

DLALC MAROOTA SANDS PROJECT

Land Capability Assessment

Prepared for:

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BASIS OF REPORT

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
630.30035-R01-v2.0	14 May 2021	Michelle Papenfus	Murray Fraser	Rod Masters
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EXECUTIVE SUMMARY

Design Collaborative has been commissioned by Deerubbin Local Aboriginal Land Council (DLALC) to prepare an Environmental Impact Statement (EIS) for a proposed State Significant friable sandstone extractive industry located at Wisemans Ferry Road, Maroota (the “Maroota Sands Project”). SLR Consulting (SLR) was engaged by Design Collaborative to complete a Land Capability Assessment (LCA) for the site to accompany the EIS.

The Maroota Sands Project is within a 180.7ha parcel of land located within the township of Maroota, NSW. The Project is anticipated to use approximately 49ha of the subject site for the extraction, processing and delivery of up to 500,000 tonnes of sand per annum. The Site’s eastern boundary is located just south of Wisemans Ferry Road and Old North Road intersection. The site extends approximately 2km east from Wisemans Ferry Road and approximately 600m to 1500m in an approximately north-south direction.

The LCA was completed in accordance with the Land and Soil Capability Assessment Scheme Second Approximation [2] and details the following:

- Potential impacts on soils and land capability (including potential erosion and land contamination); and
- The compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements in Clause 12 of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 [1], paying particular attention to agricultural land use in the region.

The Soil and Land Capability Assessment has been conducted based on the findings of a field investigation and a desktop review of reference information. The findings of this assessment include:

- Soils types within the Study Area are dominated by texture contrast soils and commonly occur with acidic and non-sodic characteristics. The soil in the study area are classified as Grey-Brown Kurosols defined by a strongly acidic nature.
- LSC classes range from Class 5 (moderately low capability land) (54%) to Class 6 (low capability land) (46%).
- Surface disturbance associated with the Project will temporarily impact the Grey-Brown Kurosols. This area represents the sites for the extraction, processing and delivery of sand which is approximately 49 ha of the Study Area.
- The areas of LSC Classes temporarily impacted by surface disturbance resulting from the Project are approximately 25.5 ha of LSC Class 5 and 21.4 ha of LSC Class 6.

The proposed quarry is located entirely within native bushland and will not directly or indirectly impact the soil quality of the land currently used for agricultural production.

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1 Introduction

Design Collaborative has been commissioned by Deerubbin Local Aboriginal Land Council (DLALC) to prepare an Environmental Impact Statement (EIS) for a proposed State Significant friable sandstone extractive industry located at Wisemans Ferry Road, Maroota (the “Maroota Sands Project”). The site location and surrounding area is shown on **Figure 1**. SLR Consulting (SLR) was engaged by Design Collaborative to complete a Land Capability Assessment (LCA) for the site.

1.1 Study Area

The Study Area is illustrated on **Figure 2**. The Maroota Sands Project (the Project) is a proposed state significant sand quarry within a 180.7ha parcel of land located within the township of Maroota, NSW. The Project is anticipated to use approximately 49ha of the subject site for the extraction, processing and delivery of up to 500,000 tonnes of sand per annum. The Site’s eastern boundary is located just south of Wisemans Ferry Road and Old North Road intersection. The site extends approximately 2km east from Wisemans Ferry Road and approximately 600m to 1500m in a roughly north-south direction.

As part of the Quarry’s proposed approximately 30 year extraction plan, the Project will develop a 30m to 35m tall highwall (Highwall) with slope angles ranging from 75° to 45° within the southern and south-eastern zone of the site.

1.2 Objective

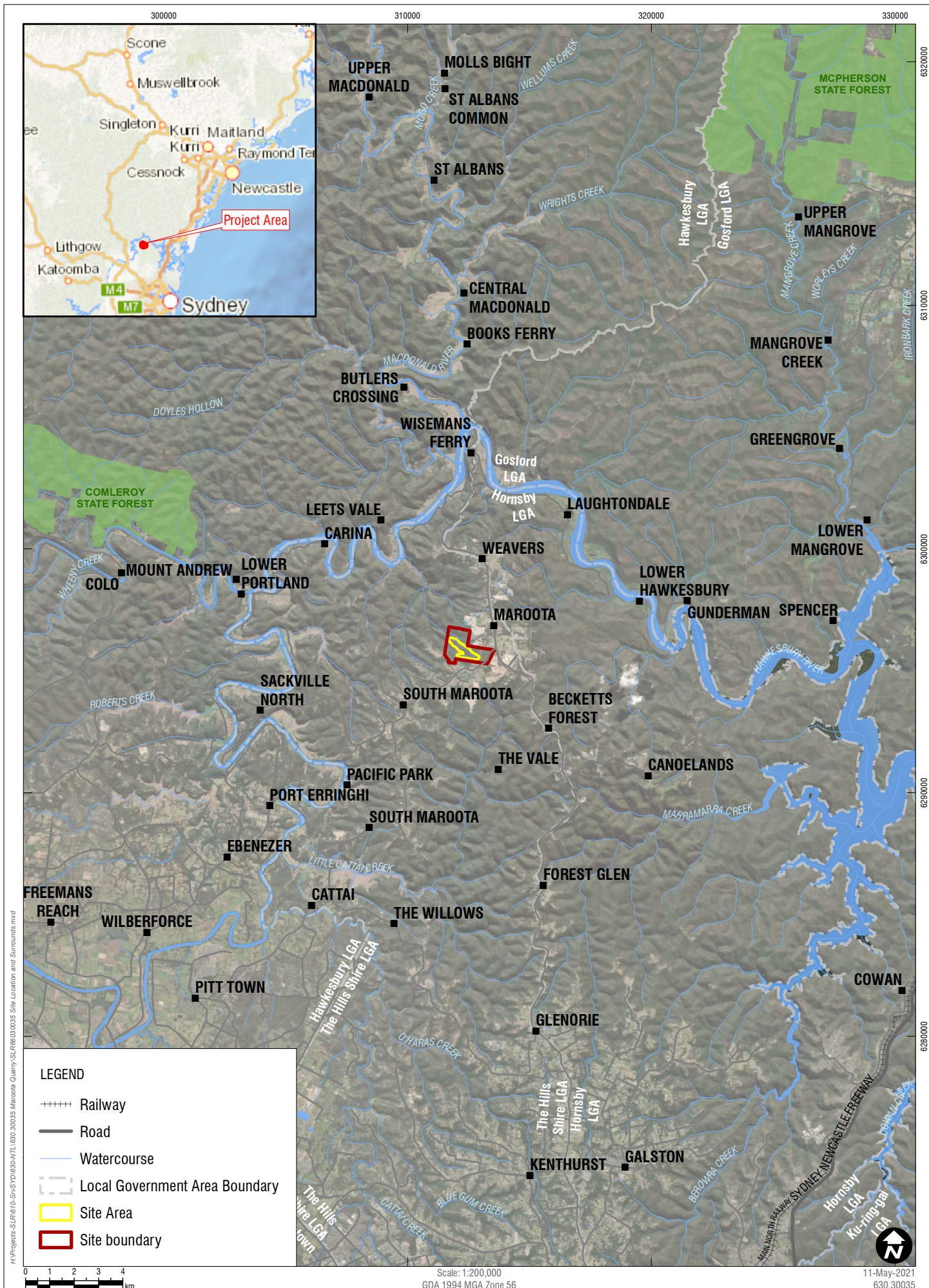
The objective of the investigation was to prepare a LCA to accompany the EIS. The LCA was completed in accordance with the Land and Soil Capability Assessment Scheme, Second Approximation [2] and details the following:

- Potential impacts on soils and land capability (including potential erosion and land contamination); and
- The compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements in Clause 12 of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 [1], paying particular attention to agricultural land use in the region.

1.3 Scope of Work

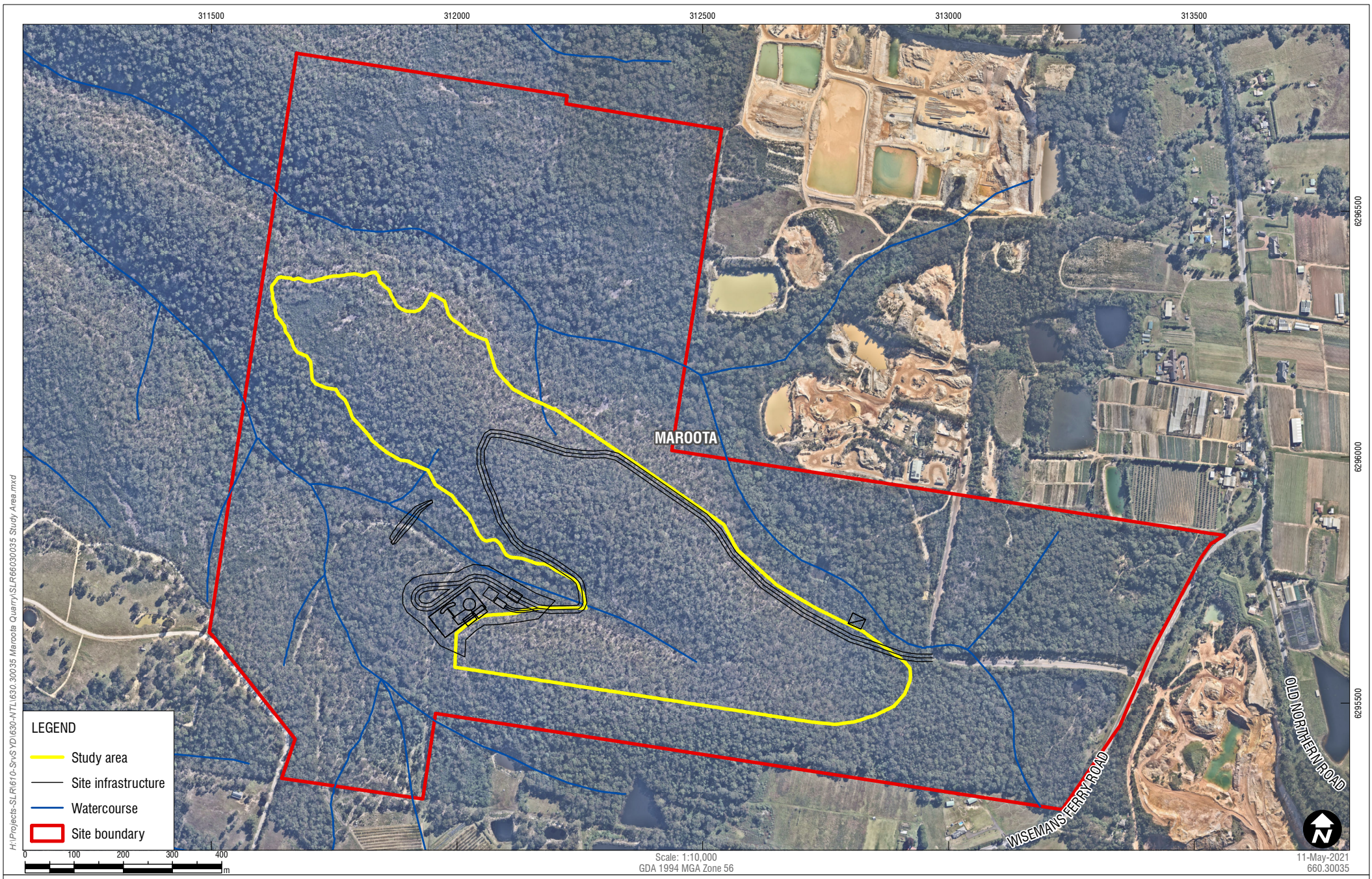
The scope of work for the Maroota Sands LCA included the following:

