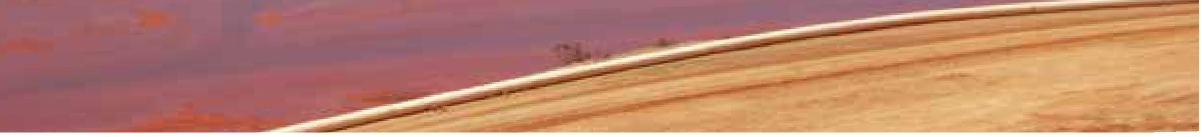



Appendix D

Soil and erosion hazard assessment




APA East Coast Grid Expansion, Moomba to Wilton Pipeline - Modification Report 1

Soil and Erosion Hazard Assessment

Prepared for APA Group
July 2021

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APA East Coast Grid Expansion, Moomba to Wilton Pipeline - Modification Report 1

Soil and erosion hazard assessment

Report Number

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Client

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7 July 2021

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7 July 2021

Executive Summary

A desktop soil and erosion hazard assessment has been conducted to identify the impact of the project elements on soil loss, considering the existing environment and soil characteristics.

As part of the erosion and hazard analysis, the physical erosion risk was calculated based on two methodologies. Firstly, erosion risk of the soil due to its physical and chemical properties was determined utilising texture derived soil erodibility factors (K-Factors) from both IECA 2008 and Loch *et al.* 1998. Secondly, the erosion hazard for the project was calculated in relation to rainfall and slope. Rainfall and slope in the project area results in a low hazard of causing erosion.

Due to the arid nature of the MW433 project site, the erosion risk is primarily wind-based. The arid nature results in an inability to rely on protective vegetation cover which is typically used in establishing erosional stability which should be considered in the preparation of detailed erosion control measures.

The greatest influence on reducing water erosion hazard is through the adoption of a drainage design that is appropriate for dispersive and non-cohesive soils – maintaining sheet flow conditions where possible, avoiding concentration of flow and ameliorating disturbed dispersive subsoils.

Maintaining and/or re-establishing soil surface cover will be fundamental for water and wind erosion control. Suitable controls include stabilisation of exposed soils and hardstand areas with trafficable and non-trafficable soil stabilising polymers; and the placement of woody debris and application of biologically activated hydraulic growth mediums on areas of temporary and permanent rehabilitation.

If the drainage design and erosion control is undertaken as described, there is very low erosion and sedimentation risk during the construction and operational phase of the project with most of the site to be covered by stabilised and/or sealed hardstands, buildings or subject to progressive rehabilitation.

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1 Introduction

1.1 Background

East Australian Pipeline Pty Ltd, part of the APA Group (APA) currently operates an underground high pressure natural gas transmission pipeline, extending from Moomba (South Australia) to Wilton (New South Wales), a distance of approximately 1,299 kilometres (km). The Moomba to Wilton Pipeline (MWP) is the mainline part of the Moomba Sydney Pipeline (MSP) and was constructed in 1976.

Initially, the pipeline was owned and operated by the Pipeline Authority, a Commonwealth agency, and generally regulated under the *Pipeline Authority Act 1973*. The MWP is now owned and operated by APA; it was gazetted as State Significant Infrastructure (SSI) on 11 December 2020 and is authorised by Pipeline Licence No. 16 (PL16).

The MWP currently operates at a forward haul capacity of approximately 489 terajoules per day (TJ/day) (AEMC 2021).

1.2 Project overview and context

NSW imports the majority of its natural gas from other states, and a gas shortfall on Australia's east coast is predicted by Winter 2023, with demand for gas forecast to outstrip supply.

APA is proposing an expansion of gas transportation capacity on its East Coast Grid that links Queensland to southern markets ahead of projected potential 2023 supply risks. Expansion would be through the construction of additional compressions stations and associated works on both the South West Queensland Pipeline (SWQP) and MWP in NSW.

The expansion will be delivered in a number of stages. The first stage of expansion works includes the construction of a single site of compression on each of the SWQP and MWP and will increase Wallumbilla to Wilton capacity by 12%. The first stage is targeted for commissioning in the first quarter of 2023 ahead of forecast southern state winter supply risks identified in the 2021 Australian Energy Market Operator (AEMO) Gas Statement of Opportunities (AEMO 2021).

The second stage of expansion works (an additional site on the SWQP and on the MWP) will add a further 13% capacity and will be staged to meet customer demand.

APA is undertaking engineering and design works on a potential third stage (three additional compressor locations on the MWP) of the East Coast Grid to add a further 25% transportation capacity. All up, these proposed capacity expansions would mean that the entirety of NSW peak demand could be met by gas flowing from northern sources.

The proposed East Coast Grid Expansion (the project) presents an optimal opportunity to maximise gas supply via existing infrastructure with minimal impact.

The five compressor stations for the East Coast Grid Expansion will be constructed at the following locations on the MWP:

- Modification 1:
  - Stage 1:
    - MW880 – Milne approximately 35 km south-west of Condobolin.

  - Stage 2:
    - MW433 – Round Hill approximately 103 km north of Wilcannia.
- Modification 2:
  - Stage 3:
    - MW162 – Binerah Downs approximately 68 km north-west of Tibooburra.
    - MW300 – Mecoola Creek approximately 70 km south-east of Tibooburra.
    - MW733 – Gilgunnia approximately 63 km south-west of Nymagee.

This report has been prepared to address the potential erosion hazard impacts for Stage 1 and 2 and to support Modification Report 1. As such, only the potential erosion hazard impacts at MW433 and MW880 have been assessed in this report. A separate report will be prepared to support Stage 3 in Modification Report 2.

The proposed locations of compressor stations on the MWP are shown in Figure 1.1.

1.3 Report purpose and method

EMM Consulting Pty Limited (EMM) has been commissioned to prepare a soil and erosion hazard assessment for the construction and operation of the project.

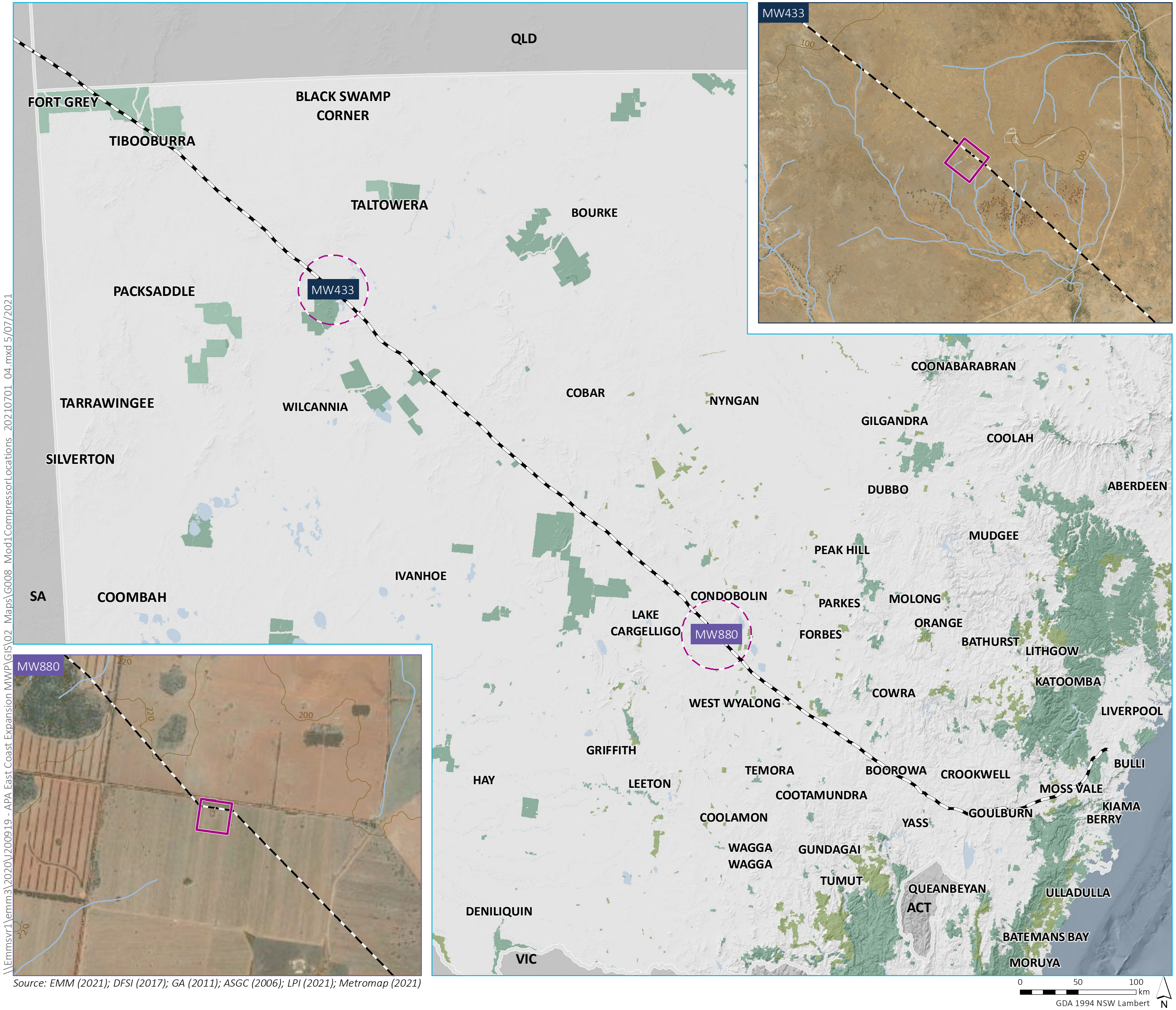
It has been prepared to satisfy the requirement of the state significant infrastructure (SSI) Standard Secretary's Environmental Assessment Requirements (SEARs) (DPE 2015) to '*assess the impacts on soil and land resources (including erosion risk or hazard), with particular attention to soil erosion and sediment transport*'.

The specific objectives of this report are to:

- describe and characterise the existing soil resources and topography; and
- identify erosion and sediment control constraints at the proposed compressor station sites with regard to soil types and landscapes, climate and topography; and nominate appropriate erosion and sediment control practises to mitigate identified erosion risk.

1.3.1 Relevant standards and guidelines

This soil and erosion hazard assessment has been undertaken with reference to the following regulatory and best-practice guidelines.



Source: EMM (2021); DFSI (2017); GA (2011); ASGC (2006); LPI (2021); Metromap (2021)

KEY
- Compressor site 30 km buffer
- State boundary
- Moomba to Wilton pipeline
- NPWS reserve
- State forest

INSET KEY
- Compressor site boundary
- Contour (10 m)
- Watercourse

Proposed location of compressor stations on the MWP

APA - East Coast Grid Expansion
Erosion hazard assessment
Modification report 1
Figure 1.1

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i Land and Soil Capability Assessment Scheme

The Land and Soil Capability Assessment Scheme (OEH 2012) assesses the capacity of subject land to support a range of land uses. It considers the inherent the biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil constraints. Potential constraints include erosion (water and wind), soil structure decline, soil acidification, salinity, waterlogging, and shallow soils and mass movement.

Each ranking is given a rating between 1 (best, highest capability land) and 8 (worst, lowest capability land). The final land and soil capability class (LSC) of the land is based on the most limiting constraints.

ii Erosion and sediment control guidelines

The assessment of erosion hazard has been undertaken with reference to the following best-practice erosion and sediment control guidelines:

- Best Practice Erosion and Sediment Control (IECA 2008).
- Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004) ("blue book").
- Managing Urban Stormwater, Soils and Construction Volume 2A Installation of Services (DECC 2008).

1.3.2 Assessment method

A desktop-based soil assessment was undertaken using existing information on soils and soil environments sourced from the following regional mapping published by government departments:

- Australian soil classification (ASC) soil type map of NSW (OEH 2017a);
- Great soil group soil type mapping of NSW (OEH 2017b);
- Hydrological soil group mapping (OEH 2017c);
- Inherent soil fertility mapping (OEH 2017d);
- Land and soil capability classes mapping (OEH 2017e); and
- NSW soil and land information system (SALIS) (DPIE 2020) accessed through eSPADE (OEH 2016).

1.4 Relevant studies

No prior soil and erosion assessments or data relevant to the project and proposed compressor station sites were available to support this report.

1.5 Limitations

This soil and erosion hazard assessment has been undertaken as a desktop assessment only and is limited to the information and inferences available.

2 Project description

2.1 Compressor station details

The East Coast Grid Expansion in NSW will be facilitated by the construction of five compressor stations along the length of the MWP. This modification report addresses the construction and operation of two compressor stations: Stage 1 (MW880) and Stage 2 (MW433).

Each compressor station will include:

- an enclosed gas turbine driven compressor unit;
- microturbine;
- compressor inlet / scrubber;
- a control equipment building;
- two fuel gas skids;
- air compressors and receivers;
- associated piping, electrical equipment, instrumentation, and controls;
- a station vent; and
- small accommodation and maintenance buildings for operations.

