6 mm	Soft
QPM20	Detailed	Flat	0	My28	3	Kandosol	60–80%	20/80	none observed	none observed	50–90%	2–6 mm	Soft
QPM21	Check	Flat	0	My28	1	Vertosol	80–100%	100 % grass	5–10 mm		-	-	Firm
QPM22	Detailed	Gently undulating	2	My28	3	Kandosol	60–80%	20/80	none observed	none observed	2–10%	2–6 mm	Firm
QPM23	Detailed	Gently undulating	3	My28	3	Kandosol	80–100%	80/20	none observed	none observed	50–90%	<20 mm	Soft
QPM24	Check	Gently undulating	2	My28	3	Kandosol	60–80%	60/40	none observed	none observed	-	-	Firm
QPM25	Check	Gently undulating	2	My28	3	Kandosol	40–60%	80/20	5–10 mm	<10 mm	50–90%	2–6 mm	Firm

Table B.1 Soil surface condition

Site	Observation	Morphology	Slope (%)	Soil Land system	SPC	ASC	Groundcover (% veg)	Veg/litter	Cracks (width mm)	Cracks (depth mm)	Coarse fragment abundance	Coarse fragment size (mm)	Surface condition
QPM26	Check	Flat	0	Ke19	1	Vertosol	80–100%	-	-		-	-	Soft
QPM27	Check	Flat	0	Ke19	1	Vertosol	80–100%	80/20	5–10 mm	<10 mm	2–10%	2–6mm	Firm

Annexure C

Soil profile descriptions

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C.1 Soil profile descriptions

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM01	1.0	1	0 to 0.1m	Gradual (50-100mm)	Light Medium Clay	Dark Brown	Moist	Weak (small, but significant force)	Weak (pedal – when displaced <1/3 peds)	2–5 mm	Subangular Blocky	2–10%	2–6 mm	Sub-angular
		2	0.2 to 0.3m	Gradual (50-100mm)	Medium Clay	Dark Brown	Moist	Weak (small, but significant force)	Moderate (pedal – when displaced >1/3 peds)	5–10 mm	Polyhedral	10–20%	6–20 mm	Sub-angular
		3	0.5 to 0.6m	Gradual (50-100mm)	Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Strong (pedal – when displaced >2/3 peds)	10–20 mm	Polyhedral	10–20%	20–60 mm	Sub-angular
		4	0.9 to 1m	Gradual (50-100mm)	Medium Heavy Clay	Pale Brown	Moist	Firm (moderate or firm force)	Strong (pedal – when displaced >2/3 peds)	10–20 mm	Polyhedral	10–20%	20–60 mm	Sub-angular

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM02	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Light Clay	Brown	Dry	Very Weak (very small force)	Massive (apedal – separates into fragments)	2–5 mm	Subangular Blocky	<2%		
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Light Medium Clay	Brown	Mod Moist	Weak (small, but significant force)	Weak (pedal – when displaced <1/3 peds)	10–20 mm	Polyhedral	10–20%		
		3	0.5 to 0.6 m	Gradual (50-100 mm)	Light Medium Clay	Brown	Mod Moist	Firm (moderate or firm force)	Moderate (pedal – when displaced >1/3 peds)	10–20 mm	Polyhedral	10–20%		
		4	0.9 to 1 m	Gradual (50-100 mm)	Medium Clay	Pale Brown	Moist	Firm (moderate or firm force)	Moderate (pedal – when displaced >1/3 peds)	20–50 mm	Polyhedral	10–20%		
QPM03	0.4	1	0 to 0.1 m	Gradual (50-100 mm)		Brown	Dry					2–10%	2–6 mm	
		2	0.3 to 0.4 m	Gradual (50-100 mm)		Brown	Mod Moist					10–20%	20–60 mm	

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM04	1.0	1	0 to 0.1 m	Gradual (50–100 mm)	Light Medium Clay	Pale Brown	Dry	Very Weak (very small force)	Massive (apedal – separates into fragments)	2–5 mm	Polyhedral	2–10%	2–6 mm	Sub-rounded
		2	0.2 to 0.3 m	Gradual (50–100 mm)	Medium Clay	Pale Brown	Moist	Firm (moderate or firm force)	Weak (pedal – when displaced <1/3 peds)	10–20 mm	Subangular Blocky	2–10%	2–6 mm	Sub-rounded
		3	0.5 to 0.6 m	Gradual (50–100 mm)	Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Moderate (pedal – when displaced >1/3 peds)	20–50 mm	Subangular Blocky	2–10%	20–60 mm	Sub-rounded
		4	0.9 to 1 m	Gradual (50–100 mm)	Medium Clay	Dark Brown	Moist	Weak (small, but significant force)	Moderate (pedal – when displaced >1/3 peds)	50–100 mm	Subangular Blocky	10–20%	20–60 mm	Sub-rounded
QPM05	0.8	1	0 to 0.1 m	Clear (20–50 mm)	Light Medium Clay	Pale Brown	Dry	Very Weak (very small force)	Massive (apedal – separates into fragments)	5–10 mm	Subangular Blocky	40–60%	2–6 mm	Rounded
		2	0.2 to 0.3 m	Gradual (50–100 mm)	Light Medium Clay	Dark Brown	Mod Moist	Firm (moderate or firm force)	Weak (pedal – when displaced <1/3 peds)	20–50 mm	Subangular Blocky	20–40%	2–6 mm	Sub-rounded
		3	0.5 to 0.6 m	Gradual (50–100 mm)	Medium Clay	Dark Brown	Mod Moist	Firm (moderate or firm force)	Moderate (pedal – when displaced >1/3 peds)	20–50 mm	Subangular Blocky	20–40%	2–6 mm	Sub-rounded
		4	0.7 to 0.8 m	Gradual (50–100 mm)	Medium Clay	Dark Brown	Mod Moist	Firm (moderate or firm force)	Moderate (pedal – when displaced >1/3 peds)	20–50 mm	Subangular Blocky	10–20%	6–20 mm	Sub-angular