- Desktop assessment of available information and mapping to determine the required site sampling program and analysis required to support the EIS technical report;
- Field investigation on the site to collect the soil and land information (including samples required for laboratory analysis);
- Interpretation of field investigation and laboratory results; and
- Soil and Land Capability report.



Regional Locality

FIGURE 1



2 Existing Biophysical Environment

2.1 Climate

Daily rainfall information was obtained from Station 67014 of the Bureau of Meteorology (BOM) [3] located less than a kilometre to the east of the site. Station 67014 (Maroota Old Telegraph Road) has a daily rainfall record from 1925 to 2020. Rainfall data for years where measurements were collected for at least 350 days of the year was assessed. **Figure 3** illustrates the variation in the yearly precipitation measured at the station. The annual precipitation ranged from 354 mm/year to 1545 mm/year. The mean annual precipitation (MAP) for the years assessed is 878 mm.

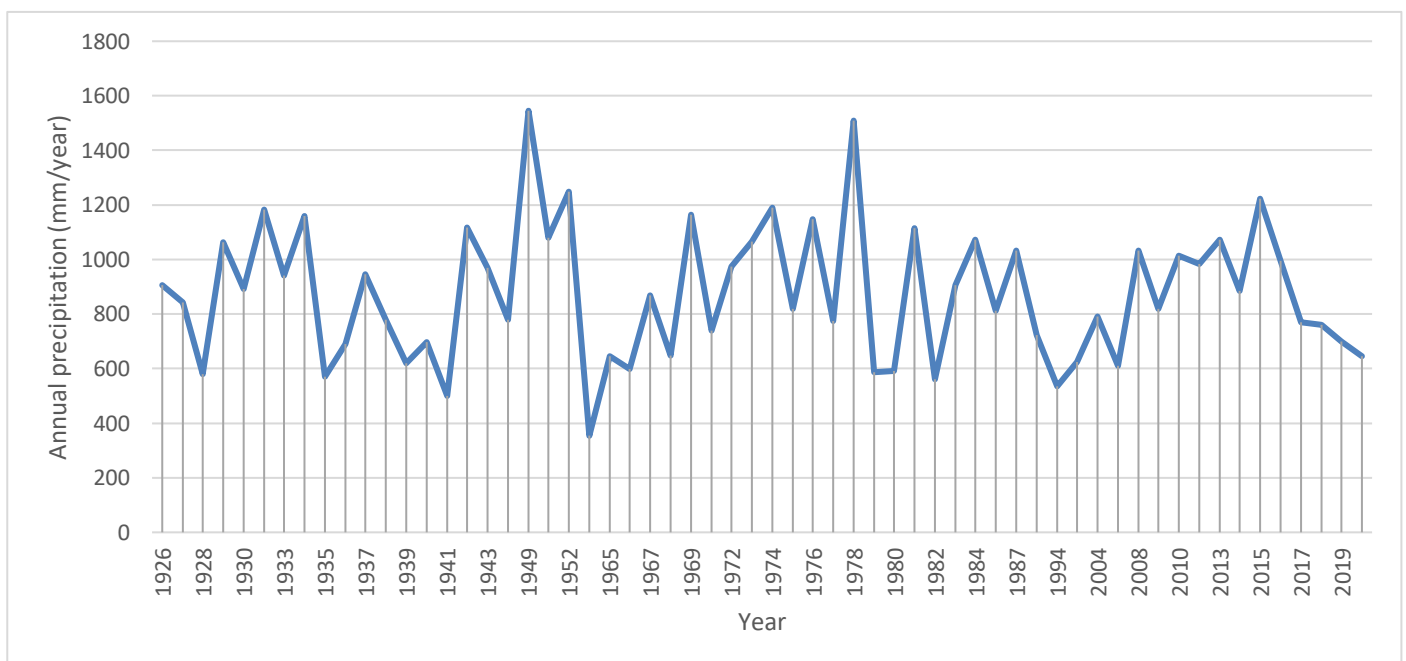


Figure 3 Yearly rainfall at BOM station 67014

2.2 Geology

Due to the resource interest within the Maroota area as a sand resource, several studies into the regional geology have been performed. Categorised by Hopkins and Ross [4], there are three main geological units:

- Maroota Sand;
- Alluvial Sand on Hawkesbury Sandstone; and
- Underlying Hawkesbury Sandstone.

Review of the Department of Land and Water Conservation Maroota Groundwater Study [5] categorises the Maroota area into 3 major lithological units (in order from youngest to oldest), outlined in **Table 1** below.

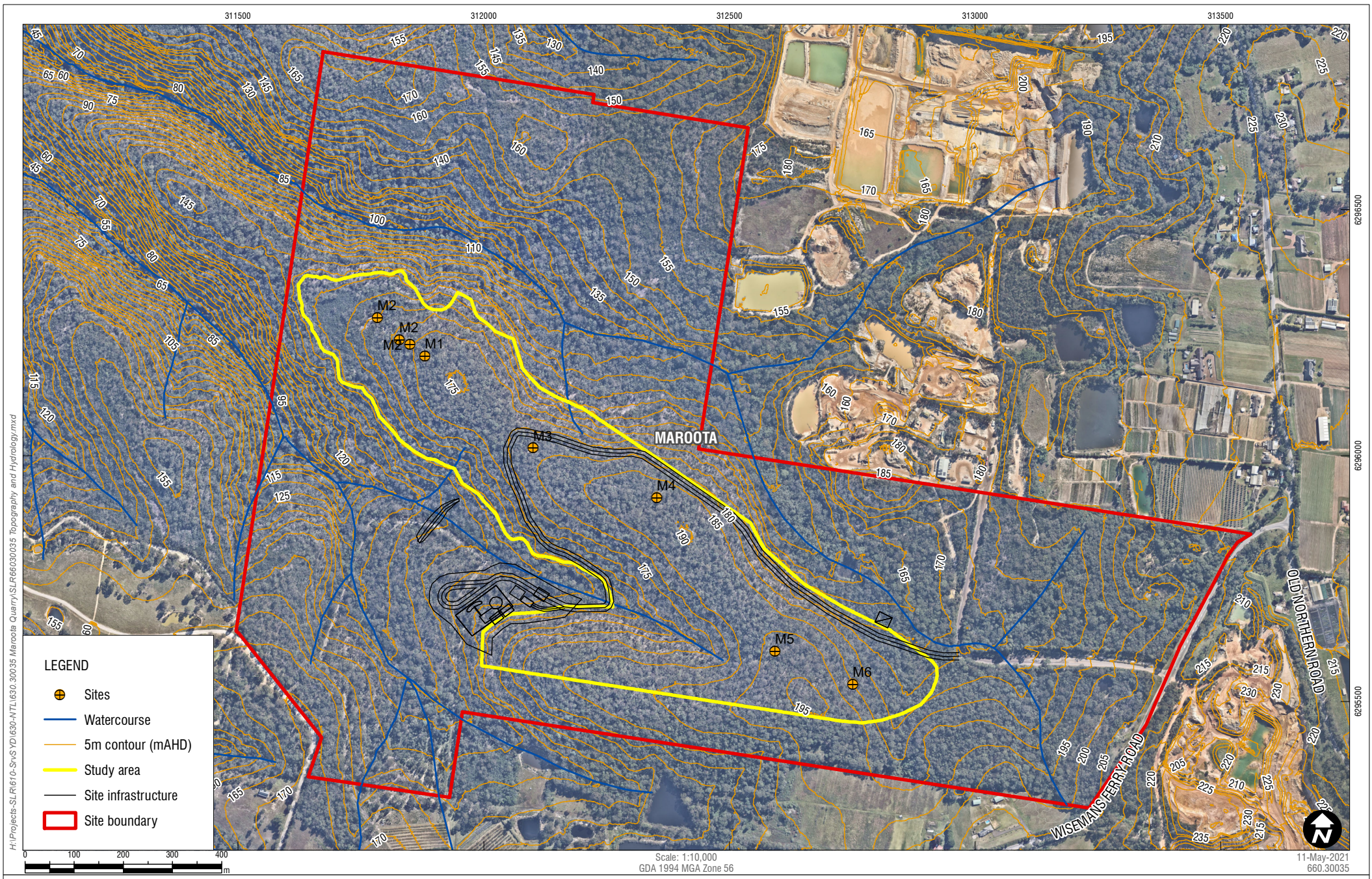
Table 1 Stratigraphic Units

Age	Unit	Lithology
Tertiary	Unnamed	Basalt
	Maroota Sand	Sand, gravel, clayey sand and clay
Triassic	Ashfield Shale	Shale and laminate
	Hawkesbury Sandstone	Quartzose sandstone and shale lenses