All facilities will be installed on driven piles or supported on structural steel skids over gravel sheeting, with the exception of the accommodation and maintenance buildings which will be constructed on concrete slab.

Both of the proposed sites for the compressor stations are on land owned by APA, with MW433 being approximately 380 m x 400 m with an area of 15.5 hectares (ha), and MW880 being approximately 400 m x 400 m with an area of 16 ha. The compressor station will have a final footprint of approximately 1.5 ha.

2.1.1 Construction

Each compressor station will require a construction footprint of approximately 3.5 ha, which will be reduced to approximately 1.5 ha for operations.

At MW433, the temporary construction workforce required to build the compressor station will be accommodated in a temporary accommodation camp, with mobilisation and demobilisation of the workforce to and from Broken Hill airport for each roster. The temporary accommodation camp will measure approximately 100 m x 100 m, with an additional 100 m x 100 m for waste water treatment. A smaller accommodation unit for operations will be included within the operational footprint on the compressor station.

At MW880, there are two options for the accommodation of the construction workforce. The preferred option is to house the workforce in short-term accommodation in Condobolin (42 km by road from the site), with potential overflow accommodation in West Wyalong (85 km by road from the site), if required. Workers will be driven to and from site each day, with between one and four buses and between five and eight cars required per day, depending on workforce numbers. The alternative option is to use a temporary accommodation camp on site (as per MW433), where mobilisation and demobilisation of the workforce will be to and from Dubbo airport for each roster.

Waste water from the construction camp (if used) will be treated and disposed of via spray irrigation on site.

Construction materials and supplies (including food and services for the temporary accommodation camps) will be sourced from relevant suppliers and transported to site. APA will use local suppliers where practicable.

At MW880, water will likely be purchased under a commercial arrangement from Lachlan Shire Council, or another local provider and transported to site by 25 kilolitre (kL) water truck. At MW433, there are two options for water supply – accessing groundwater on site, and/or purchasing water under a commercial arrangement from a local water provider and transporting it to site by 25 kL water truck. APA is investigating options to access groundwater under the relevant water sharing plans and regulations. If accessing groundwater at MW433 is feasible, then all regulatory requirements for water licences will be met, and any further assessments and approvals will be undertaken and applied for prior to water abstraction. If accessing groundwater is not feasible for all or part of the project, then the commercial purchase and transport will become the default water supply option.

The majority of construction activities will take place between 7:00 am and 6:00 pm, seven days per week. During the commissioning phase, activities will also take place between 7:00 am and 6:00 pm, seven days per week, however for the final two weeks, commissioning activities will be 24-hours per day.

i Construction activities

Construction of the compressor stations will include the following activities:

- mobilisation of construction equipment;
- establishment of access (where required);
- establishment of construction camp accommodation and associated facilities;
- establishment of access to water supply;
- site bulk earthworks including build up to match existing levels;
- installation of steel piles;
- installation of all equipment items, skids and buildings;
- installation of associated steel structures, prefabricated piping, electrical equipment, instrumentation and controls;
- supply and install communication and controls infrastructure;
- demobilisation of construction equipment;
- rehabilitation of temporary disturbance areas; and
- pre-commissioning and commissioning of compressor station.

ii Workforce

The construction of the compressor stations will require an average workforce of 40 with a peak of 80 personnel over the 12-month period. All roles are likely to be drive-in-drive-out (DIDO) or fly-in-fly-out (FIFO) and based at the construction camp when on site. The anticipated roster is three weeks on followed by one week off on a rotational basis.

There are expected to be five contracts put out to tender for the construction and commissioning of the compressor stations:

- earthworks and civil works;
- establishment of the construction camp and associated waste water treatment system;
- piling;
- structural, mechanical, piping, electrical and instrumentation construction (SMPEI); and
- compressor station pre-commissioning and commissioning.

In addition to the contractor workforce, APA will have a project team on site to manage the works.

The anticipated workforce associated with each contract is outlined in Table 2.1 below.

Table 2.1 Construction and commissioning workforce

Entity	Average workforce	Peak workforce
APA Project Team	4	10
Earthworks	10	15
Piling	6	6
SMPEI Construction	30	50
Construction Camp	8	16
Pre-commissioning and Commissioning	10	14

The anticipated workforce distribution over the 12-month construction and commissioning program is presented in Table 2.2.

Table 2.2 Monthly construction and commissioning workforce distribution

1	2	3	4	5	6	7	8	9	10	11	12
20	28	28	37	47	65	68	59	49	39	18	18

2.1.2 Operation

i Activities

The compressor stations are designed to operate remotely without onsite staff for most of their working life. They will be operated remotely from APA's control centre in Brisbane, and can operate up to 24 hours per day, seven days per week.

Typical operations activities will involve minor maintenance, calibrations, inspections, equipment performance checks, or equipment repair if needed. Operation activities will be typically carried out during daylight hours, unless an emergency requires urgent works at night. Site personnel will carry out inspections ranging from daily inspections to more rigorous inspections that may vary from one month to 4 years apart, dependent on the works. Detailed maintenance plans will be prepared for all sites.

Regulatory compliance checks will be carried out on different equipment as prescribed in applicable standards but will typically vary from one to four-year intervals subject to the equipment types. Compliance checks may include emissions testing, hazardous area compliance assessments, pressure vessel inspections, and electrical safety checks.

Major services and engine overhauls will be carried out at five-to-ten-year intervals subject to equipment condition, manufacturer's recommendations and run hours.

Once complete, the compressor stations will have an average design life of approximately 25 years. APA will continue to monitor the condition of equipment up to and beyond the end of life to ensure equipment is sound and fit for further service. Continued operation beyond the nominal design life will be subject to specific equipment condition and plant fitness assessments. The compressor station will be decommissioned when there is no further economic potential to continued use.

ii Workforce

The compressor stations are designed to operate as unmanned facilities. The typical site workforce for operation activities is expected to be one to two people.

Larger groups of up to five people associated with major services or overhauls will be required to minimise the time the compressor station is offline.

The operations workforce will comprise existing APA employees, who are unlikely to be resident locally. Additional specialist servicing will be carried out by a mix of local contractors and interstate/international based depending on the complexity of the task.

3 Existing environment

3.1 General

3.1.1 MW433 – Round Hill

MW433 is located in far north west NSW in the Barwon Darling catchment. The site is surrounded by the Paroo-Darling National Park.

The historic annual mean rainfall at the site is less than 250 millimetres (mm), with generally a wet summer and dry winter (BoM 2020).

Site topography generally slopes gently from north east to south west at a slope of 0.5–1.5% (DTA 2021), with a small hill ("Round Hill") located immediately to the east of the site.

3.1.2 MW880 – Milne

MW880 – Milne is located in central NSW in the Lachlan River catchment. Land use is dryland cropping and horticulture.

The historic annual mean rainfall at the site is less than 450 mm, with generally a wet summer and dry winter (BoM 2020).

Site topography slopes gently from west to east at 0.5–2%. Slopes to the north of the site can reach approximately 6% (DTA 2021).

3.2 Soils

A desktop-based soil assessment was undertaken using existing information on soils and soil environments to provide key information used in the erosion hazard analysis (section 4). The available soils information is detailed in sections 3.2.1 to 3.2.6 and summarised in section 3.2.7.

3.2.1 Australian Soil Classification

The ASC scheme (Isbell 2016) is a multi-category scheme with soil classes defined based on diagnostic horizons and their arrangement in vertical sequence as seen in an exposed soil profile.

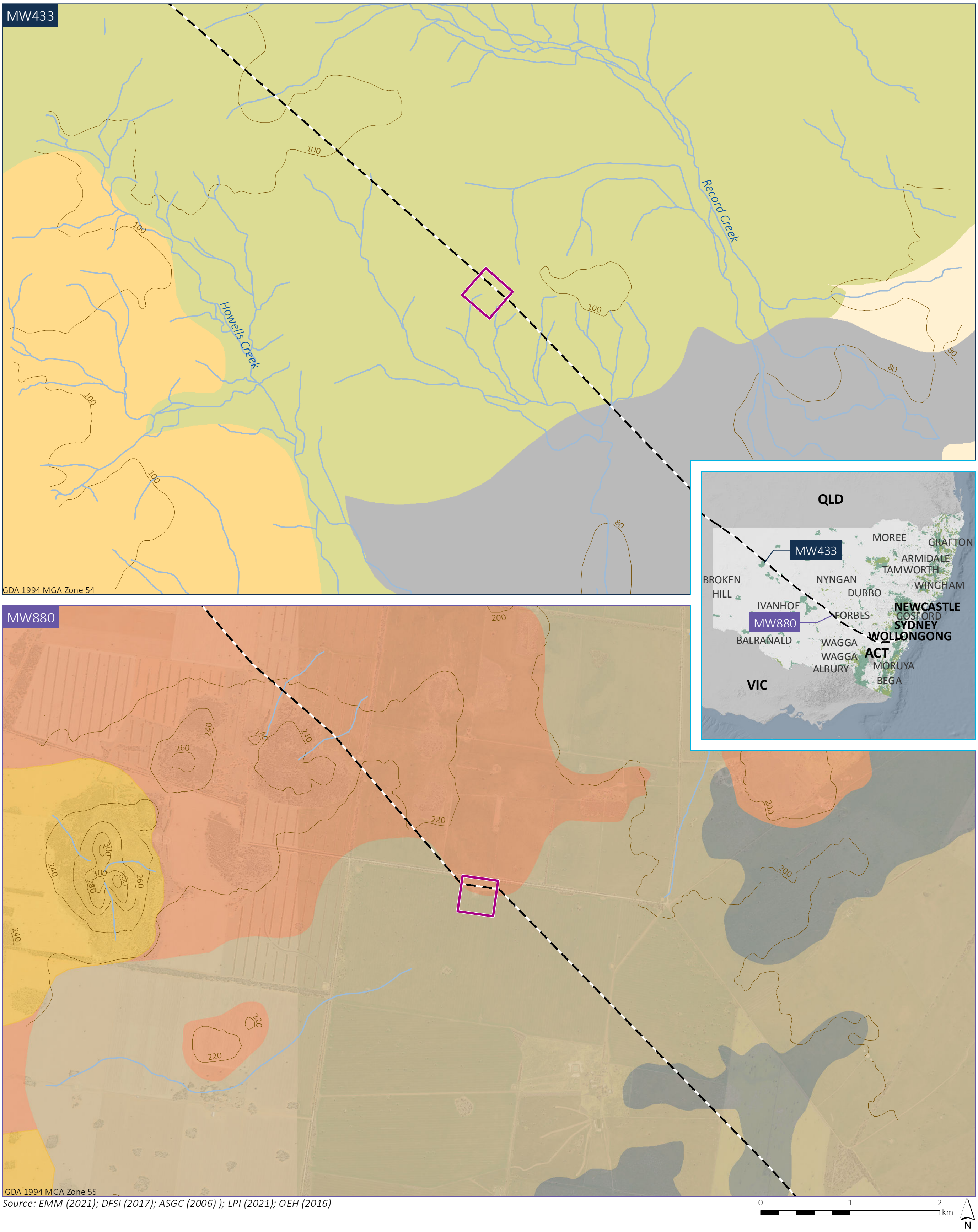
With reference to the NSW Soil and Land Information (SALIS) System (DPIE 2015–2020) through the 'eSPADE' Soil Profile Database (Version 2.0, OEH 2016), the soil types shown in regional soil mapping of the project area are presented in Table 3.1.

The ASC soil map for the project site (from OEH 2017a) is presented in Figure 3.1.

Table 3.1 Summary of regional ASC soil mapping

Site	Soil Type	ASC description [1]	Agricultural potential [2]
MW433 – Round Hill	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 B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is *sodic* and *not strongly acid.* • Soils with strongly sub-plastic upper B2 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.
MW880 – Milne	Kandosols	• Soils which lack strong texture contrast with massive or 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 is massive or has only a weak structure grade; – a maximum clay content in part of the B2 horizon of at least 15%; – the B horizon is not tenic; – lacks clear or abrupt texture contrast; and – is not calcareous throughout the solum.	• Generally low to moderate agricultural potential with moderate chemical fertility and water holding capacity.
MW880 – Milne	Chromosols	• Soils with strong texture contrast between A horizons and B horizons where the latter are not strongly acid and are not sodic. • Upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is not strongly acid and is not sodic.	• Generally moderate agricultural potential with moderate chemical fertility and water holding capacity. • Can be susceptible to soil acidification and soil structural decline. • These soils are among the most widespread soils used for agriculture in Australia, particularly those with red subsoils.

1. Isbell (2016)
2. Gray and Murphy (2002)



Source: EMM (2021); DFSI (2017); ASGC (2006)); LPI (2021); OEH (2016)

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KEY

- Compressor site
- Moomba to Wilton pipeline
- Watercourse
- Contour (10 m)

Australian Soil Classification (Order level)

- Chromosols
- Kandosols
- Rudosols
- Rudosols and Tenosols
- Sodosols
- Vertosols

Regional ASC mapping

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Figure 3.1

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3.2.2 Great Soil Groups

Great Soil Groups (GSG) is a soil classification system developed by Stace *et al.* (1968) based on the description of soil properties such as colour, texture, structure, drainage, lime, iron, organic matter and salt accumulation, as well as theories of soil formation.