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM06	1.0	1	0 to 0.1 m	Gradual (50–100 mm)	Sandy Clay Loam	Pale Red	Dry	Very Weak (very small force)	Massive (apedal – separates into fragments)	<2 mm	Subangular Blocky	<2%	2–6 mm	Rounded
		2	0.2 to 0.3 m	Gradual (50–100 mm)	Clay Loam Sandy	Red	Dry	Very Weak (very small force)	Weak (pedal – when displaced <1/3 peds)	2–5 mm	Subangular Blocky	2–10%	2–6 mm	Rounded
		3	0.5 to 0.6 m	Gradual (50–100 mm)	Clay Loam Sandy	Red	Mod Moist	Very Weak (very small force)	Moderate (pedal – when displaced >1/3 peds)	2–5 mm	Subangular Blocky	2–10%	2–6 mm	Rounded
		4	0.9 to 1 m	Gradual (50–100 mm)	Clay Loam Sandy	Red	Mod Moist	Very Weak (very small force)	Moderate (pedal – when displaced >1/3 peds)	2–5 mm	Subangular Blocky	2–10%	2–6 mm	Rounded
QPM07	0.4	1	0 to 0.1 m	Gradual (50–100 mm)		Pale Brown	Dry							
		2	0.3 to 0.4 m	Gradual (50–100 mm)		Dark Brown	Dry							

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM08 mound	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Clay Loam Sandy	Dark Brown	Dry	Firm (moderate or firm force)	Strong (pedal - when displaced >2/3 peds)	2-5mm	Subangular Blocky	2-10%		
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Dry	Strong (crushes underfoot with small force)	Strong (pedal - when displaced >2/3 peds)	5-10mm	Subangular Blocky	0		
		3	0.5 to 0.6 m	Gradual (50-100 mm)	Medium Clay	Dark Brown	Mod Moist	Strong (crushes underfoot with small force)	Strong (pedal - when displaced >2/3 peds)	10-20mm	Polyhedral	0		
		4	0.9 to 1 m	Gradual (50-100 mm)	Medium Clay	Dark Brown	Mod Moist	Strong (crushes underfoot with small force)	Strong (pedal - when displaced >2/3 peds)	10-20mm	Polyhedral	0		
QPM08 depression	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Mod Moist	Very Firm (strong force - thumb and forefinger)	Moderate (pedal - when displaced >1/3 peds)	2-5mm	Subangular Blocky	10-20%		
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Mod Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	5-10mm	Subangular Blocky	0		
		3	0.5 to 0.6 m	Gradual (50-100 mm)	Medium Clay	Dark Brown	Mod Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	5-10mm	Subangular Blocky	0		
		4	0.9 to 1 m	Gradual (50-100 mm)	Medium Clay	Dark Brown	Mod Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	10-20mm	Polyhedral	0		

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM09	0.6	1	0 to 0.1 m	Gradual (50-100 mm)		Dark Brown	Mod Moist							
		2	0.2 to 0.3 m	Gradual (50-100 mm)		Dark Brown	Moist							
		3	0.5 to 0.6 m	Gradual (50-100 mm)		Dark Brown	Moist							
QPM10	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Strong (pedal - when displaced >2/3 peds)	5-10mm	Subangular Blocky			
		2	0.2 to 0.5 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Strong (pedal - when displaced >2/3 peds)	10-20mm	Subangular Blocky			
		3	0.6 to 1 m	Gradual (50-100 mm)	Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Strong (pedal - when displaced >2/3 peds)	50-100mm	Subangular Blocky			

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM11	0.8	1	0 to 0.15 m	Gradual (50-100 mm)	Clayey Sand	Pale Brown	Moist	Weak (small, but significant force)	Weak (pedal - when displaced <1/3 peds)	<2mm	Subangular Blocky	20-40%	2-6 mm	Sub-angular
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	5-10mm	Subangular Blocky	0		
		3	0.4 to 0.5 m	Gradual (50-100 mm)	Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	5-10mm	Subangular Blocky	0		
		4	0.6 to 0.8 m	Gradual (50-100 mm)	Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	10-20mm	Subangular Blocky	0		