2.3 Topography and Hydrology

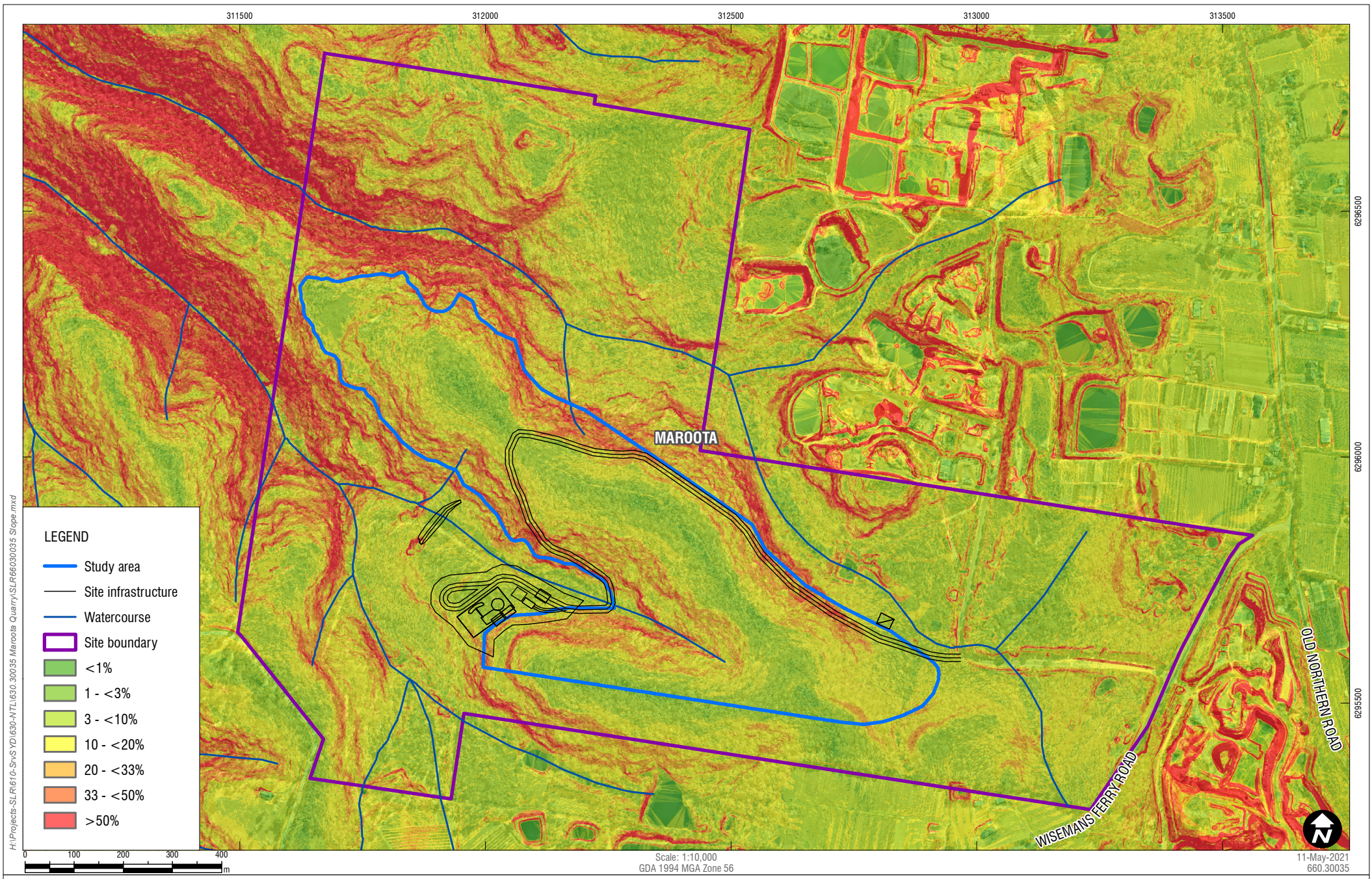
The project site is covered by ridges and low-lying valleys. The proposed extraction area on the property is sited generally on the outcropping sandstone ridge system extending north-westwards from near the frontage to Wisemans Ferry Road. Drainage from the site is via unnamed tributaries of Douglass Creek which flows initially to the northwest and then north into the Nepean River upstream of the site [6] (**Figure 4**). The slope analysis (**Figure 5**) further highlights the low-lying flats, in green.

Groundwater levels have been taken from the EMM (2020) [7]. The regional groundwater levels have been interpreted from data loggers installed in March 2017 and retrieved in March 2020. Extracted groundwater hydrographs and data logger locations indicated that water levels range from 5 to 35 metres below ground level.



Topography and Hydrology

FIGURE 4



Slope Analysis

FIGURE 5

2.4 Soil Landscape Units

Soil Landscapes Units are described as “*areas of land that have recognisable and specific topographies and soils that can be presented on maps and described by concise statements*”.

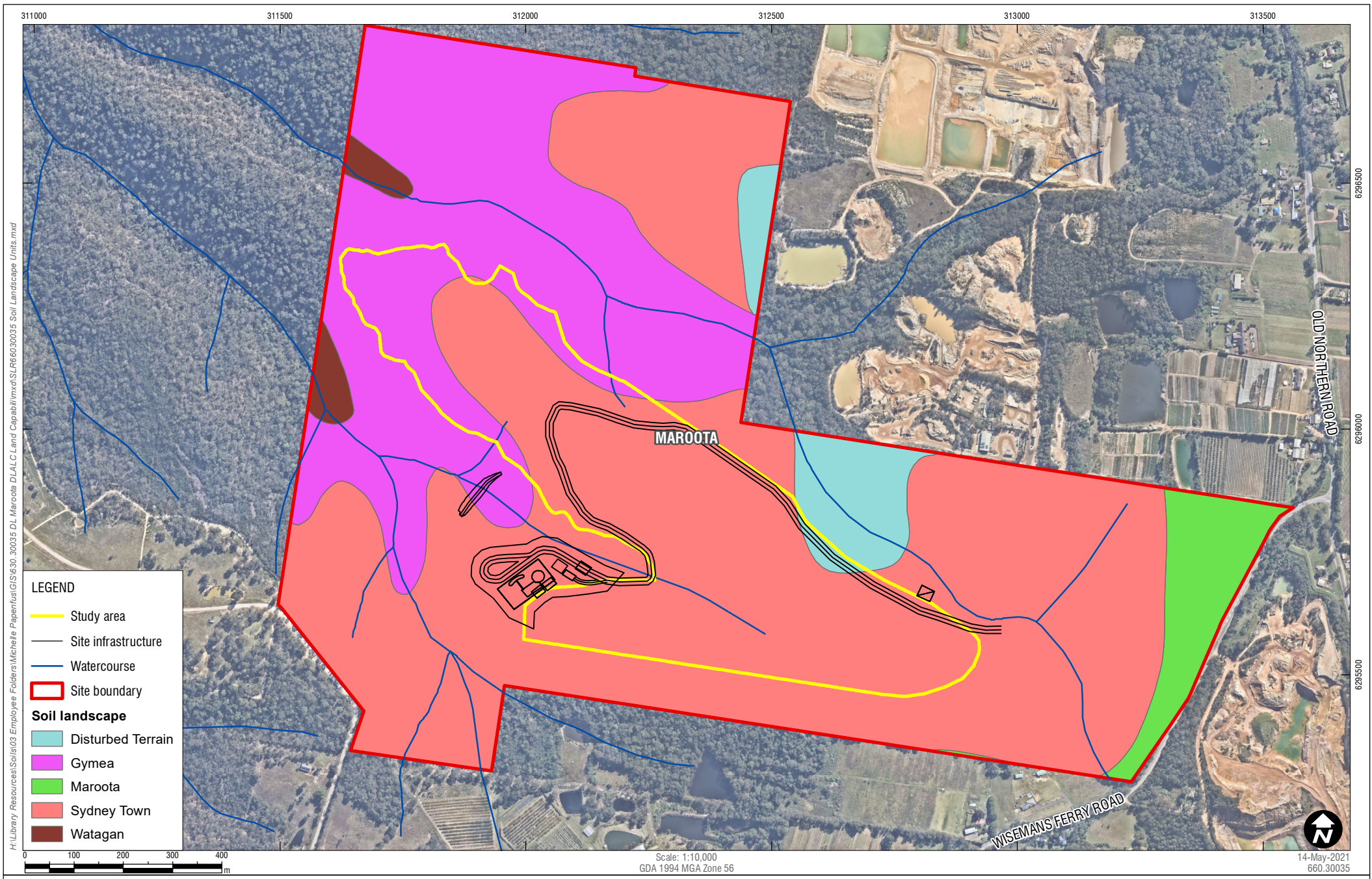
The Soil Landscape Units within the Study Area have been mapped by the former NSW Department of Land and Water Conservation, incorporating the NSW Soil Conservation Service (now part of NSW Department of Primary Industries (DPI)), on the *Soil Landscapes of the St Albans 1:100 000 Sheet* [8] shown in **Figure 6**.

Five Soil Landscape Units occur in the Study Area and are summarised in **Table 2**.

Table 2 Soil Landscape Units

Name	Ha	% of Study Area
Maroota	7	4
Sydney Town	112	63
Gymea	49	28
Disturbed Terrain	8	4
Watagan	2	1
Total	178	100

Full descriptions of each Soil Landscape Unit mapped within the Study Area follow **Figure 6**.



Source: Nearmap (March 2020)

Sheet Size : A4



Soil Landscape Units

FIGURE 6

2.4.1 Sydney Town Soil Landscape

The Sydney Town Soil Landscape unit consists of undulating to rolling low hills and moderately inclined slopes. Local relief is up to 80m, slope gradients between 5 and 25% and elevations between 100 and 200m. The landscape is characterised by moderately broad ridges and crests, moderately inclined slopes, narrow drainage lines and occasional rock benches. The land is extensively cleared low eucalypt open woodland. The soils in the landscape are varied and include shallow and deep, well to imperfectly drained Yellow Earths, Earthy Sands and some rapidly drained Siliceous Sands on crests and slopes, shallow to deep poorly drained Siliceous Sands, Leached Sands and Grey Earths in poorly drained areas and drainage lines, moderately deep to deep imperfectly drained Yellow Podzolic Soils and poorly drained Gleyed Podzolic Soils associated with shale lenses.

Limitations of the Sydney Town Soil Landscape unit include a very high erosion hazard, localised permanent waterlogging, highly permeable, strongly acid, sodic/dispersive soils with very low fertility.