Historic soil mapping identified from NSW government mapping (OEH 2017b) for the sites is displayed in Table 3.2 with their corresponding ASC equivalents.

Table 3.2 Regional soil mapping – Great soil groups

Site	ASC equivalent	GSG
MW433 – Round Hill	Sodosols	Desert Loams (DL)
MW880 – Milne	Kandosols	Red earths— less fertile (REl)
MW880 – Milne	Chromosols	Red brown earths (RBE)

3.2.3 Inherent soil fertility

Inherent soil fertility is used as a general indication of a soil's capacity to retain and release nutrients and soil water for use by vegetation and is a function of the interrelationship between physical, chemical and biological components in the soil. The scheme is a modified version of that described by Charman (1978) in Soils of New South Wales: their characterisation, classification and conservation.

The eSPADE database (OEH 2016, OEH 2017c) maps the soils of the sites as moderately-low to moderate inherent soil fertility (Table 3.3). In general terms the soils can be considered as follows:

- Moderately low fertility – soils with low fertilities that, generally, will only support vegetation suited to grazing with large inputs of fertiliser required to improve the soils and make them suitable for arable purposes.
- Moderate fertility – soils with low to moderate fertility and usually require fertiliser and/or have some physical restrictions for arable use.

Table 3.3 Inherent soil fertility

Site	ASC	Inherent soil fertility
MW433 – Round Hill	Sodosols	Moderately low
MW880 – Milne	Kandosols	Moderately low
MW880 – Milne	Chromosols	Moderate

3.2.4 Land and soil capability classes (agricultural potential)

The Land and Soil Capability Assessment Scheme (OEH 2012) ('LSC Scheme') assesses the capacity of subject land to support a range of land uses. The LSC Scheme considers the inherent biophysical features of the land and soil, and their associated hazards and limitations, to these land uses (Table 3.4). Each hazard is given a rating between 1 (best, highest capability land) and 8 (worst, lowest capability land).

Table 3.4 LSC assessment considerations

Biophysical features	Assessed hazards and limitations
Soil type	Soil structure decline
Slope	Water erosion; including sheet, rill and gully erosion
Landform position	Wind erosion
Soil acidity	Soil acidification
Soil salinity	Soil and landscape salinity and drainage
Drainage	Waterlogging
Rockiness	Shallow soils and rockiness
Climate	Mass movement

The overall LSC class of the land (OEH 2012) is based on the most limiting feature/hazard and distinguish between the inherent physical capacity of the land to sustain a range of land uses (and management practices) in the long term without leading to degradation of soil, land, air and water resources.

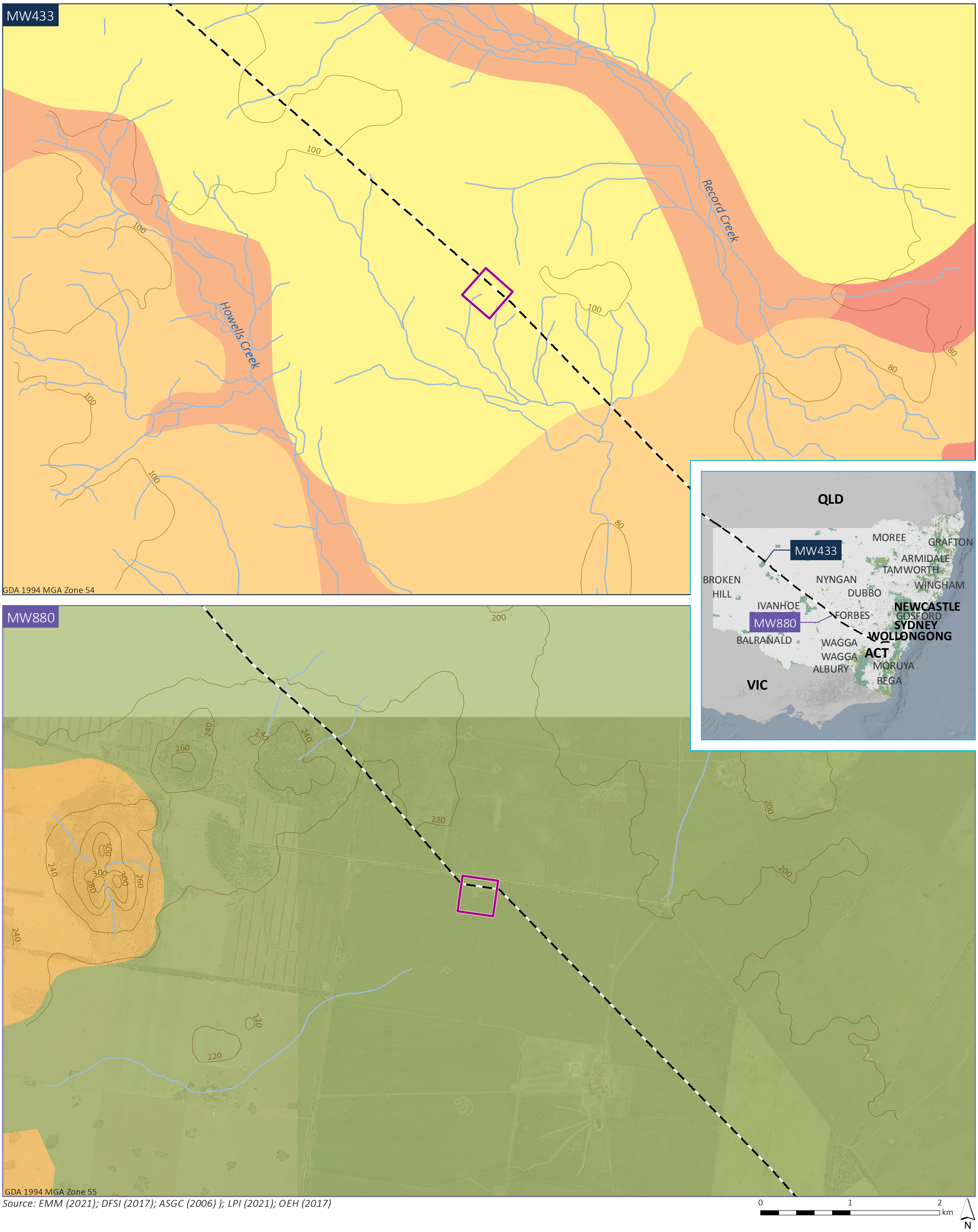
The LSC classes present at a site can be determined at various scales, ranging from state, regional to farm scale, varying in accuracy according to the information and resolution associated with them. State scale mapping has been completed for NSW, with reference to the eSPADE database (OEH 2016) and OEH (2017e) the project area is mapped as LSC Classes 3–5 (Table 3.5).

Modelled regional LSC mapping from eSPADE (OEH 2016, OEH 2017d) is presented in Figure 3.2.

Table 3.5 Land and soil classifications mapped for the project area

LSC Class [1]	LSC Class [1]	Description[1]
MW433 – Round Hill	Class 5 – Moderate-low capability land	• Land has high limitations for high-impact land uses. • Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. • The limitations need to be carefully managed to prevent long-term degradation.
MW880 – Milne	Class 3 – High capability land	• Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. • Careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.

1. OEH (2012)



Source: EMM (2021); DFSI (2017); ASGC (2006)); LPI (2021); OEH (2017)

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KEY

- Compressor site
- Moomba to Wilton pipeline
- Watercourse
- Contour (10m)

Land and soil capability (class)

- 3 | Moderate limitations
- 5 | Severe limitations
- 6 | Very severe limitations
- 7 | Extremely severe limitations
- 8 | Extreme limitations

Regional ASC mapping

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Figure 3.2

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3.2.5 Modelled soil erosion potential

Modelled sheet and rill (hillslope) soil erosion potential for the project sites based on bare soil, expressed in tonnes per hectare per year (t/ha/yr) of soil loss, is indicated within the eSPADE database (OEH 2016). This modelling was undertaken using the revised universal soil loss equation (RUSLE) and rainfall-runoff erosivity factors (R-Factors) and soil erodibility factors (K-Factors) per Yang and Yu (2015) and Yang et al (2017).

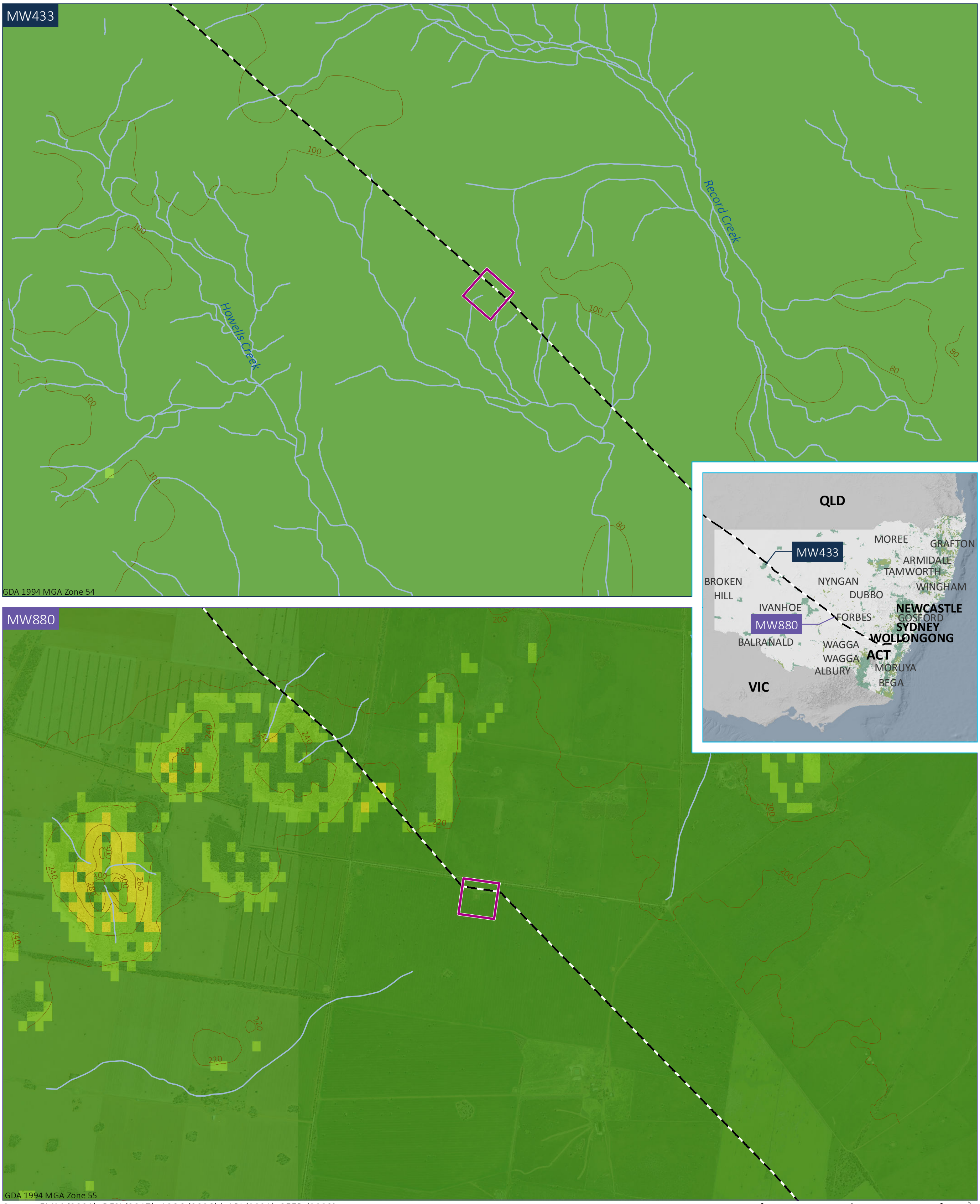
The modelled K-Factors for the project area were determined from the eSpade 2.1 database (OEH 2017e) (Figure 3.3). K-Factor represents the interaction of the susceptibility of soil or surface material to erosion, the transportability of the material and the amount and rate of run-off from a particular rain event. The modelled K-Factors range from 0.04–0.07 (t.ha.h)/(ha.MJ.mm) which indicate that the project soils have a high erosion potential (Figure 4.1). The modelled K-Factors apply to a maximum depth of 100 mm (Yang *et al.* 2017).

The modelled soil erosion only considers rainfall erosivity and not wind erosion hazard or soil electrochemical instability, however the recommended soil cover management and mitigation measures detailed in Section 4.3 address both water and wind-based erosion. Given the nature of a desktop assessment, information on the electrochemical stability of the soils is limited, but the available information is described in Section 3.2.7**.**

This modelled data suggests that erosion potential is generally <20 t/ha/yr shown in Figure 3.3. These represent generally low rates of erosion based on the scale applied to this data.