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM12	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)		<2mm	Subangular Blocky		2-6 mm	Sub-angular
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)		5-10mm	Subangular Blocky	20-40%	6-20 mm	Sub-angular
		3	0.5 to 0.6 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)		10-20mm	Subangular Blocky	40-60%	20-60 mm	Sub-angular
		4	0.7 to 0.8 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)		20-50mm	Subangular Blocky	40-60%	20-60 mm	Sub-angular
QPM12	1.0	5	1	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)		20-50mm	Subangular Blocky	40-60%	20-60 mm	Sub-angular
QPM13	0.3	1	0 to 0.1 m	Gradual (50-100 mm)		Dark Brown	Moist					0		
		2	0.2 to 0.3 m	Gradual (50-100 mm)		Dark Brown	Moist					0		

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM14	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Weak (small, but significant force)	Moderate (pedal - when displaced >1/3 peds)	2-5mm	Subangular Blocky	2-10%	2-6 mm	Sub-angular
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	5-10mm	Subangular Blocky	20-40%	6-20 mm	Sub-angular
		3	0.5 to 0.6 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	10-20mm	Subangular Blocky	40-60%	20-60 mm	Sub-angular
		4	0.9 to 1 m	Gradual (50-100 mm)	Medium Heavy Clay	Dark Brown	Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	20-50mm	Subangular Blocky	40-60%	20-60 mm	Sub-angular
QPM15	0.4	1	0 to 0.1 m	Gradual (50-100 mm)		Dark Brown	Moist					2-10%	2-6 mm	Sub-angular
		2	0.3 0.4 m	Gradual (50-100 mm)		Dark Brown	Moist					20-40%	6-20 mm	Sub-angular

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM16 depression	1.0	1	0 to 0.1	Clear (20-50 mm)	Light Medium Clay	Dark Brown	Dry	Firm (moderate or firm force)	Strong (pedal - when displaced >2/3 peds)	<2mm	Subangular Blocky	2-10%		
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Mod Moist	Firm (moderate or firm force)	Strong (pedal - when displaced >2/3 peds)	20-50mm	Subangular Blocky	10-20%		
		3	0.5 to 0.6 m	Gradual (50-100 mm)	Medium Clay	Brown	Mod Moist	Firm (moderate or firm force)	Strong (pedal - when displaced >2/3 peds)	20-50mm	Subangular Blocky	10-20%		
		4	0.9-1 m	Gradual (50-100 mm)	Medium Clay	Brown	Dry	Firm (moderate or firm force)	Strong (pedal - when displaced >2/3 peds)	5-10mm	Subangular Blocky	10-20%		

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM16 mound	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Light Medium Clay	Dark Brown	Dry	Weak (small, but significant force)	Weak (pedal - when displaced <1/3 peds)	2-5mm	Polyhedral	2-10%	2-6 mm	Sub-angular
		2	0.2 to .3 m	Gradual (50-100 mm)	Medium Clay	Dark Brown	Mod Moist	Firm (moderate or firm force)	Weak (pedal - when displaced <1/3 peds)	20-50mm	Polyhedral	20-40%	6-20 mm	Sub-angular
		3	0.5 to .6 m	Gradual (50-100 mm)	Medium Clay	Brown	Mod Moist	Very Firm (strong force - thumb and forefinger)	Moderate (pedal - when displaced >1/3 peds)	20-50mm	Subangular Blocky	20-40%	20-60 mm	Sub-angular
		4	0.9 to 1 m	Gradual (50-100 mm)	Medium Clay	Brown	Mod Moist	Weak (small, but significant force)	Weak (pedal - when displaced <1/3 peds)	5-10mm	Subangular Blocky	40-60%	20-60 mm	Sub-angular
QPM17	0.3	1	0 to 0.1 m	Gradual (50-100 mm)		Dark Brown	Mod Moist							
		2	0.2 to 0.3 m	Gradual (50-100 mm)		Dark Brown	Moist							

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM18	0.6	1	0 to 0.1 m	Gradual (50-100 mm)		Dark Brown	Mod Moist							
		2	0.2 to 0.3 m	Gradual (50-100 mm)		Dark Brown	Moist							
		3	0.5 to 0.6 m	Gradual (50-100 mm)		Dark Brown	Moist							

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM19	1.0	1	0 to 0.1 m	Gradual (50-100 mm)		Dark Brown	Mod Moist							
		2	0.2 to 0.3 m	Gradual (50-100 mm)		Dark Brown	Moist							
		3	0.5 to 0.6 m	Gradual (50-100 mm)		Dark Brown	Moist							
		4	0.9 to 1 m	Gradual (50-100 mm)		Dark Brown	Moist							
QPM20	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Sandy Clay Loam	Pale Red	Dry	Very Weak (very small force)	Massive (apedal - separates into fragments)					
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Sandy Clay Loam	Red	Dry	Very Weak (very small force)	Massive (apedal - separates into fragments)					
		3	0.5 to 0.6 m	Gradual (50-100 mm)	Clay Loam Sandy	Red	Mod Moist	Very Weak (very small force)	Weak (pedal - when displaced <1/3 peds)	5-10mm	Subangular Blocky			
		4	0.9 to 1 m	Gradual (50-100 mm)	Clay Loam Sandy	Red	Mod Moist	Very Weak (very small force)	Weak (pedal - when displaced <1/3 peds)	10-20mm	Subangular Blocky			