2.4.2 GyMEA Soil Landscape

The GyMEA Soil Landscape unit consists of undulating to rolling hills with more than 25% outcrop. Local relief is 20 to 80m with slopes of 10 to 25%. The landscape is characterised by broad convex crests, moderately inclined side slopes with wide rock benches and localised rock outcrop on low broken scarps. The land is predominantly eucalypt open forest and open woodland. The soils are varied and include shallow Siliceous Sands and Lithosols (Rudosols) associated with rock outcrop and on leading edges of benches, shallow to moderately deep Earthy Sands (Tenosols) and Yellow Earths (Tenosols) on crests and insides of benches, Yellow Podzolic Soils and Yellow Earths (Chromosols and Kurosols) on insides of benches, localised Yellow Podzolic Soils (Chromosols and Kurosols), Red Podzolic Soils (Dermosols) on shale lenses, shallow to moderately deep Siliceous Sands, Leached Sands (Rudosols) and Earthy Sands (Tenosols) along drainage lines.

Limitations to this unit include high soil erosion hazard, rock outcrop. Localised rockfall hazard, steep slopes, shallow, stony, highly permeable and strongly acid soils of very low fertility.

2.4.3 Disturbed Terrain Soil Landscape

The Disturbed Soil Landscape occurs within other landscapes and consists of level plains to hummocky terrain which have been disturbed by human activity including complete disturbance and removal or burial of soil. The local relief and slopes are highly variable. The soil surface has been cleared of the original vegetation.

The quality and limitations of the Disturbed Terrain Soil Landscape is dependent on the nature of fill materials and may include mass movement hazard, steep slopes, foundation hazard, unconsolidated low wet bearing strength materials, impermeable soils, poor drainage, low fertility and toxic materials.

2.4.4 Maroota Soil Landscape

The Maroota Soil Landscape unit consists of gently undulating rises on elevated alluvial sediments. Local relief is less than 20m, slope gradients less than 10%, and elevation ranges between 190 and 220m. The landscape is characterised by broad crests, and long and gently inclined slopes. The land is predominantly cleared open forest and woodland. The soils include moderately deep to deep Yellow Earths on crests and slopes, Podzols at heads of drainage lines and deep Gleyed Podzolic Soils associated with clay deposits.

Limitations of this landscape unit includes high erosion hazard, localised seasonal waterlogging, highly permeable and strongly acid soils with low fertility.

2.4.5 Watagan Soil Landscape

The Watagan Soil Landscape unit consists of rolling to very steep hills on fine-grained Narrabeen Group sediments. Local relief is 50 to 220 metres, with slopes greater than 25%. The landscape is characterised by narrow convex crests and ridges, steep colluvial sideslopes, occasional sandstone boulders and benches. The land is predominately uncleared tall eucalypt open-forest with closed-forest in sheltered position. The soils are varied and include shallow Lithosols / Siliceous Sands (Rudosols) and Yellow Earths (Kandosols) on coarse sandstones, shallow to deep Yellow and Red Podzolic Soils (Kurosols, Chromosols) on fine-grained bedrock, deep sandstone colluvial deposits, Yellow Earths (Kandosols), Yellow Podzolic soils (Kurosols, Chromosols) and Alluvial Soils (Rudosols) along drainage lines.

Limitations to this unit include mass movement hazards, steep slopes, soil erosion hazards, foundation hazards, occasional rock outcrops and seasonal waterlogging (localised). The rural land capability is deemed to have generally high to severe limitations to both cropping and grazing.

3 Methodology

3.1 Soil Survey Methodology

A field survey and a desktop study were undertaken to assess the Study Area. This process consisted of the components outlined in the sub-sections below. **Appendix A** contains a general glossary of terms used.

3.1.1 Reference Mapping

An initial soil map (reference map) was developed using the following resources and techniques:

- Aerial photographs and topographic maps - Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape, and mapping of features expected to be related to the distribution of soils within the Study Area. Aerial and topographical maps were provided by site.
- Reference information - Source materials were used to obtain correlations between pattern elements and soil properties that may be observable in the field. These materials included cadastral data, prior and current physiographic, geological, vegetation, and water resources studies.

- Previous reports - Previous studies were taken into consideration for soils mapping and land assessment. These include the following:
 - Soil Landscapes of the Wallerawang 1:100,000 Sheet [9]; and
 - Land and Soil Capability Spatial Data [10].

3.1.2 Field Survey

Scale

Using the Soil Landscapes of the Wallerawang 1:100,000 Sheet as a base reference, further survey work was undertaken to build on this soil data and confirm soil boundaries within the Study Area. The field survey was undertaken at a medium intensity scale of 1:100,000.

Survey Type

The field survey undertaken was an integrated survey and is a qualitative survey type. An integrated survey assumes that many land characteristics are interdependent and tend to occur in correlated sets [11]. Background reference information derived from sources cited in **Section 3.1.1** were used to predict the distribution of soil attributes in the field. The characteristics evaluated to generate the correlated sets include vegetation type, landform and geology.

The specific type of integrated survey undertaken was a 'free survey'. A free survey is a conventional form of integrated survey and its strength lies in its ability to assess soil and land at medium to detailed-scales. Survey points are irregularly located according to the survey teams' judgement to enable the delineation of soil boundaries. Soil boundaries can be abrupt or gradual, and catena and toposequences are used to aid the description of this variation.

Survey Observations

Survey observations undertaken comply with the 1:100,000 scale survey criteria prescribed in the Guidelines for Surveying Soil and Land Resources ([12]). The locations of the detailed profile sites are shown on **Figure 7**.

The recommended observation density for 1:100,000 scale survey is one observation every 100 ha. For the Maroota Site of 45ha this equates to 1 observation. Generally, a minimum of 10-30 per cent are to be Detailed Profile Descriptions (also referred to as Class I observations), 5 percent are to be Laboratory Assessed (also referred to as Class II observations), and the remainder are to be made up by Minor Class Observations (also referred to as Class IV observations). The location of the soil

The actual number of observations undertaken was 6 Class I observations. This exceeds and, therefore, satisfies the observation requirements for a 1:100,000 survey scale.

Detailed Soil Profile Observation

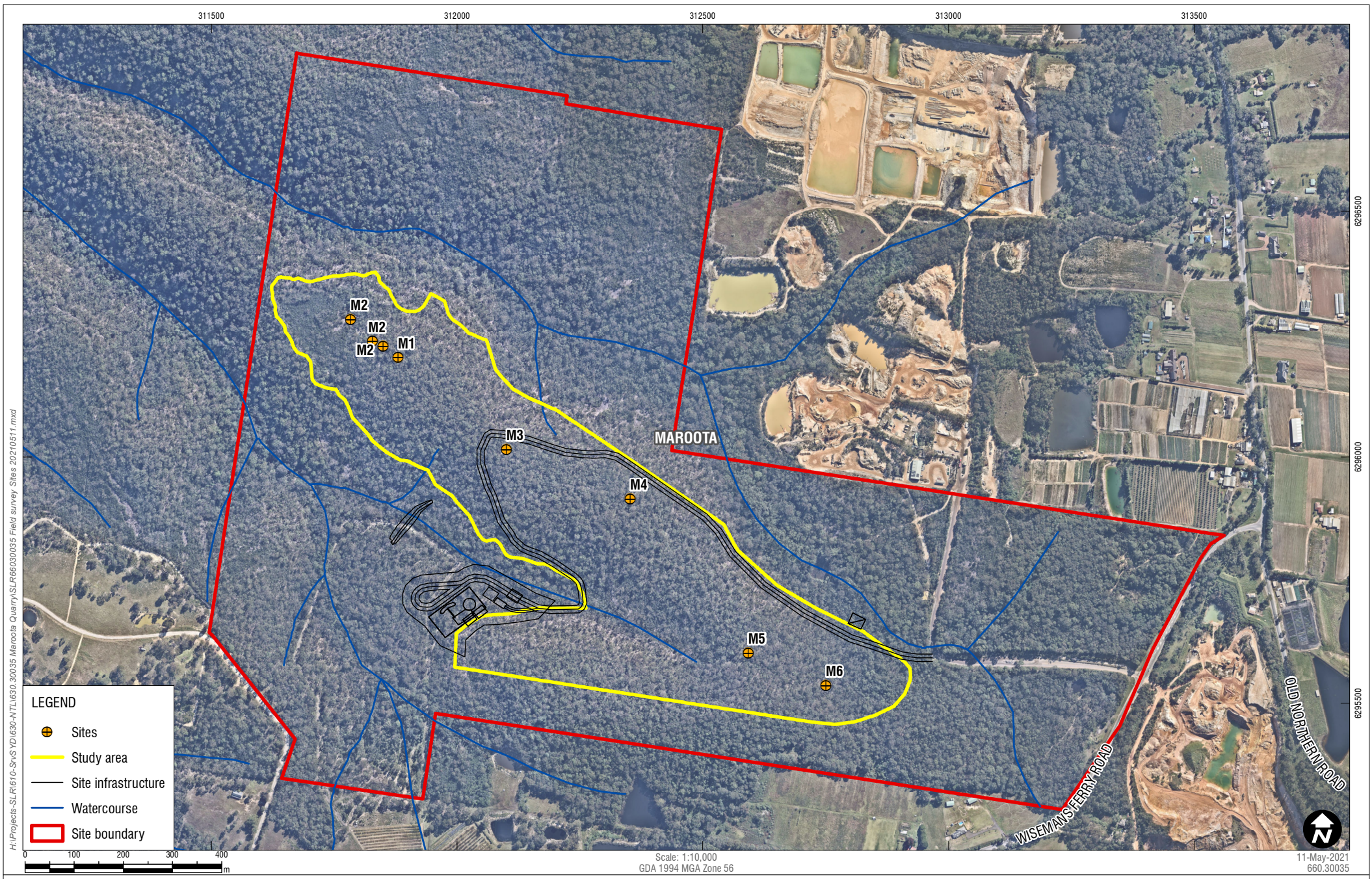
Soil profiles were assessed in accordance with the Australian Soil and Land Survey Field Handbook [13]. Information was recorded for the major parameters specified in **Table 3**.