Table 3.6 Project modelled soil erosion potential

Site	Soil erosion, bare	Modelled K factor
MW433 – Round Hill	<20 t/ha/yr	0.04–0.06
MW880 – Milne	<20 t/ha/yr	0.04–0.07



Source: EMM (2021); DFSI (2017); ASGC (2006)); LPI (2021); SEED (2020)

0 1 2 km
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KEY

- Compressor site
- Moomba to Wilton pipeline
- Watercourse
- Contour (10m)

Soil erosion - bare (t/ha/yr)

- < 20
- 20 - < 50
- 50 - < 200

Regional modelled soil erosion

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Figure 3.3

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3.2.6 Land Systems and soil landscapes

Soil landscape mapping for the western NSW area was undertaken by Walker (1991) and presented as the 'Land systems of Western New South Wales'. The eastern-most site, MW880–Milne, lies on the Soil Landscapes of the Forbes 1:250 000 Sheet, one of the soil landscape mapping areas of central NSW mapped by King (1998). The mapped land systems and soil landscapes can be seen in Figure 3.4.

With reference to the NSW Soil and Land Information (SALIS) System (DPIE 2015–2020), via the 'eSPADE' Soil Profile Database (Version 2.0, OEH 2016), the relevant land system units or soil landscapes mapped for the sites are shown in Table 3.7 and are described in Table 3.8. Typical soil characteristics for land systems and soil landscapes are described in Table 3.9 and Table 3.10 respectively (Walker 1991, King 1998).

The land system and soil landscape information gives a high-level insight into the soil types to be encountered, predominantly describing great soils groups (GSGs) of solodic and podzolic soils, red earths and lithosols.

Table 3.7 Project land systems and soil landscapes

Site	Land System	Soil Landscape
MW433 – Round Hill	Questa Park	—
MW880 – Milne	—	Weelah, Euglo

Table 3.8 Land system and soil landscape units

Land system/soil landscape and overview	Geomorphology	Soils	Vegetation	Erosion	Land management considerations and limitations	Site
Soil Land Systems						
Questa Park (QP) Extensive stony plateaux, north and north-east of White Cliffs.	Extensive, very broadly undulating stony plateaux; relief to 50 m; sparse dendritic drainage; Tertiary silcrete over flat-lying Cretaceous claystone and sandstone, partly weathered.	Plateaux with lithosols, desert loam soils and red earths with hardpans.	Treeless Mitchell grass plains with sparse black bluebush (*Maireana pyramidata*), bladder saltbush (*Atriplex vesicaria*) and three-winged bluebush (*Maireana triptera*); abundant copperburrs and grasses.	Watersheeting with localised gullying.	• Pasture management; • water erosion control; • track location; and • bush re-establishment.	• MW433 – Round Hill

Table 3.8 Land system and soil landscape units

Land system/soil landscape and overview	Geomorphology	Soils	Vegetation	Erosion	Land management considerations and limitations	Site
			Soil Landscapes			
Weelah (wl) Gently undulating rises on Ordovician sediments near Burcher and Bogandillon Swamp.	Gently undulating rises with slope gradients 1-3% and local relief <15 m. Slope lengths are 1000-3000 m. Ordovician metasediments and associated colluvium. Lithology ranges from phyllite and schist to sandstone and siltstone. Rare intermediate volcanics and limestones also occur.	Shallow to moderately deep (40-100 cm), well-drained Red Earths (Gn2.11, Um5.52; Haplic, Eutrophic and Mesotrophic Red Kandosols) occur on most slopes. Shallow (<40 cm), well-drained Lithosols (Uc1.23; Lithic Leptic Rudosols) and Red Earths (Gn2.11, Um5.11; Haplic, Eutrophic and Mesotrophic Red Kandosols) occur on crests. Drainage lines have deep (>100 cm), imperfectly drained Yellow and Red Solodic Soils (Dy2.13, Dy3.23, Dr3.53; Subnatric Eutrophic Red Sodosols; Sodic and Haplic, Eutrophic Red Chromosols). Minor Calcareous Red Earths (Gn2.16; Gn2.13; Calcic and Hypocalcic, Haplic Endic Calcarosols; Calcic and Hypocalcic, Haplic Red Kandosols) and grey-brown calcareous soils (Gn2.86; Haplic, Calcic and Hypocalcic Red Kandosols) are additionally present at some locations.	Partially to extensively cleared openwoodland. The main tree species include bimble box (*Eucalyptus populnea*), western grey box (*E. microcarpa*) and white cypress pine (*Callitris glaucophylla*). Mugga ironbark (*E. sideroxylon*) occurs on some crests and upper slopes. Understoreys are predominantly grassy with some shrubs and include broad-leaf hopbush (*Dodonaea viscosa*), silver cassia (*Senna artemisioides*), Deane's wattle (*Acacia deanei*), wilga (*Geijera parviflora*), spreading flax-lily (*Dianella revoluta*), rat's tail fescue (*Vulpia myuros*), false hairgrass (*Pentaschistis airoides*), speargrass (Stipa spp.) and barley grass (*Hordeum leporinum*). Yarran (*A. homalophylla*) is a conspicuous tall shrub species found in the understorey and is often locally abundant.	Minor sheet erosion occurs on most slopes. Erodibility is very low to moderate. Erosion hazard is moderate	• High run-on; • soil structure decline hazard; • shallow soil (localised); and • acid soils of low fertility with high potential aluminium toxicity (subsoils).	• MW880 – Milne

Table 3.8 Land system and soil landscape units

Land system/soil landscape and overview	Geomorphology	Soils	Vegetation	Erosion	Land management considerations and limitations	Site
Euglo (eg) Level plains on Quaternary alluvium and minor colluvium at Burcher, Euglo and some surrounding plains.	Level plains. Local relief is <5m and slope gradients are 0–1%. Slope lengths are long and range up to 5km.	Deep to very deep (>120 cm), imperfectly drained Red Brown Earths (Db1.13, Dr2.13, Dr3.53, Dr2.23; Calcic and Hypocalcic, Haplic Red Chromosols; Calcic and Hypocalcic, Mesonatric and Subnatric Red Sodosols) are widespread. Occasional moderately deep to deep (>80 cm), moderately well-drained Red Earths (Gn2.11, Gn2.43, Gn2.15; Haplic Eutrophic Red Kandosols) and Red Podzolic Soils (Dr4.11, Dr2.12, Dr2.51; Haplic Eutrophic Red Chromosols; Eutrophic Mesonatric and Subnatric Red Sodosols) also occur often on colluvially derived parent materials.	Extensively cleared open-woodland and tall shrubland. Trees include bimble box (*Eucalyptus populnea*), western grey box (*Eucalyptus microcarpa*), bulloak (*Allocasuarina luehmannii*), belah (*Casuarina cristata*) and white cypress pine (*Callitris glaucophylla*). Tall shrubs and small trees are rosewood (*Alectryon oleifolius*), yarran (*Acacia homalophylla*), myall (*Acacia pendula*), warrior bush (*Apophyllum anomalum*), wilga (*Geijera parviflora*) and emu bush (*Eremophila longifolia*). Understoreys include rough speargrass (*Stipa scabra*), variable rat's tail fescue (*Vulpia myuros*), small-flowered wallaby grass (*Danthonia setacea*), wallaby grass (*D. monticola; D. spp.*), golden sunray (*Helipterum glutinosum*), purple burr-daisy (*Calotis cuneifolia*), barley grass (*Hordeum leporinum*), wingless fissure-weed (*Maireana enchylaenoides*), knob sedge (*Carex inversa*), false hairgrass (*Pentaschistis airoides*), windmill grass (*Chloris truncata*) and curly windmill grass (*Enteropogon acicularis*).	Negligible water erosion. Considerable wind erosion may occur from areas lacking a protective ground cover. Soil erodibility is high for surface soils and moderate for subsoils. Water erosion hazard is generally low. Wind erosion hazard is moderate to high.	• Wind erosion hazard; • alkaline, sodic/dispersible, saline (localised) soils of low fertility, high erodibility (topsoils) with hardsetting surfaces; and • soil structure decline hazard.	• MW880 – Milne

Table 3.9 Land system soil units

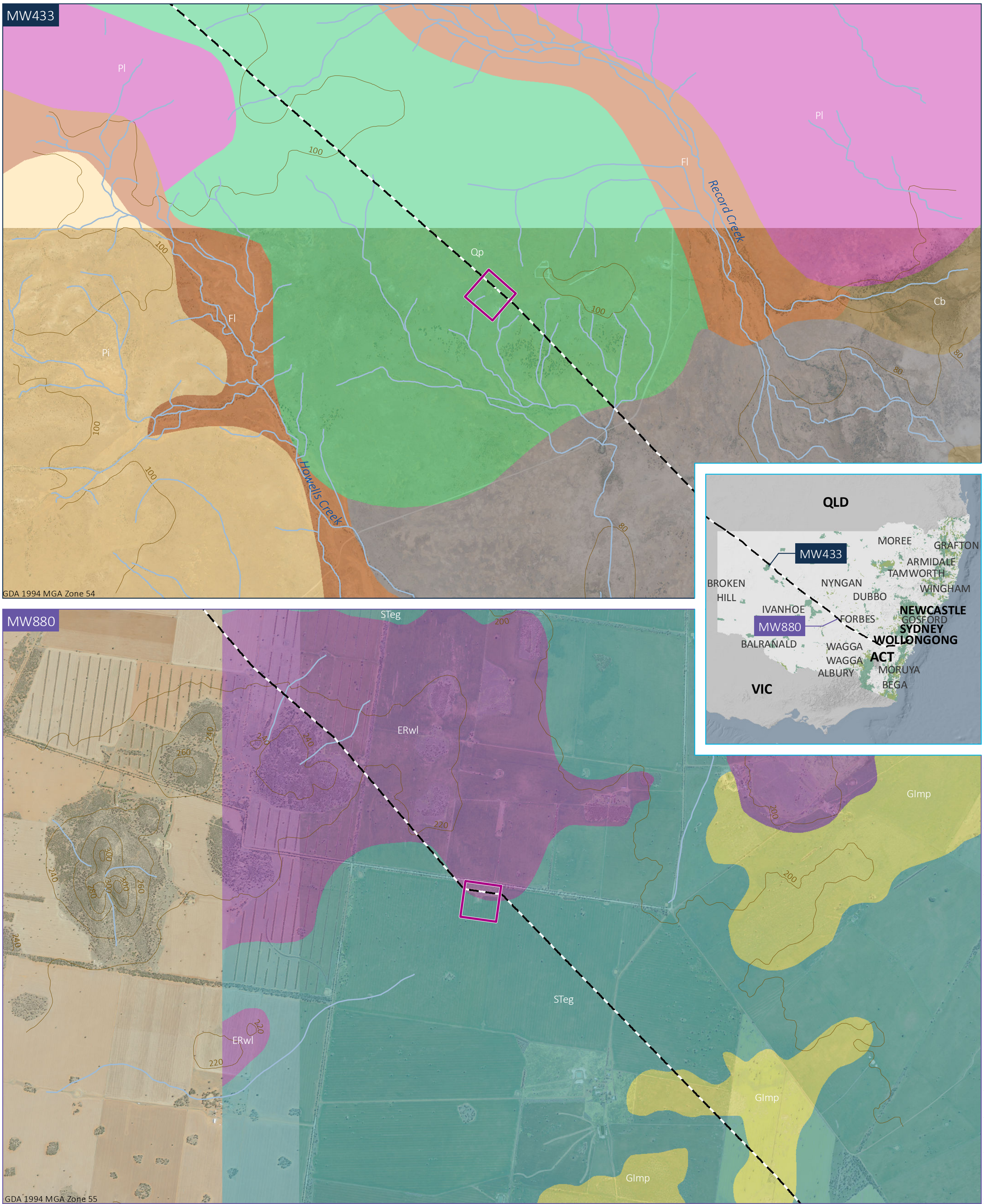
Landform	Soils	Erosion	Vegetation
		Questa Park (QP)	
Stony ridges and crests: slopes to 3% and to 2 km long; angular silcrete stone cover; relief to 50m.	Shallow neutral red earths and lithosols with hardpan (Gn 2.12, Um 5.31, Um 1.43) overlying yellow and grey silcrete.	Moderate watersheeting.	Isolated mulga (*Acacia aneura*); scattered bladder saltbush (*Atriplex vesicaria*), black bluebush (*Maireana pyramidata*), and threewinged bluebush (*Maireana triptera*); bottlewashers (*Enneapogon avenaceus*) and streaked poverty-bush (*Sclerolaena tricuspis*).
Stony plains and stable interfluves: slopes to 2% and to 2 km long; contour pattern of stony risers with stone-free steps.	Stony risers: reddish-brown desert loams with hardpan (Dr 1.16, 1.36, 1.15, 1.35) Stone-free steps: red cracking clays (Ug 5.3) with gypsum and carbonate at depth.	Minor gullying when surface is disturbed.	Bare. Isolated caustic vine (*Sarcostemma australe*); abundant curly mitchell grass (*Astrebla lappacea*), bottlewashers (*Enneapogon avenaceus*) and other grasses, copperburrs (*Sclerolaena spp.)* and desert Chinese lantern (*Abutilon otocarpum*).
Gravelly slopes: to 2% slope and to 2 km long.	Red desert loams with hardpan (Dr 1.16, 1.36, 1.15, 1.35), overlying decomposing sediments.	Moderate watersheeting.	Scattered dead finish (*Acacia tetragonophylla*); black bluebush; bottlewashers and copperburrs.
Minor drainage lines: to 100m wide, channels to 5m wide and 2m deep.	Gravelly red hardpan soils (Gn 2.12, Gn 2.18) with angular stone overlying decomposing rock.	Moderate gully erosion.	Scattered dead finish and mulga; fuchsiabush (*Eremophila serrulata*) and three winged bluebush; windmill grass (*Chloris truncata*), queensland blue grass (*Dichanthium sericeum*), native millet (*Panicum decompositum*) and copperburrs.