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM21	0.5	1	0.1 to 0.3 m	Gradual (50-100 mm)		Pale Red	Dry							
		2	0.4 to 0.5 m	Gradual (50-100 mm)		Red	Dry							
QPM22	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Sandy Clay Loam	Pale Red	Dry	Very Weak (very small force)	Massive (apedal - separates into fragments)					
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Clay Loam Sandy	Red	Dry	Very Weak (very small force)	Massive (apedal - separates into fragments)					
		3	0.5 to 0.6 m	Gradual (50-100 mm)	Clay Loam Sandy	Red	Mod Moist	Very Weak (very small force)	Weak (pedal - when displaced <1/3 peds)	5-10mm	Subangular Blocky			
		4	0.9 to 1 m	Gradual (50-100 mm)	Clay Loam Sandy	Red	Mod Moist	Very Weak (very small force)	Weak (pedal - when displaced <1/3 peds)	10-20mm	Subangular Blocky			

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM23	1.0	1	0 to 0.1 m	Gradual (50-100 mm)	Light Clay	Pale Red	Dry	Very Weak (very small force)	Massive (apedal - separates into fragments)	2-5mm	Polyhedral	<2%	2-6 mm	Sub-angular
		2	0.2 to 0.3 m	Gradual (50-100 mm)	Light Clay	Red	Mod Moist	Very Firm (strong force - thumb and forefinger)	Massive (apedal - separates into fragments)	2-5mm	Subangular Blocky	<2%	2-6 mm	Sub-angular
		3	0.5 to 0.6 m	Gradual (50-100 mm)	Clay Loam Sandy	Red	Mod Moist	Very Firm (strong force - thumb and forefinger)	Weak (pedal - when displaced <1/3 peds)	10-20mm	Subangular Blocky	<2%	2-6 mm	Sub-angular
		4	0.9 to 1 m	Gradual (50-100 mm)	Clay Loam Sandy	Red	Mod Moist	Very Firm (strong force - thumb and forefinger)	Weak (pedal - when displaced <1/3 peds)	20-50mm	Subangular Blocky	40-60%	20-60 mm	Sub-angular
QPM24	0.5	1	0 to 0.1 m	Gradual (50-100 mm)		Pale Brown	Dry	Very Weak (very small force)	Massive (apedal - separates into fragments)			<2%	2-6 mm	Sub-angular
		2	0.2 to 0.3 m	Gradual (50-100 mm)		Red	Dry	Very Weak (very small force)	Weak (pedal - when displaced <1/3 peds)			<2%	2-6 mm	Sub-angular
		3	0.4 to 0.5 m	Gradual (50-100 mm)		red	Dry	Very Weak (very small force)	Weak (pedal - when displaced <1/3 peds)			<2%	2-6 mm	Sub-angular

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
		1	0 to 0.1 m	Gradual (50-100 mm)		Pale Brown	Dry	Very Weak (very small force)	Massive (apedal - separates into fragments)			<2%	2-6 mm	Sub-angular
QPM25	0.5	2	0.2 to 0.3 m	Gradual (50-100 mm)		Red	Dry	Very Weak (very small force)	Weak (pedal - when displaced <1/3 peds)			<2%	2-6 mm	Sub-angular
		3	0.4 to 0.5 m	Gradual (50-100 mm)			Dry	Very Weak (very small force)	Weak (pedal - when displaced <1/3 peds)			<2%	2-6 mm	Sub-angular
		1	0 to 0.1 m	Gradual (50-100 mm)		Dark Brown	Dry	Firm (moderate or firm force)	Weak (pedal - when displaced <1/3 peds)	5-10mm	Subangular Blocky	2-10%	2-6 mm	
QPM26	0.5	2	0.2 to 0.3 m	Gradual (50-100 mm)		Dark Brown	Mod Moist	Firm (moderate or firm force)	Weak (pedal - when displaced <1/3 peds)	20-50mm	Subangular Blocky	<2%	2-6 mm	
		3	0.4 to 0.5 m	Gradual (50-100 mm)		Dark Brown	Mod Moist	Firm (moderate or firm force)						

Table C.1 Soil surface condition

Site	Total depth (m)	Observation	Sample depth (m)	Boundary	Texture	Colour (rapid)	Consistence		Pedality			Coarse fragments		
						Primary	Moisture	Strength	Grade	Size	Type	Abundance (%)	Size (mm)	Shape
QPM27	0.5	1	0 to 0.1 m	Gradual (50-100 mm)		Dark Brown	Dry	Firm (moderate or firm force)	Weak (pedal - when displaced <1/3 peds)	5-10mm	Subangular Blocky	2-10%	2-6 mm	
		2	0.2 to 0.3 m	Gradual (50-100 mm)		Dark Brown	Mod Moist	Firm (moderate or firm force)	Weak (pedal - when displaced <1/3 peds)	20-50mm	Subangular Blocky	<2%	2-6 mm	
		3	0.4 to 0.5 m	Gradual (50-100 mm)		Dark Brown	Mod Moist	Firm (moderate or firm force)	Moderate (pedal - when displaced >1/3 peds)	20-50mm	Subangular Blocky	<2%	2-6 mm	

Annexure D
Laboratory certificates

EMM
creating opportunities

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eastwest geo ag enviro

ANALYSIS REPORT SOIL

PROJECT NO:	**EW221239**	**Date of Issue:**	**04/08/2022**
Customer:	EMM Consulting	Report No:	3
Address:	Suite 01 20 Chandos Street ST LEONARDS NSW 2065	Date Received:	4/07/2022
		Matrix:	Soil
Attention:	Harry Savage	Location:	E210671
Phone:	0416 295 292	Sampler ID:	Client
Fax:		Date of Sampling:	30/05/2022
Email:	hsavage@emmconsulting.com.au	Sample Condition:	Acceptable

Comments:
This report supercedes any previous report with this reference. 3a = severe dispersion of the remould. 3b = moderate to slight dispersion of the remould.

Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

Signed: Stephanie Cameron
Laboratory Operations Manager

ASPAC PROFICIENT LAB
Visit www.aspac-australasia.com to view our certification details.

East West is certified by the Australian-Asian Soil & Plant Analysis Council to perform various soil and plant tissue analysis. The tests reported herein have been performed in accordance with our terms of accreditation.

This analysis relates to the sample submitted and it is the client's responsibility to make certain the sample is representative of the matrix to be tested.

Samples will be discarded one month after the date of this report. Please advise if you wish to have your sample/s returned.

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM01	QPM04	QPM04	QPM04
				DEPTH	0-0.1m	0-0.1m	0.2-0.3m	0.5-0.6m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-1**	**221239-2**	**221239-3**	**221239-4**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	7.17	7.69	8.97	9.04
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	6.30	6.86	7.97	8.13
Chloride Soluble	DA	DAP-06	mg/kg	2	32.8	28.4	45.9	109
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.13	0.17	0.23	0.36
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	2259	2458	NA	NA
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	24.1	20.7	18.7	39.6
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	3.87	5.58	4.02	4.88
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	332	434	NA	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	2.12	1.71	NA	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	88.6	143	NA	NA
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	11.1	8.60	NA	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	1.84	1.28	NA	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	2.15	2.55	NA	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	28.9	14.1	NA	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	79.8	25.8	NA	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	1.47	1.42	NA	NA
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	1529	1529	1529	619
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	2140	1660	2740	2540
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	900	840	1320	1840
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	128	128	368	828
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	3.92	3.92	3.92	1.59
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	10.7	8.30	13.7	12.7
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	7.50	7.00	11.0	15.3
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	0.56	0.56	1.60	3.60
ECEC	Calculation	PMS-15C1	cmol/kg	na	22.7	19.8	30.2	33.2
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	1.43	1.19	1.25	0.83

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

Test Parameter	Method Description	Method Reference	Units	LOR	221239-1	221239-2	221239-3	221239-4
				CLIENT SAMPLE ID	QPM01	QPM04	QPM04	QPM04
				DEPTH	0-0.1m	0-0.1m	0.2-0.3m	0.5-0.6m
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.52	0.56	0.36	0.10
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	17.3	19.8	13.0	4.78
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	47.2	42.0	45.3	38.2
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	33.1	35.4	36.4	46.2
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	2.45	2.81	5.29	10.8
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	1.5	1.7	NA	NA
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	55.6	60.8	NA	NA
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	14.0	15.6	NA	NA
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	21600	27200	NA	NA
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	5.9	4.9	NA	NA
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	817	1020	NA	NA
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	27.0	32.0	NA	NA
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	30.8	33.6	NA	NA
Total Potassium	ICP-OES	PMS-09	mg/kg	40	3160	4010	NA	NA
Total Calcium	ICP-OES	PMS-09	mg/kg	100	2600	2930	NA	NA
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	2610	3680	NA	NA
Total Sodium	ICP-OES	PMS-09	mg/kg	40	173	223	NA	NA
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	242	259	NA	NA
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	17000	17500	NA	NA
Emerson Aggregate Test	Class	PMS-21	Number	na	3a	3a	3b	4
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	NA	NA
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.3	2.3	0.6	2.0
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	28.3	38.7	32.6	35.8

ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

					QPM01	QPM04	QPM04	QPM04
				CLIENT SAMPLE ID				
				DEPTH	0-0.1m	0-0.1m	0.2-0.3m	0.5-0.6m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-1**	**221239-2**	**221239-3**	**221239-4**
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	24.7	30.4	20.6	22.3
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	5.9	5.8	5.8	3.8
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	40.8	22.8	40.4	36.0

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM04	QPM05	QPM05	QPM06
				DEPTH	0.9-1m	0-0.1m	0.5-0.6m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-5**	**221239-6**	**221239-7**	**221239-8**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	9.01	7.26	9.18	6.87
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	8.25	6.24	8.19	6.34
Chloride Soluble	DA	DAP-06	mg/kg	2	265	10.5	518	79.3
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.91	0.04	0.44	0.10
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	1077	NA	1669
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	131	4.18	<0.50	5.66
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	7.20	4.34	3.94	5.74
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	246	NA	225
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	0.87	NA	1.76
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	20.2	NA	23.6
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	NA	3.37	NA	8.90
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	1.38	NA	0.74
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	0.57	NA	1.47
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	33.9	NA	18.1
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	39.8	NA	79.8
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	<0.20	NA	0.40
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	185	NA	311	255
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	2140	NA	1860	920
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	1760	NA	500	340
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	1468	NA	148	20
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.47	NA	0.80	0.65
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	10.7	NA	9.30	4.60
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	14.7	NA	4.17	2.83
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	6.38	NA	0.64	0.09
ECEC	Calculation	PMS-15C1	cmol/kg	na	32.2	NA	14.9	8.17
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.73	NA	2.23	1.62