Table 3 Field Assessment Parameters

Descriptor	Application
Horizon Depth	Weathering characteristics, soil development
Field Colour	Permeability, susceptibility to dispersion/erosion
Field Texture Grade	Erodibility, hydraulic conductivity, moisture retention, root penetration
Boundary Distinctness and Shape	Erosional/dispositional status, textural grade
Consistence Force	Structural stability, dispersion, ped formation
Structure Pedality Grade	Soil structure, root penetration, permeability, aeration
Structure Ped and Size	Soil structure, root penetration, permeability, aeration
Stones – Amount and Size	Water holding capacity, weathering status, erosional/depositional character
Roots – Amount and Size	Effective rooting depth, vegetative sustainability
Ants, Termites, Worms, etc.	Biological mixing depth

Global positioning system readings were taken for all sites where detailed soil descriptions were recorded. Vegetation type and land use were also recorded. Soil exposures were photographed during field operations, with photographs being a useful adjunct to description of land attributes.

Soil layers at each profile site were also assessed according to a procedure devised by Elliot and Reynolds [14] for the recognition of suitable topdressing material in the event surface disturbance occurs in the future. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence.



Field Survey Sites

FIGURE 7

3.1.3 Soil Laboratory Assessment

Soil samples from the soil profile assessed were utilised in the laboratory testing programme. Samples were analysed to:

- classify soil taxonomic classes;
- determine land and soil capability classes; and
- determine suitability of soil as topdressing material.

Soil samples of approximately 1 – 2 kilograms (kg) were collected from each soil layer. In total, eight soil samples from three sites were dispatched to the EAL for analysis. A Certificate of Analyses for these results are contained in **Appendix B**. The selected physical and chemical laboratory analysis parameters and their relevant application are listed in **Table 4**.

Table 4 Laboratory Analysis Parameters

Property	Application	Method
Coarse fragments (>2mm)	Soil workability, root development	Sieve and hydrometer
Particle size distribution (PSA) (<2mm)	Nutrient retention, exchange properties, erodibility, workability, permeability, sealing, drainage, interpretation of most other physical and chemical properties and soil qualities	
Soil acidity/basicity (pH)	Nutrient availability, nutrient fixation, toxicities (especially aluminium and magnesium, liming, sodicity, correlation with other physical, chemical and biological properties)	1:5 soil/water extract
Electrical conductivity (EC)	Appraisal of salinity hazard in soil substrates or groundwater, total soluble salts	
Cation exchange capacity (CEC) and exchangeable cations	Nutrient status, calculation of exchangeable sodium percentage (ESP), assessment of other physical and chemical properties, especially dispersivity, shrink-swell, water movement, aeration	(AgTU)+ extraction

3.1.4 Soil Type Nomenclature

The applicable technical standard adopted for the Project is the Australian Classification System (ASC). This standard is routinely used as the soil classification system in Australia.

3.2 Land and Soil Capability

The LSC classification applied to the Study Area is in accordance with the OEH guideline *The Land and Soil Capability Assessment Scheme; Second Approximation* [2]. This scheme uses the biophysical features of the land and soil to derive detailed rating tables for a range of land and soil hazards. The scheme consists of eight classes, which classify the land based on the severity of long-term limitations. The LSC classes are described in **Table 5** and their definition has been based on two considerations:

- The biophysical features of the land to derive the LSC classes associated with various hazards; and

- The management of the hazards including the level of inputs, expertise and investment required to manage the land sustainably.

Table 5 Land and Soil Capability Classification

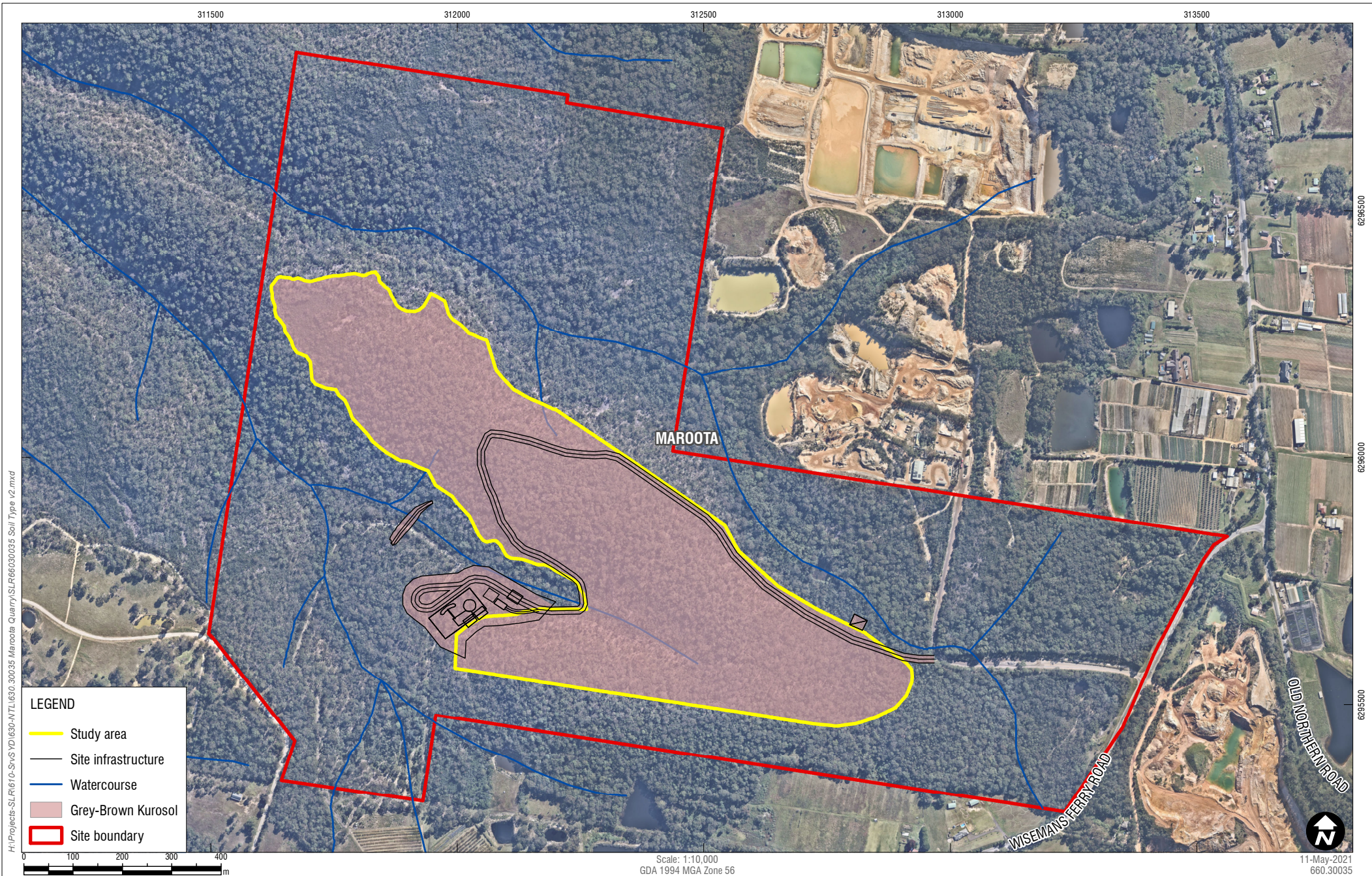
Class	Land and Soil Capability
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, conservation)	
1	Extremely high capability land: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	Very high capability land: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
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. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
4	Moderate capability land: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
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.
Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)	
6	Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
7	Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

4 Soil Survey Results

One Soil Unit was identified during the soil survey, a Grey-Brown Kurosol with a subdominant soil type comprising a Yellow Kandosol.

4.1 Soil Unit 1: Grey-Brown Kurosol

Kurosols are soils with a strong texture contrast between the A horizons and a strongly acidic B horizon. Kurosols dominate the Study Area representing five of the six profiles assessed in the soil survey. Full profile descriptions for each of the five soil types follow **Figure 8**.



Sheet Size : A4

Representative Soil Type

FIGURE 8

4.1.1 Dystrophic Brown Kurosol

Table 6 Summary: Dystrophic Brown Kurosol (Site 1)

Overview	
	
Landscape Site 1	
ASC Name	Dystrophic Brown Kurosol
Representative Site	Site 1
Other Mapped Sites	2, 3, 4, 5
Survey Type	Detailed Lab
Dominant Topography	Upper Plateau
Dominant Land Use	Native Woodland
Vegetation	Hakea, Eucalypt
Inherent Soil Fertility	Moderately Low
Slope (%)	7
Surrounding Slope (%)	20 – 30
Aspect	North-West

Table 7 Dystrophic Brown Kurosol (Site 1)

Profile	Horizon / Depth (m)	Description
	A1 0.0 – 0.20	Brown (7.5YR 4/2) sandy loam, weak crumb structure <10 mm peds with weak consistence and a rough fabric. Nil mottling, 10% gravel content 5-10 mm, nil segregations, abundant fine roots. Well drained with a clear and even boundary. Sampled 0.0 – 0.10
	B21 0.20 – 0.60	Yellowish-brown (10YR 5/8) sandy clay loam, moderately structured 10-20 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, 20% cobble content 40-60 mm, nil segregations, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.30 – 0.40
	B22 0.60 – 0.80	Yellowish-brown (10YR 5/8) light-medium clay, moderately structured 15-30 mm blocky peds with strong consistence and a rough fabric. 20% distinct grey mottles, 10% gravel content 5-10 mm, nil segregations, coarse roots common. Moderately drained with a clear and even boundary. Sampled 0.60 – 0.70
	BC +0.80	Weathered sandstone. Not sampled

* Field Munsell Colour used due to high percentage of mottling.