Table 3.10 Soil landscape soil units

Soils type	Horizon	Description	Fertility	Soil conservation recommendations	Sustainable land use recommendations
Weelah (wl)					
Lithosols	Topsoil	Dark reddish brown (5YR 3/4) light sandy clay loam to sandy loam A1 horizon; massive to weakly pedal, earthy, very weak, brittle; field pH 5.5. Grades into weathered bedrock at <10 cm.	Soil profile fertility is very low. Soils have a moderate to very low cation exchange capacity. Levels of exchangeable magnesium, potassium and sodium are moderate to high. Exchangeable calcium levels are very low to moderate. Apart from the Solodic Soils which are strongly sodic, soils are generally non-sodic to slightly sodic. Phosphorus is deficient and phosphorus sorption capacity is moderately high to high. Soils are acid and have a moderate pH buffering capacity. Salinity levels are typically very low.	Apart from topsoils which are unsuitable for soil conservation earthworks, other soil materials on this landscape are generally suitable for soil conservation earthworks. Shallow soil depths on some areas may restrict the construction of some earthworks with a lack of soil materials.	Capable of sustaining both cropping and grazing. Land capability is largely class III with some areas of class IV and VI lands on some upper slopes and crests.
Yellow and red solodic soils	Topsoil	Dark reddish brown (5YR 3/6) sandy loam A1 horizon; massive, earthy; field pH 6.5. Clear boundary to either subsoil or dull reddish brown (2.5YR 5/4) sandy loam A2 horizon; massive, earthy, non-bleached; field pH 6.5. Clear boundary at 50 cm to subsoil.			
	Subsoil	Dull reddish brown (5YR 5/4) orange (5YR 6/6) to reddish brown (5YR 4/8) medium clay B horizon; moderately pedal, angular blocky smooth-faced peds (10-20 mm); field pH 8.5-9.0. Layer extends below 100 cm.			
Calcareous red earths	Topsoil	Dark reddish brown (5YR 3/6) sandy loam A1 horizon; massive, earthy; field pH 6.5. Clear to gradual boundary at 15 cm to either a weakly differentiated A2 horizon or subsoil.			
	Subsoil	Reddish brown (5YR 4/8) sandy clay loam B2 horizon; massive, earthy; field pH 7.0; few (2-20%) manganese concretions, very few to few (0-20%) calcareous segregations at depth. Subsoil extends below 100 cm.			

Table 3.10 Soil landscape soil units

Soils type	Horizon	Description	Fertility	Soil conservation recommendations	Sustainable land use recommendations
			Euglo (eg)		
Red earths	Topsoil	Dark reddish brown (5YR 3/3) sandy clay loam A1 horizon; massive, earthy, non-sticky; field pH 5.5. Abrupt boundary at 10 cm to either subsoil or a weakly differentiated dark reddish brown (5YR 3/4), sandy clay loam A2 horizon; massive, earthy, non-sticky. Abrupt boundary at 25 cm to...	General soil fertility is low. Soils have a low cation exchange capacity at the surface increasing to high in the subsoil. Levels of exchangeable calcium range from low at the surface to high in the subsoil. Moderate to high levels of exchangeable potassium and sodium occur and the soils are generally strongly sodic at depth. Phosphorus is typically deficient in all soils and the phosphorus sorption capacity is moderately high. Soils are alkaline at depth and have a moderate to high pH buffering capacity. Localised areas with saline subsoils occur.	Topsoils are generally unsuitable with an earthwork category rating of J. Subsoils are more suitable and soils tested had earthwork category ratings of B and G.	Capable of sustaining both grazing and cropping with low soil moisture the major limitation. Hardsetting surface horizons and surface crusting may inhibit the germination and early development of crops and pastures. Poorly structured sodic subsoils may restrict deep root penetration in some soils and deep-ripping and/or the use of soil ameliorants such as gypsum may be necessary to improve soil structure. A protective ground cover should be maintained to prevent wind erosion. Land capability is mostly class II.
	Subsoil	Dark reddish brown (5YR 3/4) sandy clay loam B2 horizon; weakly pedal, smooth-faced peds; field pH 7.5. Layer continues below 60 cm.			
Red podzolic soils	Topsoil	Dark reddish brown (5YR 3/6) sandy clay loam A1 horizon; massive, earthy, non-sticky, crumbly, moderately weak, non-plastic; field pH 6.0. Abrupt boundary at 5 cm to a dark reddish brown (2.5YR 3/6) sandy clay loam A2 horizon; massive, earthy non-sticky, brittle, moderately weak; field pH 5.5. Sharp boundary at 15 cm to...			
	Subsoil	Reddish brown (2.5YR 4/8) medium clay B2 horizon; moderately pedal, polyhedral smooth-faced peds, slightly sticky, brittle, few coarse fragments; field pH 5.5. Horizon extends below 80 cm.			



Source: EMM (2021); DFSI (2017); ASGC (2006)); LPI (2021); SEED (2020)

KEY

- Compressor site
- Moomba to Wilton pipeline
- Watercourse
- Contour (10 m)

Forbes soil landscapes

- Euglo - STed
- Myall park - GImp
- Weelah - ERwl

Land systems of Western NSW

- Cobham - LSCb
- Flowers - Fl
- Pirillie - Pi
- Pulchra - LSPl
- Questa Park - LSQp
- Yapunyah - LSYp

Regional land systems and soil landscape mapping

APA - East Coast Grid Expansion
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Figure 3.4

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3.2.7 Desktop review summary

A summary of the available land and soil mapping available from eSPADE (OEH 2016) characteristics and their associations is presented in Table 3.11.

Table 3.11 Regional soil mapping summary

Site	Land system/soil landscape	ASC	GSG	Inherent soil fertility	LSC class	Modelled K factor
MW433 – Round Hill	Questa Park	Sodosols	Desert Loams (DL)	Moderately low	5	0.04–0.06
MW880 – Milne	Weelah, Euglo	Kandosols, Chromosols	Red earths— less fertile (REl), Red brown earths (RBE)	Moderately low, Moderate	3	0.04–0.07

i Soil erosion constraints

As discussed in Section 3.2.5, this desktop erosion assessment is subject to the availability and reliability of information, particularly on the electrochemical stability of soils. Due to a lack of site-specific sampling and soil chemical data, the desktop information described in Section 3.2.6 is the best source of insight on soil electrochemical stability.

The information provided in the Land Systems (Walker 1991) contains no specific description of soil limitations, though information can be inferred from the highlighted hazards of the land systems. The gullying hazard noted in Questa Park indicates the presence of soil sodicity or dispersive soils.

The soil landscapes of King (1998) contain more soil specific information, including classification under the ASC to a great group level. Mesonatric and subnatric Sodosols, which are sodic and strongly sodic (exchangeable sodium percentage of >6–15% and 15–25% respectively), are present in both the Weelah and Euglo soil landscapes. Land management considerations and limitations for the Weelah landscape highlights soil structure decline hazard and acid soils of low fertility with high potential aluminium toxicity (subsoils). This indicates likely acidic soil pH (Aluminium typically being a constraint when soil pH is <5.5) and soil structural decline is again typically associated with sodic or dispersive soils. The Euglo hazards include alkaline, sodic/dispersible, saline (localised) soils of low fertility, high erodibility (topsoils) with hardsetting surfaces and soil structure decline hazard which indicate or state the likely presence of sodic or dispersive soils.

4 Erosion hazard analysis

The process for the assessment of erosion hazard in NSW is detailed in section 4.4.1 of Landcom (2004). It is a two-step process that considers overall project erosion hazard in considering slope and rainfall erosivity (R-Factor) and then a more detailed assessment where land soil loss classes (SLC) are determined using annual soil loss calculated using the revised universal soil loss equation (RUSLE) using site specific slopes and a nominal slope length of 80m. The SLC dictates specific erosion management and mitigation measures as detailed in Landcom (2004).

An assessment of the erodibility of the soil itself is important as the presence or absence of a highly erodible dispersive soil will significantly influence the project drainage, erosion and sediment control requirements.

When a sodic soil (exchangeable sodium percentage (ESP) >6%), or a magnesic soil (exchangeable magnesium percentage (EMP) >20%) comes into contact with non-saline water, water molecules are drawn in-between the clay platelets causing the clay to swell to such an extent that individual clay platelets are separated from the aggregate. This process is known as dispersion. Dispersive soils have an extreme rill, gully and tunnel erosion risk and can erode irrespective of surface treatments (eg rock lining) applied to the soil surface.

4.1 Soil erosion hazard analysis

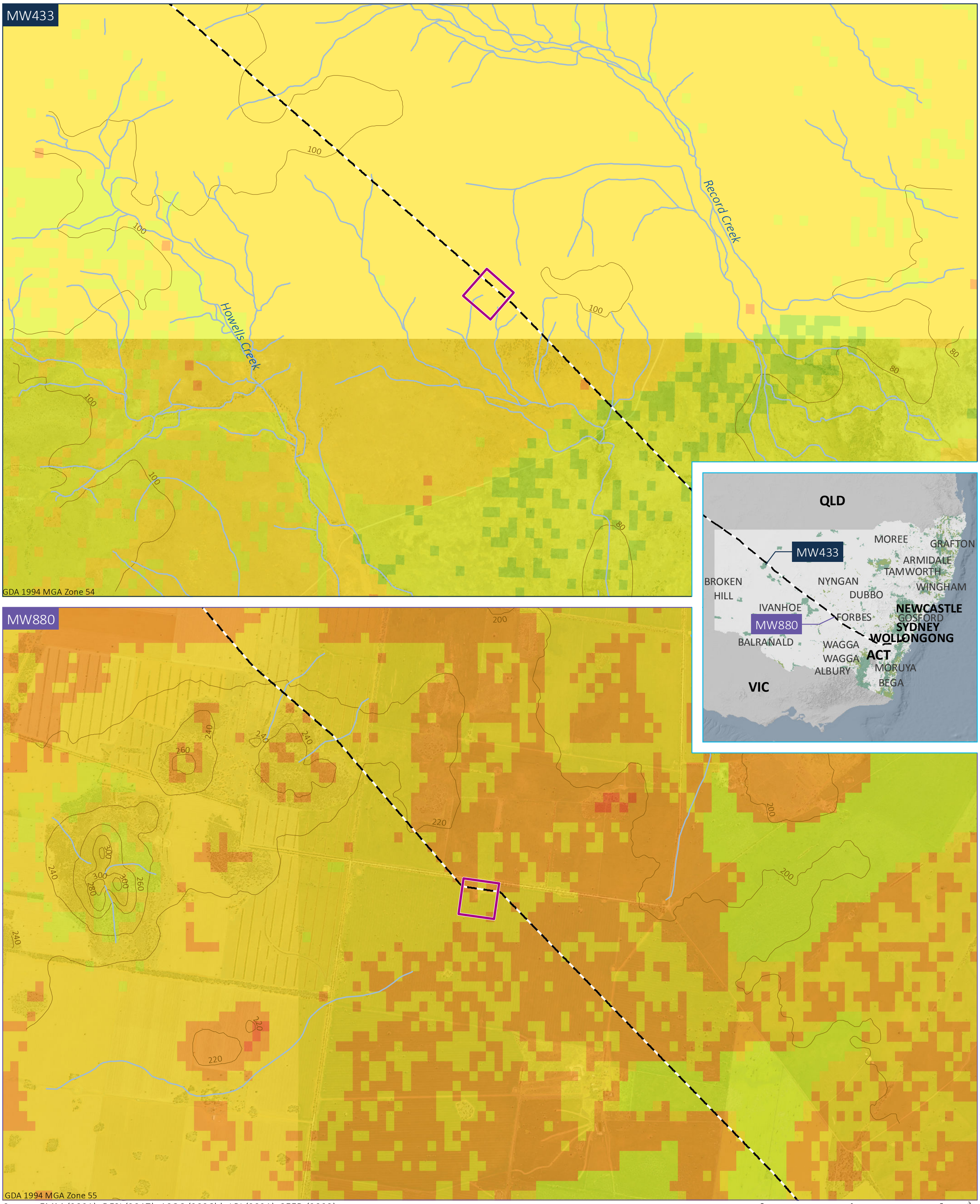
The erosion potential of a soil is determined by its physical and chemical properties and is expressed as its K-Factor (t.ha.h)/(ha.MJ.mm). Table 4.1 provides a soil erodibility ranking for K-Factor from Rosewell (1993).