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PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM04	QPM05	QPM05	QPM06
				DEPTH	0.9-1m	0-0.1m	0.5-0.6m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-5**	**221239-6**	**221239-7**	**221239-8**
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.03	NA	0.19	0.23
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	1.47	NA	5.35	8.00
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	33.2	NA	62.4	56.3
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	45.5	NA	27.9	34.7
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	19.8	NA	4.32	1.06
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	1.7	NA	0.9
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	55.6	NA	30.7
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	12.3	NA	9.0
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	21600	NA	13700
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	5.4	NA	3.5
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	1060	NA	239
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	25.0	NA	20.0
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	25.5	NA	15.2
Total Potassium	ICP-OES	PMS-09	mg/kg	40	NA	477	NA	797
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	2930	NA	1620
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	2110	NA	1370
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	257	NA	196
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	118	NA	155
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	15100	NA	7720
Emerson Aggregate Test	Class	PMS-21	Number	na	4	3a	4	8
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	160	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	2250	NA	NA
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	825	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	190	NA	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	1.5	<0.1	0.3	0.9
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	41.0	24.4	28.3	45.4

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM04	QPM05	QPM05	QPM06
				DEPTH	0.9-1m	0-0.1m	0.5-0.6m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-5**	**221239-6**	**221239-7**	**221239-8**
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	19.3	36.5	26.9	26.6
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	3.9	5.6	1.7	7.8
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	34.3	33.4	42.7	19.2

ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM06	QPM06	QPM06	QPM08 dep
				DEPTH	0.2-0.3m	0.5-0.6m	0.7-0.8m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-9**	**221239-10**	**221239-11**	**221239-12**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	7.82	8.88	8.59	7.48
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	6.54	7.62	7.23	6.46
Chloride Soluble	DA	DAP-06	mg/kg	2	78.2	345	348	76.4
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.11	0.31	0.28	0.09
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	987
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	2.64	1.16	2.57	3.12
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	3.87	4.41	4.31	3.79
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	91.7
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	1.08
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	11.2
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	4.24
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	1.66
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.37
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	23.9
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	37.8
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	0.84
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	64.0	31.0	NA	199
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	440	360	NA	2940
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	440	860	NA	1300
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	448	1228	NA	568
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.16	0.08	NA	0.51
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	2.20	1.80	NA	14.7
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	3.67	7.17	NA	10.8
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	1.95	5.34	NA	2.47
ECEC	Calculation	PMS-15C1	cmol/kg	na	7.98	14.4	NA	28.5
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.60	0.25	NA	1.36

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PROJECT NO: EW221239 **Location: E210671**

Test Parameter	Method Description	Method Reference	Units	LOR	QPM06	QPM06	QPM06	QPM08 dep
				DEPTH	0.2-0.3m	0.5-0.6m	0.7-0.8m	0-0.1m
					221239-9	221239-10	221239-11	221239-12
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.04	0.01	NA	0.05
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	2.06	0.55	NA	1.79
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	27.6	12.5	NA	51.6
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	46.0	49.8	NA	38.0
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	24.4	37.1	NA	8.66
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	1.6
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	56.8
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	14.1
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	26400
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	6.9
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	918
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	28.0
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	33.2
Total Potassium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	659
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	3030
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	2820
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	438
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	121
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	20700
Emerson Aggregate Test	Class	PMS-21	Number	na	1	1	1	3a
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	150	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	1300	NA
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	675	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	760	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.2	0.4	0.2	0.1
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	41.6	37.3	38.5	17.5

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PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM06	QPM06	QPM06	QPM08 dep
				DEPTH	0.2-0.3m	0.5-0.6m	0.7-0.8m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-9**	**221239-10**	**221239-11**	**221239-12**
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	32.5	31.0	32.3	20.9
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	3.7	3.5	7.4	11.3
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	21.9	27.8	21.8	50.3

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PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM08 dep	QPM08 dep	QPM08 dep	QPM08 mnd
				DEPTH	0.2-0.3m	0.5-0.6m	0.9-1m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-13**	**221239-14**	**221239-15**	**221239-16**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	7.94	7.80	6.89	7.50
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	7.12	6.95	6.44	6.52
Chloride Soluble	DA	DAP-06	mg/kg	2	608	1120	1540	95.8
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.42	0.69	0.99	0.13
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	1727
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	2.62	1.83	<0.50	3.09
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	3.71	3.00	2.68	3.39
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	147
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	1.54
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	15.4
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	11.5
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	1.20
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.43
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	21.9
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	37.8
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	0.40
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	104	90.0	78.0	126
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	3740	3140	2340	3740
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	1280	1220	1100	960
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	1108	1288	1488	448
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.27	0.23	0.20	0.32
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	18.7	15.7	11.7	18.7
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	10.7	10.2	9.17	8.00
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	4.82	5.60	6.47	1.95
ECEC	Calculation	PMS-15C1	cmol/kg	na	34.5	31.7	27.5	29.0
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	1.75	1.54	1.28	2.34