Table 8 Chemical Parameters: Dystrophic Brown Kurosol (Site 1)

Layer	pH (1:5 water)		ESP		ECe		Ca:Mg	
	Unit	Rating	%	Rating	dS/m	Rating	Ratio	Rating
A1	5.3	Strongly Acidic	2.8	Non-Sodic	0.3	Non-Saline	0.5	Low
B21	5.4	Strongly Acidic	2.8	Non-Sodic	0.2	Non-Saline	0.1	Low
B22	4.7	Very Strongly Acidic	1.3	Non-Sodic	0.3	Non-Saline	0.3	Low

4.1.2 Brown Kurosol

Table 9 Summary: Brown Kurosol (Site 2)

Overview	
	
Landscape Site 2	
ASC Name	Brown Kurosol
Representative Site	Site 2
Other Mapped Sites	1, 3, 4, 5
Survey Type	Detailed Observation
Dominant Topography	Plateau Edge
Dominant Land Use	Native Woodland Sandstone Plateau
Vegetation	Hakea, Eucalypt
Inherent Soil Fertility	Moderately Low
Slope (%)	6 – 15
Surrounding Slope (%)	20 – 30
Aspect	North-West

Table 10 Profile: Brown Kurosol (Site 2)

Profile	Horizon / Depth (m)	Description
	A1 0.0 – 0.05	Brown (7.5YR 4/3) sandy loam, weak crumb structure <10 mm peds with weak consistence and a rough fabric. Nil mottling, 20% gravel content 5-10 mm, nil segregations, nil roots. Well drained with an abrupt and even boundary. Sampled 0.0 – 0.05
	C +0.05	Sandstone bedrock. Not sampled

Table 11 Field Chemical Parameters: Brown Kurosol (Site 2)

Layer	Field pH		Field Dispersion	Field Effervescence
	Unit	Rating	Rating	Rating
A	5	Strongly Acidic	Nil	Nil

4.1.3 Brown Kurosol

Table 12 Summary: Brown Kurosol (Site 3)

Overview	
	
Landscape Site 3	
ASC Name	Brown Kurosol
Representative Site	Site 3
Other Mapped Sites	1, 2, 4, 5
Survey Type	Detailed Observation
Dominant Topography	Plateau Edge
Dominant Land Use	Native Woodland
Vegetation	Hakea, Eucalypt, Tussock Grass
Inherent Soil Fertility	Moderately Low
Slope (%)	6
Surrounding Slope (%)	20 – 30
Aspect	North-West

Table 13 Profile: Brown Kurosol (Site 3)

Profile	Horizon / Depth (m)	Description
	A1 0.0 – 0.10	Brown (7.5YR 4/2) sandy loam, weak crumb structure <10 mm peds with weak consistence and a rough fabric. Nil mottling, 10% gravel content 5-10 mm, nil segregations, abundant fine roots. Well drained with a clear and even boundary. Sampled 0.0 – 0.10
	B21 0.10 – 0.30	Yellowish-brown (10YR 5/6) clay loam, moderately structured 10-30 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, 10% gravel content 5-10 mm, nil segregations, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.20 – 0.30
	B22 0.30 – 0.60	Yellow (2.5YR 7/6) light clay, moderately structured 20-40 mm blocky peds with strong consistence and a rough fabric. 20% distinct grey mottles, nil gravel content, nil segregations, coarse roots common. Moderately drained with a clear and even boundary. Sampled 0.40 – 0.50
	BC +0.60	Weathered sandstone. Not sampled

Table 14 Field Chemical Parameters: Brown Kurosol (Site 3)

Layer	Field pH		Field Dispersion	Field Effervescence
	Unit	Rating	Rating	Rating
A1	5	Strongly Acidic	Nil	Nil
B21	5	Strongly Acidic	Nil	Nil
B22	5	Strongly Acidic	Nil	Nil

4.1.4 Magnesic Grey Kurosol

Table 15 Summary: Magnesic Grey Kurosol (Site 4)

Overview	
	
Landscape Site 4	
ASC Name	Magnesic Grey Kurosol
Representative Site	Site 4
Other Mapped Sites	1, 2, 3, 5
Survey Type	Detailed Lab
Dominant Topography	Upper Plateau
Dominant Land Use	Native Woodland
Vegetation	Eucalypt, Tussock Grass
Inherent Soil Fertility	Moderately Low
Slope (%)	4
Surrounding Slope (%)	20 – 30
Aspect	North-East

Table 16 Profile: Magnesic Grey Kurosol (Site 4)

Profile	Horizon / Depth (m)	Description
	A1 0.0 – 0.20	Grey (2.5Y 5/1) sandy loam, weak crumb structure <10 mm peds with weak consistence and a rough fabric. Nil mottling, <10% gravel content 5-10 mm, nil segregations, abundant fine roots. Well drained with a clear and even boundary. Sampled 0.0 – 0.10
	B21 0.20 – 0.40	Light brownish-grey (2.5Y 6/2) light clay, moderately structured 10-20 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, 10% gravel content 5-10 mm, nil segregations, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.20 – 0.30
	B22 0.40 – 0.80	Pale brown (2.5Y 7/4) medium clay, moderately structured 20-40 mm blocky peds with strong consistence and a rough fabric. 20% distinct yellow mottles, nil gravel content, nil segregations, coarse roots common. Moderately drained with a clear and even boundary. Sampled 0.50 – 0.60
	BC +0.80	Weathered sandstone. Not sampled

Table 17 Chemical Parameters: Magnesic Grey Kurosol (Site 4)

Layer	pH (1:5 water)		ESP		ECe		Ca:Mg	
	Unit	Rating	%	Rating	dS/m	Rating	Ratio	Rating
A1	5.2	Strongly Acidic	0.8	Non-Sodic	0.3	Non-Saline	0.5	Low
B21	5.3	Strongly Acidic	1.5	Non-Sodic	0.1	Non-Saline	<0.1	Low
B22	5.4	Strongly Acidic	2.1	Non-Sodic	0.1	Non-Saline	<0.1	Low

4.1.5 Grey Kurosol

Table 18 Summary: Grey Kurosol (Site 5)

Overview	
	
Landscape Site 5	
ASC Name	Grey Kurosol
Representative Site	Site 5
Other Mapped Sites	1, 2, 3, 4
Survey Type	Detailed Observation
Dominant Topography	Plateau Edge
Dominant Land Use	Native Woodland
Vegetation	Eucalypt, Tussock Grass
Inherent Soil Fertility	Moderately Low
Slope (%)	10
Surrounding Slope (%)	20 – 30
Aspect	South-East

Table 19 Profile: Grey Kurosol (Site 5)

Profile	Horizon / Depth (m)	Description
	A1 0.0 – 0.10	Dark grey (10YR 4/1) sandy loam, weak crumb structure 5-10 mm peds with weak consistence and a rough fabric. Nil mottling, nil stone content, nil segregations, abundant fine roots. Well drained with a clear and even boundary. Sampled 0.0 – 0.10
	B21 0.10 – 0.25	Greyish brown (10YR 5/2) light clay, moderately structured 10-20 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, <10% gravel content 5-10 mm, nil segregations, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.15 – 0.25
	B22 0.25 – 0.50	Yellowish brown (10YR 5/6) light-medium clay, moderately structured 10-30 mm blocky peds with strong consistence and a rough fabric. 20% distinct yellow mottles, nil gravel content, nil segregations, coarse roots common. Moderately drained with a clear and even boundary. Sampled 0.50 – 0.60
	BC +0.50	Weathered sandstone. Not sampled

Table 20 Field Chemical Parameters: Grey Kurosol (Site 5)

Layer	Field pH		Field Dispersion	Field Effervescence
	Unit	Rating	Rating	Rating
A1	5	Strongly Acidic	Nil	Nil
B21	5	Strongly Acidic	Nil	Nil
B22	5	Strongly Acidic	Nil	Nil

4.2 Sub Dominant Soil Type: Yellow Kandosol

4.2.1 Mesotrophic Yellow Kandosol

Kandosols are soils which lack strong texture contrast between the A and B horizons, have massive or weakly structured B horizons and are not calcareous throughout. Kandosols have a maximum clay content in some part of the B horizon which exceeds 15%.

Table 21 Summary: Mesotrophic Yellow Kandosol (Site 6)

Overview	
	
Landscape Site 6	
ASC Name	Mesotrophic Yellow Kandosol
Representative Site	Site 6
Other Mapped Sites	Nil
Survey Type	Detailed Lab
Dominant Topography	Lower Slope
Dominant Land Use	Native Woodland
Vegetation	Eucalypt, Casuarina
Inherent Soil Fertility	Moderately Low
Slope (%)	15
Surrounding Slope (%)	20 – 30
Aspect	South-East

Table 22 Profile: Mesotrophic Yellow Kandosol (Site 6)

Profile	Horizon / Depth (m)	Description
	A1 0.0 – 0.20	Greyish-brown (10YR5/2) sandy loam, weak crumb structured 5-10 mm peds with weak consistence and a rough fabric. Nil mottling, nil stone content, nil segregations, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.0 – 0.10
	B2 0.20 – 0.40	Light yellowish-brown (2.5Y 6/4) clay loam, moderately structured 10-30 mm blocky peds with moderate consistence and a rough fabric. Nil mottles, nil gravel content, nil segregations, coarse roots common. Well drained with a gradual and even boundary. Sampled 0.20 – 0.30
	BC +0.40	Weathered sandstone. Not sampled

Table 23 Chemical Parameters: Mesotrophic Yellow Kandosol (Site 6)

Layer	pH (1:5 water)		ESP		ECe		Ca:Mg	
	Unit	Rating	%	Rating	dS/m	Rating	Ratio	Rating
A1	5.4	Strongly Acidic	1.4	Non-Sodic	0.2	Non-Saline	0.2	Low
B2	5.8	Moderately Acidic	4.4	Non-Sodic	0.1	Non-Saline	0.1	Low

4.3 Land and Soil Capability

4.3.1 Calculating LSC classes

The biophysical features of the land that are associated with various hazards are broadly soil, climate and landform and more specifically: slope, landform position, acidity, salinity, drainage and rockiness.

The eight hazards associated with these biophysical features that are assessed by the scheme are:

1. Water erosion
2. Wind erosion
3. Soil structure decline
4. Soil acidification
5. Salinity
6. Water logging
7. Shallow soils and rockiness
8. Mass movement

Each hazard is assessed against set criteria tables, as described in the LSC Guideline; each hazard for the land is ranked from 1 through to 8 with the overall ranking of the land determined by its most significant limitation.

Hazard 1: Water Erosion

The Study Area lies within the Eastern NSW Division, and the appropriate criteria for this division were used in the assessment. Assessment of water erosion hazard is almost solely dependent on the slope percentage of the land, based on each Soil Landscape Unit. The only exception is land which falls within the slope range of 10 to 20%, which may be designated LSC Class 4 or LSC Class 5 depending on the presence of gully erosion and/or sodic/dispersible soils.