Table 4.1 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

As detailed in section 3.2.5, the modelled K-Factors for the project area were determined from the eSpade 2.1 database (OEH 2016, OEH 2017e) (Figure 4.1). The modelled K-Factors range from 0.04–0.07 t ha h ha^{-1}MJ^{-1}mm^{-1} which indicate that the project soils have a high erosion potential.

No site soil sampling was undertaken in this assessment, however the mapped soil landscapes identified the presence of sodic subsoils in both project areas. Loch *et al.* 1998 determined various sodic soils to have a K-Factor ranging from 0.056–0.106 t ha h ha^{-1}MJ^{-1}mm^{-1}. A K-Factor of 0.071 t ha h ha^{-1}MJ^{-1}mm^{-1} has been adopted to determine the erosion hazard of project subsoils as a 'worst case' if sodic subsoils are exposed.



Source: EMM (2021); DFSI (2017); ASGC (2006)); LPI (2021); SEED (2020)

KEY

- Compressor site
- Moomba to Wilton pipeline
- Watercourse
- Contour (10 m)

RUSLE K Factor

- < 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.04
- 0.04 - 0.05
- 0.05 - 0.06
- 0.06 - 0.07
- > 0.07

Modelled RUSLE K Factors

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4.1.1 Slope and rainfall erosivity erosion hazard analysis

The overall project water erosion hazard is determined using the process described in section 4.4.1 of Landcom (2004); however, as it does not consider the K-Factor, the erosion hazard can be considerably underestimated. If a low erosion hazard is determined, no further delineation of erosion hazard is required. If a high erosion hazard is determined, then further assessment to determine the SLC is required.

SLCs are determined by calculating the annual average soil loss using the RUSLE with a nominal 80 m slope length and soil surface cover factor (C-Factor); RUSLE calculates the annual average erosion in tonnes per hectare (t/ha) from rill and inter-rill (sheet) erosion. It does not consider gully or tunnel erosion and does not calculate peak erosion. Landcom (2004)[1] nominates additional requirements for land of SLC 4 and higher.

The first step in the hazard assessment uses a nomograph from Figure 4.6 of Landcom (2004) (reproduced as Figure 4.2) that considers slope of the land and the Rainfall Erosivity (R-Factor) to provide a low or high erosion hazard.

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

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

where, S is the 2-year ARI, 6-hour rainfall event (0.5EY, 6-hour event) in mm/h (Rosewell & Turner 1992). For the project S values (BoM 2020) and the calculated R-Factor for the project sites are shown in Table 4.2.

Table 4.2 Project R-Factors

Site	S (2-year ARI, 6-hour rainfall event)	R-Factor
MW433 – Round Hill	4.68	749.7
MW880 – Milne	5.87	990.3

Slope ranges and erosion hazard for the key project elements are provided in Table 4.3. Project slopes are shown in Figure 4.3.

1 Landcom (2004), section 4.4.2(c)

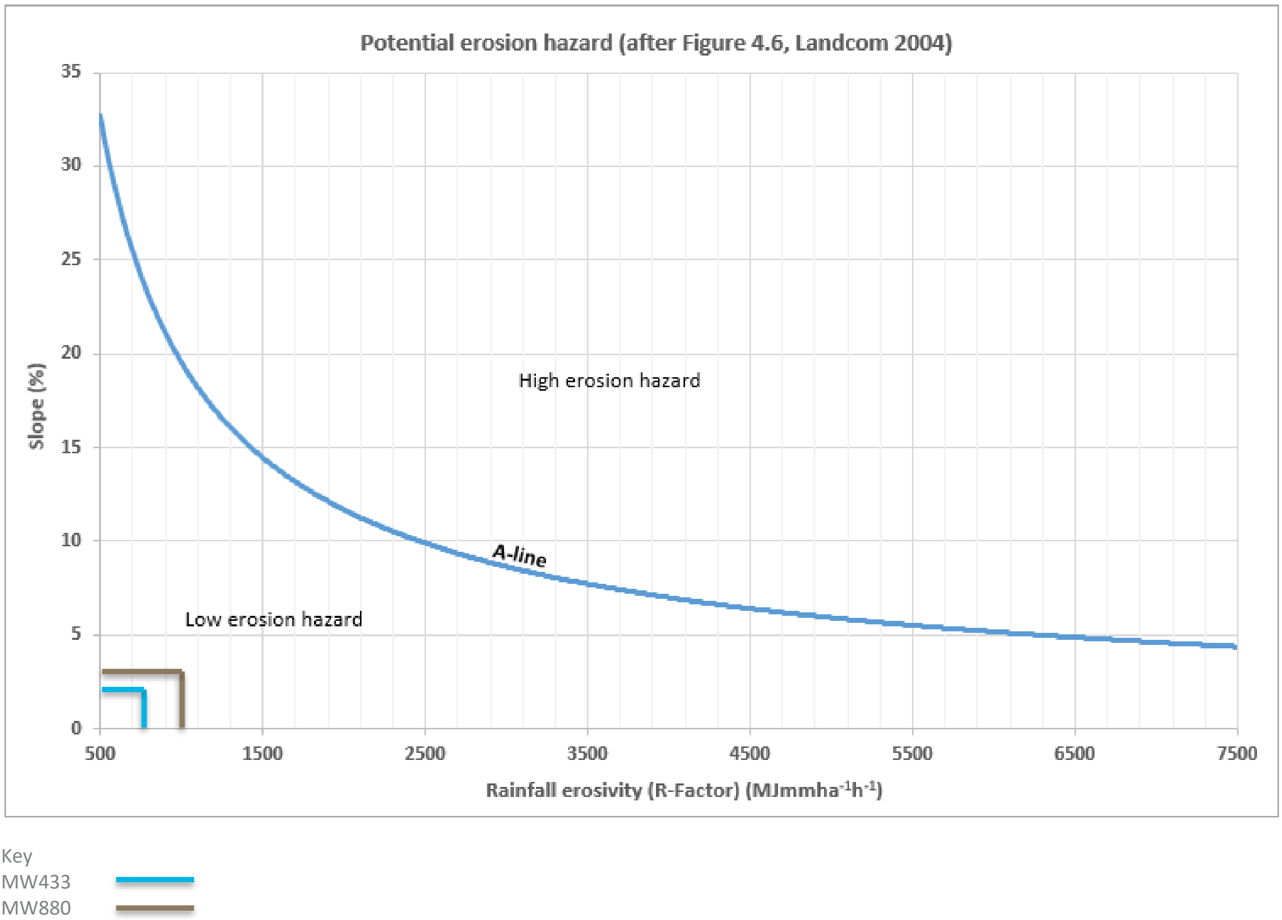


Figure 4.2 Assessment of potential erosion hazard (Landcom 2004)

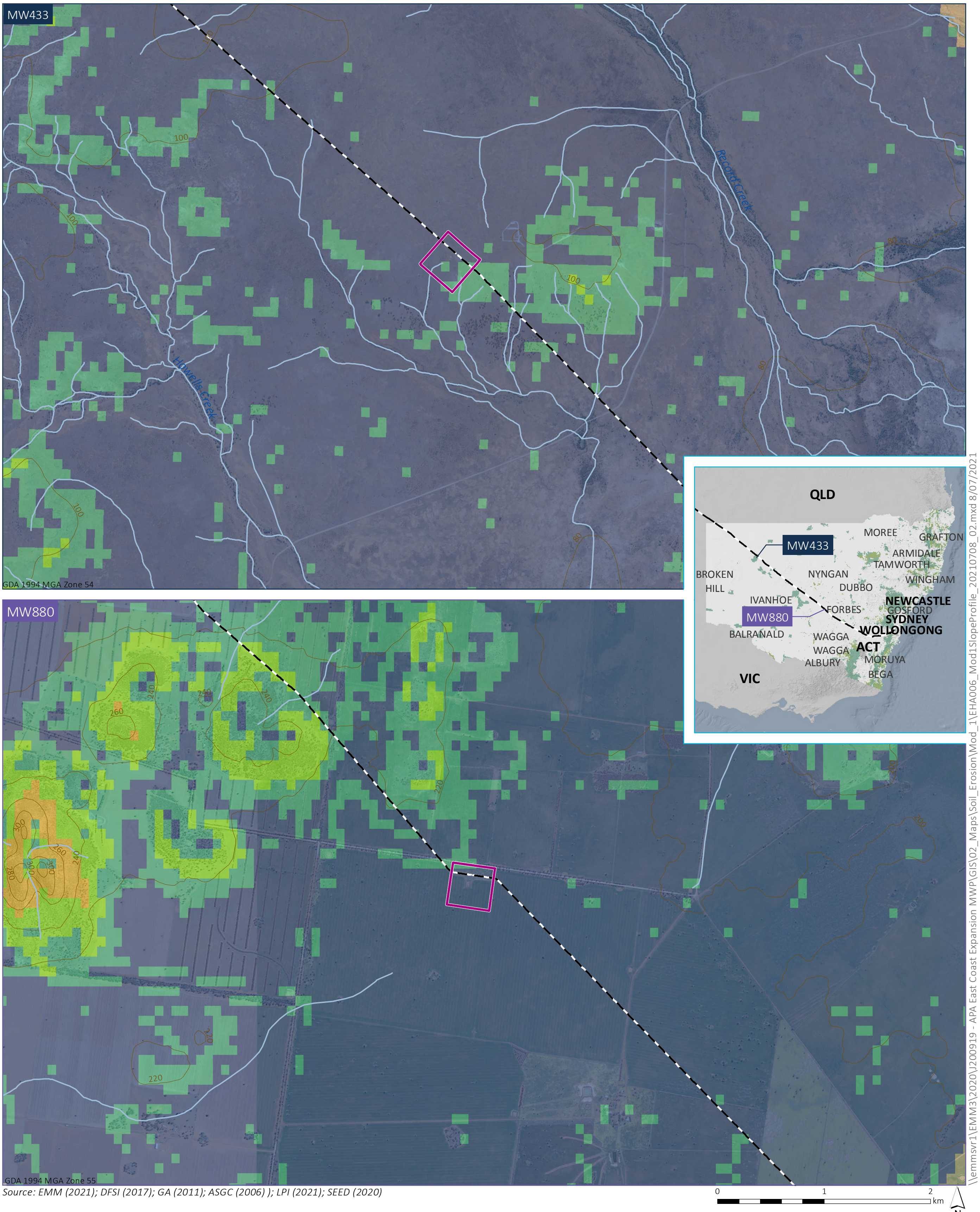
Table 4.3 Slope ranges and erosion hazard for key project elements

Project element	Slope (min %)[2]	Slope (max %)[2]	Critical slope (%)[1]	Erosion hazard
MW433 – Round Hill	0.5	1.6	24	Low
MW880 – Milne	0.6	3.2	19	Low

1. Slope value, according to Key
2. MW433, where R-Factor intercepts the A-line indicating the critical slope required for erosion hazard to become high
3. Hillslope values marked as (*) obtained from National Map (DTA 2021)

Applying the project R-factors and slope to the erosion hazard nomograph results in a low erosion risk due to low slope and rainfall erosivity. On this basis, further analysis of SLCs is not required.

Even though the slope and erosion hazard risk has been assessed as low, given the predominantly arid nature of the MW433 site, the low annual rainfall amounts makes it challenging to establish and maintain vegetative soil surface cover. Kirby (1969) determined that peak erosion rates in natural catchments in the USA occurs where annual average rainfall ranges between 300–350 mm/yr. This means that other forms of soil surface cover such as timber debris, soil stabilisation polymers, hydro-mulches and gravel mulches will be required to provide adequate erosion protection until adequate vegetation cover establishes.