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PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM08 dep	QPM08 dep	QPM08 dep	QPM08 mnd
				DEPTH	0.2-0.3m	0.5-0.6m	0.9-1m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-13**	**221239-14**	**221239-15**	**221239-16**
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.03	0.02	0.02	0.04
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	0.77	0.73	0.73	1.12
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	54.3	49.5	42.5	64.5
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	31.0	32.1	33.3	27.6
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	14.0	17.7	23.5	6.72
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	1.4
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	51.3
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	13.5
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	23700
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	6.4
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	979
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	28.0
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	29.7
Total Potassium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	682
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	4180
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	2860
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	480
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	207
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	18000
Emerson Aggregate Test	Class	PMS-21	Number	na	3b	3b	3a	3b
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	NA	NA
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.2	<0.1	<0.1	0.1
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	17.0	17.2	18.1	22.7

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

					QPM08 dep	QPM08 dep	QPM08 dep	QPM08 mnd
				CLIENT SAMPLE ID				
				DEPTH	0.2-0.3m	0.5-0.6m	0.9-1m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-13**	**221239-14**	**221239-15**	**221239-16**
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	13.4	20.8	21.8	23.4
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	13.2	14.7	11.4	11.2
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	56.3	47.2	48.8	42.6

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PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM08 mnd	QPM08 mnd	QPM08 mnd	QPM16 dep
				DEPTH	0.2-0.3m	0.5-0.6m	0.7-0.8m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-17**	**221239-18**	**221239-19**	**221239-20**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	8.77	8.54	8.15	8.11
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	8.07	7.98	7.57	7.37
Chloride Soluble	DA	DAP-06	mg/kg	2	1640	2300	2165	31.1
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	1.21	1.61	1.26	0.07
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	1386
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	3.77	4.83	5.17	2.20
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	3.39	3.39	3.32	2.60
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	430
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	1.47
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	9.72
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	8.56
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.92
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.45
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	13.5
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	23.8
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	<0.20
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	70.0	62.0	59.0	507
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	2540	2140	1700	5340
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	1140	1240	1160	1260
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	1548	1868	1728	168
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.18	0.16	0.15	1.30
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	12.7	10.7	8.50	26.7
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	9.50	10.3	9.67	10.5
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	6.73	8.12	7.51	0.73
ECEC	Calculation	PMS-15C1	cmol/kg	na	29.1	29.3	25.8	39.2
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	1.34	1.04	0.88	2.54

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM08 mnd	QPM08 mnd	QPM08 mnd	QPM16 dep
				DEPTH	0.2-0.3m	0.5-0.6m	0.7-0.8m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-17**	**221239-18**	**221239-19**	**221239-20**
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.02	0.02	0.02	0.12
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	0.62	0.54	0.59	3.31
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	43.6	36.5	32.9	68.1
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	32.6	35.3	37.4	26.8
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	23.1	27.7	29.1	1.86
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	2.9
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	46.2
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	17.7
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	49300
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	14.5
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	2950
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	58.0
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	57.7
Total Potassium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	4800
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	6860
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	5760
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	302
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	176
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	35200
Emerson Aggregate Test	Class	PMS-21	Number	na	3b	3b	3a	5
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	NA	NA
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.1	<0.1	<0.1	0.2
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	23.4	18.7	17.0	12.4

ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM08 mnd	QPM08 mnd	QPM08 mnd	QPM16 dep
				DEPTH	0.2-0.3m	0.5-0.6m	0.7-0.8m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-17**	**221239-18**	**221239-19**	**221239-20**
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	20.5	19.4	18.3	16.9
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	9.4	9.4	9.0	17.3
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	46.6	52.5	55.6	53.3

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

					QPM16 dep	QPM16 dep	QPM16 dep	QPM16 mnd
				CLIENT SAMPLE ID				
				DEPTH	0.2-0.3m	0.5-0.6m	0.8-0.9m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-21**	**221239-22**	**221239-23**	**221239-24**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	8.72	8.82	8.28	7.92
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	7.84	7.90	7.70	7.24
Chloride Soluble	DA	DAP-06	mg/kg	2	66.6	220	1810	32.2
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.22	0.29	0.99	0.08
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	1873
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	2.42	2.96	1.47	6.21
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	2.41	2.60	3.24	3.87
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	375
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	1.98
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	8.15
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	7.97
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	1.14
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.53
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	21.9
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	29.8
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	<0.20
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	311	241	255	367
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	5140	3740	3340	5740
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	1560	1220	1360	1200
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	888	888	1428	228
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.80	0.62	0.65	0.94
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	25.7	18.7	16.7	28.7
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	13.0	10.2	11.3	10.0
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	3.86	3.86	6.21	0.99
ECEC	Calculation	PMS-15C1	cmol/kg	na	43.4	33.3	34.9	40.6
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	1.98	1.84	1.47	2.87