Hazard 2: Wind Erosion

There are four factors used to assess wind erosion hazard for each soil type. Three criteria were assessed to be consistent for each soil type:

- Average rainfall determines the capacity of the land to maintain vegetative cover and keep soil wet. The average rainfall for the region is 878 millimetres [3], and therefore the Study Area lies within the “greater than 500 millimetres rainfall” category for the purpose of assessing wind erosion hazard.
- Wind erosive power for the Study Area has been mapped as “Low” [2].
- Exposure of the land to wind was also determined to be “Low” throughout the Study Area.

The determining factor with regard to wind erosion hazard was therefore the erodibility of each soil type as determined by soil texture according the LSC Guideline.

Hazard 3: Soil Structure Decline

Soil structure decline is assessed on soil characteristics, including surface soil texture, sodicity (laboratory tested) and degree of self-mulching (field tested). These parameters assess the soil structure, stability and resilience of the soil.

Hazard 4: Soil Acidification

The soil acidification hazard is assessed using three criteria, being soil buffering capacity, pH and mean annual rainfall. In this assessment, soil buffering capacity was based on soil Great Soil Group; surface soil pH and a regional mean annual rainfall range of 700 to 900 millimetres.

Hazard 5: Salinity

The salinity hazard is determined through a range of data and criteria. The recharge potential for the site was determined based on an average annual rainfall of 878 millimetres, with annual evaporation of 1,400 to 1,600 millimetres [3]. This would suggest a moderate recharge potential.

Based on the annual rainfall data (878 millimetres) and an average annual evapotranspiration of 800 to 900 millimetres, a low discharge potential for the site due to a likely balanced rate of water flow. The Study Area according to the Salt Store Map of NSW, is located in an area of low salt store. However, due the current available scale of this mapping, laboratory tested EC_e values were used to determine salt store.

Hazard 6: Water Logging

Water logging was determined by the soils drainage characteristics, specifically field sample evidence of mottling, soil texture attributes as well as slope and climate.

Hazard 7: Shallow Soils and Rockiness

The shallow soils and rockiness hazard is determined by an estimated exposure of rocky outcrops and average soil depth.

Hazard 8: Mass Movement

The mass movement hazard is assessed through a combination of three criteria; mean annual rainfall, presence of mass movement and slope class.

4.3.2 Land and Soil Capability Assessment

Land within the Study Area has been classified into LSC Classes 5 and 6, as listed in **Table 24**.

Table 24 Land and Soil Capability Assessment

Soil Type		LSC Hazard Criteria								
Site	ASC Great Group	1	2	3	4	5	6	7	8	LSC
1	Dystrophic Brown Kurosol	3	2	4	5	1	2	3	1	5
2	Brown Kurosol	4	2	4	5	1	2	3	1	5
3	Brown Kurosol	3	2	4	5	1	2	3	1	5
4	Magnesian Grey Kurosol	3	2	4	5	1	2	3	1	5
5	Grey Kurosol	4	2	4	5	1	2	3	1	5
6	Mesotrophic Yellow Kandosol	6	2	4	5	1	2	6	1	6

Classes 5 and 6 comprised 24 ha and 22 ha of land within the Study Area respectively, as shown in **Figure 9** and **Table 25**. The limitations associated with each LSC Class are discussed below.

Table 25 Land and Soil Capability Areas

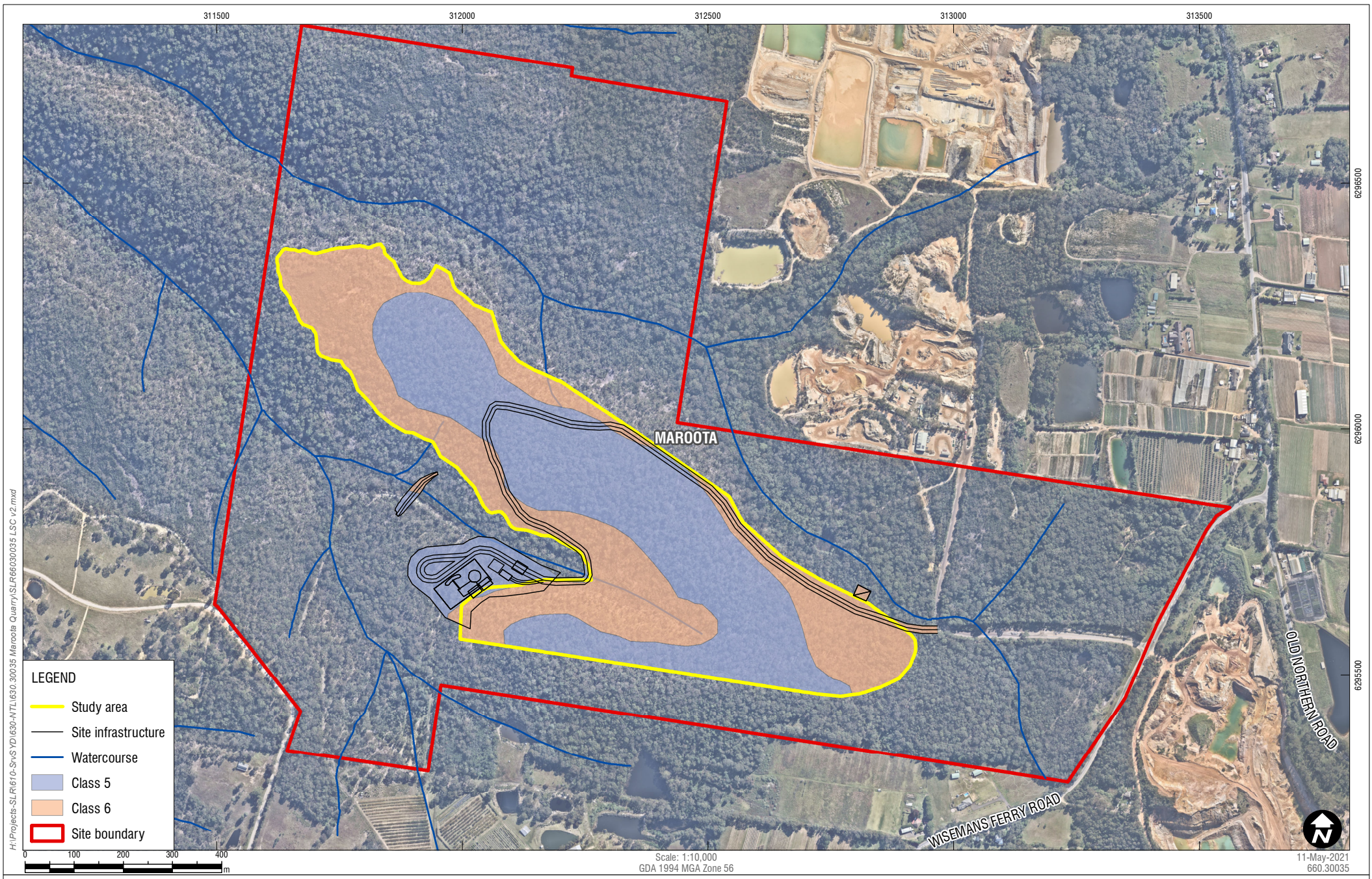
Disturbance eArea	Total area (Ha)	LSC 5	LSC 6
Extraction area	43.7	22.7	21.0
Site infrastructure areas	2.8	2.7	0.2
Access haul road	0.1	0.0	0.1
Surface water dam	0.2	0.1	0.1
Total	46.9	25.5	21.4
Percentage of total area	100%	54%	46%

LSC Class 5 Land

Class 5 land is represented by a Grey-Brown Kurosol on areas of less than 20% slope. This classification indicates a moderate to low land capability, with severe limitations to high impact land management uses such as cropping. This land is generally more suitable for grazing with some limitations, or very occasional cultivation for pasture establishment. The limiting factor for LSC Class 5 within the Study Area is slope with soil acidification. It covers the major portion of the Study Area (54%).

LSC Class 6 Land

Class 6 land is represented by a Grey-Brown Kurosol (with a sub-dominant soil type Yellow Kandosol) on areas of greater than 20% slope. This classification indicates Low capability land with very high limitations for high-impact land uses. The land is considered capable for a limited set of low-impact land uses such as grazing, forestry, nature conservation and some horticulture. Careful management of limitations is required to prevent severe land and environmental degradation. The limiting factors for LSC Class 6 land within the Study Area are shallow soils and rockiness. LSC Class 6 land comprises 46% of the Study Area.



H:\Projects\SLR\610-SWS\YD\630-NTL\630.30035 Maroota Quarry\SLR66030035 LSC v2.mxd

Source: Nearmap (March 2020)

Sheet Size : A4



Land and Soil Capability

FIGURE 9

4.3.3 Surrounding Landuse

Clause 12 of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 [1] stipulates the following:

12 Compatibility of proposed mine, petroleum production or extractive industry with other land uses

Before determining an application for consent for development for the purposes of mining, petroleum production or extractive industry, the consent authority must—

- a. consider—*
 - (i) the existing uses and approved uses of land in the vicinity of the development, and*
 - (ii) whether or not the development is likely to have a significant impact on the uses that, in the opinion of the consent authority having regard to land use trends, are likely to be the preferred uses of land in the vicinity of the development, and*
 - (iii) any ways in which the development may be incompatible with any of those existing, approved or likely preferred uses, and*
- b. evaluate and compare the respective public benefits of the development and the land uses referred to in paragraph (a)(i) and (ii), and*
- c. evaluate any measures proposed by the applicant to avoid or minimise any incompatibility, as referred to in paragraph (a)(iii).*

The proposed quarry is located entirely within native bushland and will not directly or indirectly impact land currently used for agricultural production. There are existing sand quarries located directly to the south, east and north of the proposed quarry. There are orchards and other small-scale horticulture to the south of the proposed quarry which are separated by a minimum 100 metre buffer of native bushland.

5 Summary

The Soil and Land Capability Assessment has been conducted based on the findings of a field investigation and a desktop review of reference information. The findings of this assessment include:

- Soils types within the Study Area are dominated by texture contrast soils and commonly occur with acid and non-sodic characteristics. The soil in the study area are classified as Grey-Brown Kurosols defined by a strongly acidic nature.
- LSC classes range from Class 5 (moderately low capability land) (54%) to Class 6 (low capability land) (46%).
- Surface disturbance associated with the Project will temporarily impact the Grey-Brown Kurosols. This area represents the sites for the extraction, processing and delivery of sand which is approximately 49 ha of the Study Area.
- The areas of LSC Classes temporarily impacted by surface disturbance resulting from the Project are approximately 25.5 ha of LSC Class 5 and 21.4 ha of LSC Class 6.
- The proposed quarry is located entirely within native bushland and will not directly or indirectly impact the soil quality of the surrounding land currently used for agricultural production.