Source: EMM (2021); DFSI (2017); GA (2011); ASGC (2006)); LPI (2021); SEED (2020)

KEY

Compressor site

Moomba to Wilton pipeline

Watercourse

Contour (10m)

Slope

0 - 2 %

2 - 5 %

5 - 10 %

10 - 20 %

Project area slope percentages

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Figure 4.3

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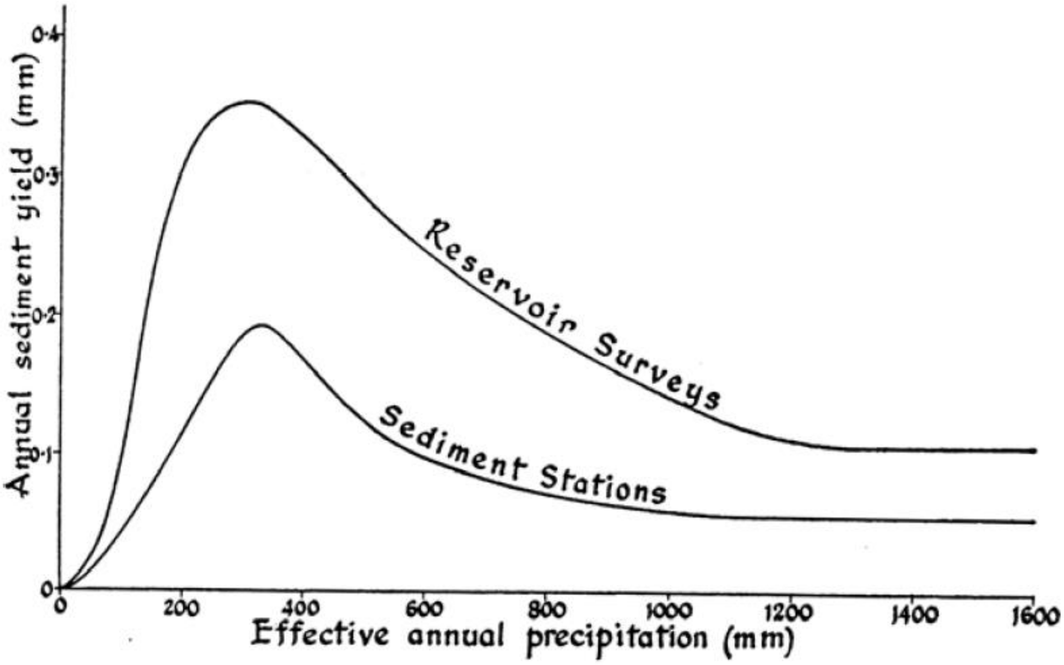


Figure 4.4 Relationship between annual rain and erosion (Kirby 1969)

4.2 Wind erosion hazard

There is no known documented method for assessing or ranking wind erosion hazard in Australia. Sandy soils are more at risk of wind erosion due to the larger soil particles drying more rapidly than smaller particles and single grained particles are easier to detach by the wind.

The erosive power of wind increases exponentially with velocity and the length of unobstructed terrain (fetch) over which the wind flows is important in allowing the wind to gain momentum and increase its erosive power (Salem 1991). Movement of highly erosive soils typically starts at a wind velocity of 25–30 kilometres per hour (km/hr) at a height of 0.3 cm above the soil surface (Hopkins *et al.* 1937).

The presence of soil surface cover (vegetation, rock, timber debris) is also critical as surface roughness decreases the velocity of the wind at the soil surface.

The generally low rainfall and high evaporation at the project sites limit the ability to germinate and sustain vegetation cover and significant areas of soil disturbance were observed during desktop assessment utilising aerial imagery.

Vegetation of 50% is recommended for sandy-loams and 70% for sands to provide adequate protection from wind erosion in agricultural cropping areas (Government of SA 2020).

Daily mean wind velocities measured at BoM weather stations (Table 4.4) in proximity to the sites are typically below those that would initiate wind erosion; however, it is anticipated that higher wind velocities would be anticipated during weather events that would initiate wind erosion.

The wind erosion hazard can be mitigated by the recommended control measures.

Table 4.4 Site wind speeds

Site	BoM weather station (number)	Daily mean wind speed (9am/3pm) (kph)
MW433 – Round Hill	White Cliffs Post Office (046042)	12.7/13.8
MW880 – Milne	Condobolin Ag. Research station (050052)	13.0/14.6

Further project specific management and mitigation measures are provided in section 4.3**.**

4.3 Erosion hazard summary

The overall erosion hazard of the compressor stations and associated facilities at MW433 and MW880 is low due to the flat gradient of the proposed construction areas and volume and intensity of rainfall. Erosion risk is greatest when soils are exposed to wind and rain during the clearing and early constructed phases of the project but can be readily mitigated as detailed in section4.4.

Site MW433 has a slightly higher erosion hazard due to the potential presence of dispersive subsoils and lower annual average rainfall making it more challenging to establish vegetation to provide short- and long-term soil surface cover. This can be managed by gypsum treating the dispersive soils if exposed and using non-vegetative means to provide soil surface cover such as soil stabilising polymers, timber debris, and gravels as detailed in section 4.4.

Calculated soil losses do not trigger the need for sediment basins and a strong focus on erosion control as recommended to minimise the generation of sediment and turbid run-off combined with conventional temporary sediment control will provide the necessary level of environmental protection.

4.4 Management and mitigation measures

APA will implement reasonable and practicable measures to minimise short and long-term soil erosion and the adverse effects of sediment transport to minimise the potential of environmental harm and to minimise damage to assets and the need for re-work during and post construction.

This will be achieved by applying the key fundamental principles of erosion and sediment control detailed in Landcom (2004) and DECC (2008) as well as utilising specialist advice to develop appropriate technical solutions to the identified site constraints and erosion hazards (sections 3 to 4).

4.4.1 Appropriately integrate the development into the site

The facility design generally utilises the existing topography and minimises the need for extensive land reshaping and regrading works.

Where possible, any access roads should be located to avoid areas with upstream run-on water catchments to minimise the need to construct longitudinal drainage.

Any required cut and fill should employ slope design rules and stabilisation measures guided by material erosion and agronomic characterisation of the site soils.

4.4.2 Construction planning – erosion and sediment control

Best practice construction planning involves the early recognition and management of those components of the project and construction process that can significantly influence the impacts that construction may have on the surrounding environment.

A soil and water management plan (SWMP) should be prepared for the project. The SWMP should be underpinned by primary erosion and sediment control plans (PESCPs) that will be prepared for all discrete disturbance areas. The PESCPs should be living documents to be updated as site conditions change or current PESCPs fail to meet necessary performance objectives. The content requirements of the SWMP and PESCPs are prescribed in Landcom (2004) and DECC (2008).

It is recommended that soil sampling and characterisation is undertaken at each compressor station site to accurately determine site-specific erosion risk and inform soil and water management plans (SWMPs) and erosion and sediment control plans (ESCPs).

4.4.3 Minimise the extent and duration of soil disturbance

The highest erosion risk for the project is during the construction and rehabilitation phases when soils are stripped and any dispersive subsoils are exposed. Major land disturbing works will be scheduled to avoid the higher rainfall erosivity periods and the highest wind velocity periods where practical. If these works are carried out during periods of higher rainfall or higher wind velocity, soil and erosion control measures will be adjusted to ensure appropriate management of erosion and sediment.

Any highly erodible subsoils will be ameliorated (typically with gypsum) to reduce ESP to <6% and Ca:Mg ratio to <0.1, and where required for construction purposes, compacted. Hardstands are expected to be gravel sheeted, and concreted where required. Gravel sheeted areas will be constructed with a polymer emulsion pavement to increase CBRs, reduce erosion, reduce turbid runoff and dust emissions. Soil stabilising polymers will be utilised to protect soil stockpiles and exposed areas.

Land disturbances will be restricted to those areas required for the current stage of works.

4.4.4 Control water movement through the site

The PESCPs prepared for each of the surface construction areas will address the temporary and permanent requirements of each area. Due to the low slope gradients, sheet flow velocities are unlikely to exceed the maximum permissible velocity of the site soils, as per IECA (2008) (Table 4.5) during the land clearing phase, however, as the soil runoff coefficients change as a result of soil compaction during the construction, higher sheet flow velocities that may exceed the maximum permissible velocities of the site soils can be anticipated.

Where necessary, soil stabilising polymers should be applied to exposed soils to protect them from rain drop splash erosion and sheet flows.

Site drainage will be designed to maximum sheet flow where possible. Construction of diversion drains, channels and table drains will be minimised to the maximum possible extent where practicable.

The construction of longitudinal drainage on access roads will be avoided to the maximum possible extent with run-off turned away using back-push diversion banks instead of excavated drains where possible. Where excavated drains are required, they will be broad based, shallow and trapezoidal shaped to minimise the depth and velocity of flow.

Drains will be lined where design flow velocity exceeds the maximum permissible velocity of the soils to protect the soil from erosion. Drain linings will be specified in the PESCPs.

Table 4.5 Maximum permissible velocities for different soil types (after IECA 2008a)

Soil description	Allowable velocity	Impacted by the project
Extremely erodible soils	0.3 m/s	Potentially
Sandy soils	0.45 m/s	Yes
Highly erodible soils	0.4 to 0.5 m/s	Yes
Sandy loam soils	0.5 m/s	Yes
Moderately erodible soils	0.6 m/s	Yes
Silty loam soils	0.6 m/s	-
Low erodible soils	0.7 m/s	-
Firm loam soils	0.7 m/s	-
Stiff clay very colloidal soils	1.1 m/s	-

Where required, up-slope clean run-on water should be diverted around soil disturbances and unstable slopes in a manner that minimises soil erosion and the saturation of soils within active work areas. There are minimal established watercourses present at the sites, though there is an ephemeral first-order stream present at MW433.

Any clean upstream run-on water catchment identified during the design phase should be diverted around active construction areas. Any clean water diversions should avoid the use of excavated drains particularly at MW433 where dispersive soils are expected to be present. Constructed landforms should be located to utilise the natural drainage features to the maximum practicable extent.

4.4.5 Minimise soil erosion

Due to the erosion risk associated with the presence of dispersive soils, priority will be given to the prevention, or at least minimisation, of soil erosion rather than allowing erosion to occur and relying on sediment control measures to trap and contain sediment and turbid runoff. This is particularly important where it is not possible or is impractical to divert turbid runoff to a sediment basin.

Sediment basins are required where soil loss calculations exceed 150 tonnes per hectare (t/ha/y) and/or land disturbance exceeds 2,500 m^2. The disturbed area at each site is expected to be approximately 22ha and therefore triggers the disturbance triggers however the calculated annual average soil loss for MW 880 is 93m^3/ha/y and for MW430 is 79m^3/ha/y which is well below the soil loss trigger.

EMM therefore considers that a focus on erosion is more appropriate for the site conditions.

Appropriate erosion protection should be incorporated into all stages of soil disturbance and should be appropriate for the erosion risk posed by the potentially dispersive or non-cohesive site soils. The electrochemical instability of the site soils should be ameliorated by the incorporation of gypsum into the soil at rates determined by site-specific soil testing, especially at MW880-Milne.

EMM recommends that any gravel sealed hardstand areas of road should be constructed with a polymer emulsion pavement to increase CBR's, reduce erosion, reduce dust emissions and the generation of turbid run-off. Polymer emulsion pavements are constructed via the following process:

- Scarify the surface to a depth of 50 mm.
- Apply trafficable soil polymer such as GRT 5000 (1-part polymer to 6 parts water) to the ripped surface at a rate of 300 mL/m^2.
- Re-scarify before the polymer dries to mix.
- Apply additional polymer at the same rate.
- Grade to achieve the necessary trail profile before the polymer dries.
- Compact with sheeps foot roller followed by a steel drum roller.
- Apply a polymer seal coat (1-part polymer to 8 parts water) at a rate of 300 mL/m^2.

As detailed in section 4.4.4, site drainage should be designed to maximise sheet flow where possible. Construction of diversion drains, channels and table drains should be minimised to the maximum possible extent where practicable.

On access roads, the construction of longitudinal drainage should be avoided to the maximum possible extent with run-off turned away using back-push diversion banks instead of excavated drains where possible. Where excavated drains are required, they should be broad based, shallow and trapezoidal shaped to minimise the depth and velocity of flow.

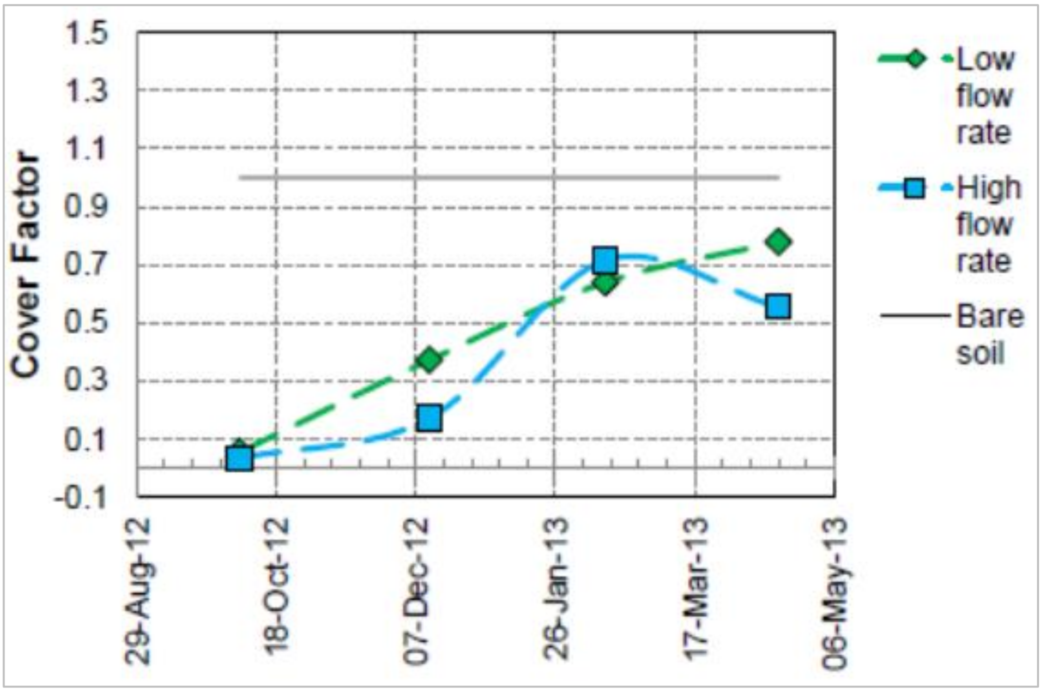
Drains should be lined where design flow velocity exceeds the maximum permissible velocity of the soils to protect the soil from erosion. Drain linings will be specified in the drainage design drawings and the PESCPs.