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM16 dep	QPM16 dep	QPM16 dep	QPM16 mnd
				DEPTH	0.2-0.3m	0.5-0.6m	0.8-0.9m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-21**	**221239-22**	**221239-23**	**221239-24**
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.06	0.06	0.06	0.09
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	1.84	1.85	1.87	2.32
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	59.3	56.1	47.9	70.6
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	30.0	30.5	32.5	24.6
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	8.90	11.6	17.8	2.44
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	2.9
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	48.7
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	19.7
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	49200
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	70.0
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	3520
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	17.4
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	57.3
Total Potassium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	3920
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	7750
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	5360
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	349
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	238
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	32400
Emerson Aggregate Test	Class	PMS-21	Number	na	3b	3b	3b	5
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	NA	NA
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.6	<0.1	0.7	0.9
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	26.2	29.7	26.2	25.8

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PROJECT NO: EW221239 **Location: E210671**

					CLIENT SAMPLE ID	QPM16 dep	QPM16 dep	QPM16 dep	QPM16 mnd
					DEPTH	0.2-0.3m	0.5-0.6m	0.8-0.9m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**		**221239-21**	**221239-22**	**221239-23**	**221239-24**
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na		19.0	19.8	16.4	21.8
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na		11.3	11.3	11.4	15.4
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na		42.9	39.3	45.3	36.1

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM16 mnd	QPM16 mnd	QPM16 mnd	QPM20
				DEPTH	0.2-0.3m	0.5-0.6m	0.8-0.9m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-25**	**221239-26**	**221239-27**	**221239-28**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	8.57	8.69	8.38	6.32
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	7.65	7.87	7.70	5.13
Chloride Soluble	DA	DAP-06	mg/kg	2	47.8	335	895	17.9
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.14	0.37	0.70	0.01
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	2054
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	3.68	2.44	3.00	<0.50
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	3.32	4.34	3.63	2.76
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	194
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	1.00
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	12.4
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	6.03
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.50
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.47
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	35.9
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	12.2
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	0.51
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	269	227	213	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	5140	3740	3340	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	1340	1360	1440	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	468	888	1128	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.69	0.58	0.55	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	25.7	18.7	16.7	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	11.2	11.3	12.0	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	2.03	3.86	4.90	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	39.6	34.5	34.2	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	2.30	1.65	1.39	NA

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PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM16 mnd	QPM16 mnd	QPM16 mnd	QPM20
				DEPTH	0.2-0.3m	0.5-0.6m	0.8-0.9m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-25**	**221239-26**	**221239-27**	**221239-28**
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.06	0.05	0.05	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	1.74	1.69	1.60	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	64.9	54.2	48.9	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	28.2	32.9	35.1	NA
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	5.14	11.2	14.4	NA
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	1.7
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	101
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	7.6
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	25650
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	4.7
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	730
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	18.5
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	8.25
Total Potassium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	348
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	1790
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	241
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	64.0
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	84.5
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	5100
Emerson Aggregate Test	Class	PMS-21	Number	na	5	3b	3b	3a
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	220
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	NA	1750
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	125
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	50.0
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.2	0.8	1.3	0.1
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	28.7	43.9	38.8	44.3

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PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM16 mnd	QPM16 mnd	QPM16 mnd	QPM20
				DEPTH	0.2-0.3m	0.5-0.6m	0.8-0.9m	0-0.1m
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-25**	**221239-26**	**221239-27**	**221239-28**
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	18.3	14.1	15.1	26.8
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	9.9	5.7	7.9	5.5
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	43.0	35.5	37.0	23.3

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PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	**QPM20**	**QPM20**	**QPM20**	
				DEPTH	**0.2-0.3m**	**0.5-0.6m**	**0.9-1m**	
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-29**	**221239-30**	**221239-31**	
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	6.36	6.06	6.22	
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	5.39	5.53	5.76	
Chloride Soluble	DA	DAP-06	mg/kg	2	12.5	17.1	26.2	
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.01	0.04	0.05	
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	<0.50	14.6	22.8	
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	<2.00	2.29	4.49	
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	NA	NA	
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	NA	NA	
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	

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ANALYSIS REPORT

PROJECT NO: EW221239 **Location: E210671**

				CLIENT SAMPLE ID	QPM20	QPM20	QPM20	
				DEPTH	0.2-0.3m	0.5-0.6m	0.9-1m	
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-29**	**221239-30**	**221239-31**	
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	NA	NA	
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	NA	NA	
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	NA	NA	
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	NA	NA	
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	NA	
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	
Total Potassium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	
Emerson Aggregate Test	Class	PMS-21	Number	na	5	5	5	
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	150	150	50.0	
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	1250	800	750	
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	125	125	125	
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	50.0	50.0	50.0	
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.2	0.4	0.4	
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	41.3	39.7	37.5	

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				DEPTH	0.2-0.3m	0.5-0.6m	0.9-1m	
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**221239-29**	**221239-30**	**221239-31**	
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	31.5	25.8	25.2	
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	3.6	3.8	5.6	
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	23.3	30.3	31.3	

Soils are air dried at 40^{0}C and ground <2mm.

NB: LOR is the Lowest Obtainable Reading.

DOCUMENT END

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