A large portion of the land disturbed by the project following construction will be hardstand post construction and will have a very low erosion risk. The key erosion risk areas will be any soil stockpiles or cut and fill batters, temporary construction areas, the ephemeral creek diversion (if required) (MW433) and any up-stream run-on catchment.

APA may need to consider sourcing organic and woody wastes to be utilised for soil erosion protection purposes on stockpiles and rehabilitated areas. This is especially important at MW433, where annual rainfall is less than 300−350 mm/y and vegetation cannot be relied on for short- or long-term erosional stability. Therefore, use of alternative surface protection is critical. Surface soil cover of 70% will be established to protect from wind erosion, using soil stabilising polymers, timber debris or suitable alternatives, especially in areas disturbed by construction.

i Promptly stabilise disturbed areas

Hydraulically applied soil stabilising polymers can provide erosion protection equivalent to 60% grass cover for up to three months using a 10% solution applied at 1 litres per square metre (L/m^2) (Figure 4.5; from Landloch & SEEC (2013)) and are therefore recommended as an important temporary erosion control in sheet flow environments within the site, particularly in preparation for periods of predicted rainfall, wind or during construction shut down periods.



Source: Landloch and SEEC (2013)

Figure 4.5 C-Factor assessment of soil stabilising polymers

Landcom (2004) nominates target stabilisation timing and standards for disturbed areas during construction and post-construction (Table 4.6). The project should consider these requirements.

Landcom (2004) recommends scheduling land disturbing activities for times of low rainfall erosivity in sensitive environments. Major disturbance works will be scheduled to avoid high rainfall periods (summer months), if practicable. Where works during summer months are unavoidable, erosion controls such as soil stabilising polymers or other suitable soil erosion protection will be provided to achieve C-Factors higher than 0.1 when the 3-day rainfall forecast suggests that rain is likely.

Indicative C-Factors for various erosion control and revegetation techniques can be found in Table A3 in Landcom (2004) and on reputable product suppliers web sites.

Table 4.6 Maximum C-Factors during construction and post-construction[1]

Feature/area	C-Factor	Requirement
During construction		
Waterways and land below the 2 yr ARI flood levels including stockpiles	0.10	When working in waterways and flood prone lands a C-Factor of ≤0.1 is to be achieved if the 3-day forecast indicates rain causing runoff is likely.
Land above 2 yr ARI flood levels flood levels (including stockpiles).	0.15	A C-Factor of ≤0.15 is to be achieved within 20 working days of inactivity, even though works might continue later.
Post construction		
Waterways and other areas subjected to concentrated flows	0.05	Applies after 10 working days from completion of formation and before they are allowed to carry any concentrated flows.
Stockpiles	0.10	Applies after 10 working days from completion of formation. Maximum C-Factor of 0.10 equals 60 percent ground cover
All other land	0.15	In periods of expected 'low' rainfall erosivity during the rehabilitation period, achieve a C-Factor of less than 0.15. Maximum C-factor of 0.15 equals 50% ground cover
	0.10	In periods of 'moderate' to 'high' rainfall erosivity during the rehabilitation period, achieve a C-Factor of less than 0.1. Set in motion a program that should ensure it would reduce permanently to less than 0.05 within a further 60 days.

Non-operational areas such as cut and fill batters and stockpiles will be progressively stabilised in accordance with the timeframes nominated in (Table 4.6).

4.4.6 Maximise sediment retention on site

APA should implement all reasonable and practicable measures needed to protect downstream waters and adjacent properties from the adverse effects of sediment and turbid water discharge.

As discussed in section 4.4.5, EMM considers that a focus on erosion control to minimise soil dispersion and the generation of turbid runoff will offer an appropriate level of environmental protection. Topical application of gypsum over exposed soil surfaces and gravel hardstand areas prior to rainfall in combination with polymer emulsion pavements and polymer application to stockpiles and exposed soils will minimise erosion and the generation of turbid runoff.

Given the sandy nature of some site soils, especially in the western end of the pipeline, it is expected that runoff will infiltrate relatively quickly, and sediment will be retained close to the source. There will be a major focus on erosion control during the construction and operational phases of the project which will minimise the generation of sediment and turbid runoff.

4.4.7 Drainage, erosion and sediment control maintenance

All drainage, erosion and sediment control measures should be maintained in proper working order until their function is no longer required. To assist in achieving these requirements, PESCPs should include construction, inspection and maintenance requirements for all drainage, erosion, and sediment control measures.

Inspections are recommended to be undertaken 24 hours prior to predicted rainfall events and immediately following rainfall events that cause run-off and periods of strong winds, and weekly during periods of no rain.

All clean and dirty water, debris and sediment removed from drainage, erosion and sediment control measures must be disposed of in a manner that will not create erosion, sedimentation, or a pollution hazard.

Upon decommissioning any drainage, erosion and sediment control measures, all materials used to form the control measures should be disposed of appropriately.

4.4.8 Drainage, erosion and sediment control monitoring

PESCPs are living documents that can and should be modified as site conditions change, or if the adopted control measures fail to achieve the required treatment standard. When site personnel detect a notable failure in the adopted control measures, the source of the failure will be investigated, and appropriate amendments made to the controls and PESCPs.

4.4.9 Summary of commitments

The following commitments will minimise impacts to soil and erosion associated with the project:

Table 4.7 Summary of commitments – soil and erosion

Stage	Commitment ID	Commitment
Construction	GE-01	The approved construction footprint, including vegetation clearing extent and environmental or heritage features within the construction footprint, will be clearly demarcated and identified during the construction stage with survey pegs and at some locations with flagging, bunting, barrier mesh or similar. No go zones will be clearly marked and communicated as such.
Construction	GE-02	All temporary infrastructure will be decommissioned and removed at the completion of construction
Construction	GE-03	Rehabilitation of disturbed areas will commence progressively as soon as practicable during and after construction, and will be carried out in accordance with the SWMP and Landcom (2004).
Construction	AQ-01	Stabilisation of exposed soils will be undertaken as soon as practicable , and dust suppression undertaken as required using water sprays, water extension agents, soil stabilising polymers or other media on: • unpaved work areas subject to traffic or wind; • exposed soil; • main haulage routes, as required; • sand, spoil and aggregate stockpiles; and • during the loading and unloading of dust generating materials. When water is used for dust suppression, it will not be applied in a way that causes ponding or runoff.

Table 4.7 Summary of commitments – soil and erosion

Stage	Commitment ID	Commitment
Design Construction Operation	WS-01	A soil and water management plan (SWMP) will be prepared for the project and underpinned by primary erosion and sediment control plans (PESCPs) for all discrete disturbance areas, prepared and updated in accordance with Landcom (2004) and certified by a CPESC. Soil characterisation will be required at each compressor station site to accurately determine site-specific erosion risk to inform PESCPs. Surface water and runoff management to be considered in the final engineering design will be detailed in the SWMP and PESCPs. PESCPs will include construction, inspection and maintenance requirements for all drainage, erosion, and sediment control measures. PESCPs will include appropriate erosion and sediment controls for all stages of soil disturbance will be appropriate for the erosion risk posed by potentially dispersive or non-cohesive site soils, and adjusted to account for weather events such as high winds or rainfall. PESCPs will also set out roles and responsibilities for personnel and procedures to be followed if there is a failure in the adopted control measures.
Design Construction	WS-02	Any required cut and fill will employ slope design rules and stabilisation measures guided by material erosion and agronomic characterisation of the site soils.
Design Construction	WS-03	Major land disturbance works will be scheduled to avoid periods of high wind, where practicable. Soil and erosion control measures will be adjusted to ensure appropriate management of erosion and sediment during adverse weather.
Design Construction	WS-04	Site drainage will be designed to maximise sheet flow where possible. Construction of diversion drains, channels and table drains will be minimised to the maximum possible extent where practicable.
Construction	WS-05	Following removal of temporary infrastructure, the waste water spray field at MW433 will be appropriately rehabilitated.
Design Construction	WS-06	Minimise disturbance to the existing watercourses at MW433 and avoid the use of excavated drains where dispersive soils are expected to be present. Constructed landforms will be located to utilise the natural drainage features to the maximum practicable extent.
Design Construction	WS-07	Priority will be given to the prevention or minimisation of soil erosion rather than allowing erosion to occur and relying on sediment control measures to trap and contain sediment and turbid runoff.
Construction	WS-08	Soils will be ameliorated by the incorporation of gypsum into the soil at rates determined by site-specific soil testing. Hardstands will be gravel sheeted or concreted, and stabilised or strengthened where required.
Construction	WS-09	Organic and woody wastes should be considered for soil erosion protection purposes on stockpiles and rehabilitated areas. This is especially important at MW433, where annual rainfall is less than 300 to 350 mm/y and vegetation cannot be relied on for short- or long-term erosional stability.
Design Construction	WS-10	All reasonable and practicable measures needed to protect downstream waters and adjacent properties from the adverse effects of sediment and turbid water discharge will be implemented.
Construction Operation	WS-11	Site areas containing potential contaminants (such as fuel, oil, grease and chemicals) will be covered and/or bunded in accordance with Australian Standard AS1940: The storage and handling of flammable and combustible liquids to prevent contamination of stormwater runoff, with offsite disposal of captured water/contaminants.

Table 4.7 Summary of commitments – soil and erosion

Stage	Commitment ID	Commitment
Design Construction Operation	WS-12	Temporary and permanent onsite wastewater management systems will: • be appropriate for each site based on consideration of the site layout, site conditions and relevant environmental constraints; and • be designed, constructed, operated, maintained and decommissioned in accordance with best practise and relevant guidelines (including WaterNSW 2019), applicable standards (including AS/NZS 1547:2012 On-site domestic wastewater management) and local Council requirements.
Construction Operation	WS-13	All required water licensing and approvals will be obtained to support water supply arrangements for each site during construction and operation.
Design Construction Operation	WS-14	Stormwater runoff from buildings will be captured in rainwater tanks for use on site, to minimise demand for imported water.

5 Conclusion and recommendations

A soil and erosion hazard assessment has been conducted to identify the impact of the project elements on soil loss in consideration of the above-mentioned factors.

As part of the erosion and hazard analysis, the physical erosion risk was calculated based on two methodologies. Firstly, erosion risk of the soil due to its physical and chemical properties was determine utilising texture derived soil erodibility factors (K-Factors) from both IECA 2008 and Loch *et al.* 1998. The erosion risk was high due to the noted electrochemical instability of the site soils at MW880 in desktop information. Secondly, the erosion hazard for the project was calculated in relation to rainfall and slope, for which the rainfall erosivity for the project area is estimated to range from 750–990 MJ.mm ha^{-1} h^{-1}. This means rainfall and slope in the project area has a low hazard of causing erosion.

Due to the arid nature of MW433 the erosion risk shifts from water-based to primarily wind-based. The arid nature of the site also results in an inability to rely on protective vegetation cover which is typically used in establishing erosional stability which should be considered in the preparation of detailed erosion control measures.

The objective of erosion and sediment control practices is to take all reasonable and practicable measures to minimise short and long-term soil erosion, whilst minimising sediment transport which can cause damage to assets and result in the need for re-work during and post construction.

The greatest influence on reducing water erosion hazard is through the adoption of a drainage design that is appropriate for dispersive and non-cohesive soils – maintaining sheet flow conditions where possible, avoiding concentration of flow and the excavation of dispersive subsoils.

Maintaining and/or re-establishing soil surface cover will be fundamental for wind erosion control. Suitable controls include stabilisation of exposed soils and hardstand areas with trafficable and non-trafficable soil stabilising polymers; and the placement of woody debris and application of biologically activated hydraulic growth mediums on areas of temporary and permanent rehabilitation.

If the drainage design is undertaken as described, there is very low erosion and sedimentation risk during the operational phase of the project with most of the site to be covered by sealed hardstands, buildings or subject to progressive rehabilitation.

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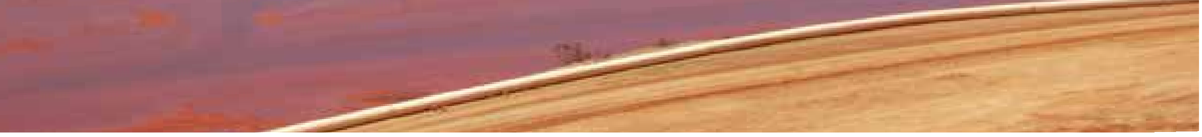




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