6 References

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- [18] J. Formosa, "Groundwater Springs in the Maroota Area. Bachelor of Applied Science thesis (unpublished)," University of Technology, Sydney, 1998.
- [19] Graham Lee & Associates Pty Ltd, "Investigation of Sand & Sandstone Resources GLA2017-01," Deerubbin Local Aboriginal Land Council, Maroota, 2017.

APPENDIX A

Glossary

Term	Definition																														
A1 horizon	Mineral horizon at or near the surface with some accumulation of humified organic matter, usually darker in colour than underlying horizons and with maximum biological activity for any given soil profile (NCST, 2009)																														
A2 horizon	Mineral horizon having either, alone or in combination, less organic matter, sesquioxides, or silicate clay than immediately adjacent horizons. It is usually differentiated from the A1 horizon by its paler colour (NCST, 2009)																														
Acid soil	Soil with a pH of less than 6.5 (Rayment and Lyons, 2011)																														
Alkaline soil	Soil with a pH greater than 7.4 (Rayment and Lyons, 2011)																														
API	Aerial photograph interpretation																														
Australian Soil Classification (ASC)	This is a multi-category scheme with classes defined on the basis of diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed soil profile (Isbell and NCST, 2016)																														
B horizon	Horizons consisting of one or more mineral soil layers characterised by one or more of the following: a concentration of silicate clay, iron, aluminium, organic material or several of these; a structure and/or consistence unlike that of the A horizons above or of any horizons below; stronger colours, usually expressed as higher chroma and/or redder hue, than those of the A horizons above or of those horizons below (NCST, 2009)																														
Bicarb. or acid extr. P	A measure of available soil phosphorus using a bicarbonate extract or acid extract																														
C horizon	Layers below the solum (AB profile) of consolidated or unconsolidated material, usually partially weathered, little affected by pedogenic processes, and either like or unlike the material from which the solum presumably formed																														
Ca:Mg	Ratios of exchangeable calcium (Ca) to exchangeable magnesium (Mg) are used to support assessments of subsoil dispersibility where Ca:Mg <0.1 are often associated with highly dispersive subsoils. Ca:Mg ratings <table><tr><th>Ratio</th><th>Rating</th></tr><tr><td><0.1</td><td>Very low</td></tr><tr><td>0.1-1</td><td>Low</td></tr><tr><td>1-2</td><td>Medium</td></tr><tr><td>>2</td><td>High</td></tr></table>	Ratio	Rating	<0.1	Very low	0.1-1	Low	1-2	Medium	>2	High																				
Ratio	Rating																														
<0.1	Very low																														
0.1-1	Low																														
1-2	Medium																														
>2	High																														
Cation exchange capacity	CEC is a measure of a soils capacity to hold and exchange cations influenced by factors such as organic matter, clay percentage and clay type and pH. CEC ratings Exchangeable cations classification (Hazelton and Murphy, 2007) <table><tr><th>Cations</th><th>Very low</th><th>Low</th><th>Moderate</th><th>High</th><th>Very high</th></tr><tr><td>Ca (meq/100g)</td><td>0-2</td><td>2-5</td><td>5-10</td><td>10-20</td><td>>20</td></tr><tr><td>Mg (meq/100g)</td><td>0-0.3</td><td>0.3-1.0</td><td>1-3</td><td>3-8</td><td>>8</td></tr><tr><td>K (meq/100g)</td><td>0-0.2</td><td>0.2-0.3</td><td>0.3-0.7</td><td>0.7-2.0</td><td>>2</td></tr><tr><td>Na (meq/100g)</td><td>0-0.1</td><td>0.- 0.3</td><td>0.3-0.7</td><td>0.7-2.0</td><td>>2</td></tr></table>	Cations	Very low	Low	Moderate	High	Very high	Ca (meq/100g)	0-2	2-5	5-10	10-20	>20	Mg (meq/100g)	0-0.3	0.3-1.0	1-3	3-8	>8	K (meq/100g)	0-0.2	0.2-0.3	0.3-0.7	0.7-2.0	>2	Na (meq/100g)	0-0.1	0.- 0.3	0.3-0.7	0.7-2.0	>2
Cations	Very low	Low	Moderate	High	Very high																										
Ca (meq/100g)	0-2	2-5	5-10	10-20	>20																										
Mg (meq/100g)	0-0.3	0.3-1.0	1-3	3-8	>8																										
K (meq/100g)	0-0.2	0.2-0.3	0.3-0.7	0.7-2.0	>2																										
Na (meq/100g)	0-0.1	0.- 0.3	0.3-0.7	0.7-2.0	>2																										
Cultivated	Turning and/or breaking soil into smaller aggregates and aerating it prior to planting crops or pastures using implements such as disc ploughs and tynes																														
Dermosols	ASC Soil Order classification – Soils with structured B2 horizons and lacking strong texture contrast between A and B horizons (Isbell & NCST, 2016)																														

Term	Definition																																				
Electrical conductivity (EC)	Measure of concentration of electrically charged water soluble salts (in a 1:5) soil water suspension. Used to quantify soil salinity																																				
Emerson aggregate (class) test (EAT)	Clay dispersion is semi-quantitatively measured using the Emerson aggregate test. This test measures the instability of soil structure when immersed in water. Definition of Emerson class (AS1289.3.8.1—2006) <table><tr><th>Emerson class</th><th>Definition</th></tr><tr><td>Class 1</td><td>Air-dried crumbs of soil show a strong dispersing reaction, i.e. a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10 min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay</td></tr><tr><td>Class 2</td><td>Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognizable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs</td></tr><tr><td>Class 3</td><td>The soil remoulded at the plastic limit disperses in water</td></tr><tr><td>Class 4</td><td>The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present</td></tr><tr><td>Class 5</td><td>The remoulded soil does not disperse in water and the 1:5 soil/water suspension remains dispersed after 5 min</td></tr><tr><td>Class 6</td><td>The remoulded soil does not disperse in water and the 1:5 soil/water suspension begins to flocculate within 5 min</td></tr><tr><td>Class 7</td><td>The air-dried crumbs of soil remain coherent (do not disperse) in water and swells</td></tr><tr><td>Class 8</td><td>The air-dried crumbs of soil remain coherent (do not disperse) in water and do not swell</td></tr></table>	Emerson class	Definition	Class 1	Air-dried crumbs of soil show a strong dispersing reaction, i.e. a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10 min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay	Class 2	Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognizable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs	Class 3	The soil remoulded at the plastic limit disperses in water	Class 4	The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present	Class 5	The remoulded soil does not disperse in water and the 1:5 soil/water suspension remains dispersed after 5 min	Class 6	The remoulded soil does not disperse in water and the 1:5 soil/water suspension begins to flocculate within 5 min	Class 7	The air-dried crumbs of soil remain coherent (do not disperse) in water and swells	Class 8	The air-dried crumbs of soil remain coherent (do not disperse) in water and do not swell																		
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Fertility	Soil fertility (the capacity of the soil to support plant growth in a given climatic regime) is a function of the physical, chemical, and biological characteristics of the soil. Indices used include organic carbon, cation exchange capacity (CEC), exchangeable cations, nitrate nitrogen, ammonium nitrogen, total Kjeldahl nitrogen (TKN), and available phosphorus (P). Some soil nutrient level ratings from Rayment and Lyons (2011) include: <table><tr><th>Analyte</th><th>Very low</th><th>Low</th><th>Moderate</th><th>High</th><th>Very high</th></tr><tr><td>TKN (%)</td><td><0.05</td><td>0.05-0.15</td><td>0.15-0.25</td><td>0.25-0.5</td><td>>0.5</td></tr><tr><td>Bicarb. & acid extr. P (mg/kg)</td><td><10</td><td>10-20</td><td>>20-40</td><td>>40-100</td><td>>100</td></tr><tr><td>Organic carbon (%)</td><td><0.5</td><td>0.5-1.5</td><td>>1.5-2.5</td><td>>2.5-5.0</td><td>>5.0</td></tr></table> Generally, desired soil nitrate level is 10-50 mg/kg, so the following ratings have been used: <table><tr><th>Analyte</th><th>Very low</th><th>Low</th><th>Moderate</th><th>High</th><th>Very high</th></tr><tr><td>Nitrate N (mg/kg)</td><td><1</td><td>1-5</td><td>5-10</td><td>10-50</td><td>>50</td></tr></table>	Analyte	Very low	Low	Moderate	High	Very high	TKN (%)	<0.05	0.05-0.15	0.15-0.25	0.25-0.5	>0.5	Bicarb. & acid extr. P (mg/kg)	<10	10-20	>20-40	>40-100	>100	Organic carbon (%)	<0.5	0.5-1.5	>1.5-2.5	>2.5-5.0	>5.0	Analyte	Very low	Low	Moderate	High	Very high	Nitrate N (mg/kg)	<1	1-5	5-10	10-50	>50
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Analyte	Very low	Low	Moderate	High	Very high																																
Nitrate N (mg/kg)	<1	1-5	5-10	10-50	>50																																
Gravel	Soil particles in the size range >2.0-60 mm (NCST, 2009)																																				
Gully erosion	A wide and deep incision into topsoil and subsoil layers resulting from erosion by expansion of rill erosion and/or collapse of tunnel erosion																																				
Horizon	A layer within the soil profile with morphological characteristics and properties different from layers below and /or above it																																				

Term	Definition																																							
Mottles	The presence of more than one soil colour in the same soil horizon, not including segregations or cutan colours																																							
Ped	An individual natural soil aggregate consisting of a cluster of primary particles. Ped faces may have limited to much accommodation to the faces of surrounding peds																																							
Permian	Period of geological time that spans 47 million years from the end of the Carboniferous period 298.9 million years ago (Mya) to the beginning of the Triassic period 251.902 Mya																																							
Project site	The affected ROWs on land identified as Lot 2 on SP295959 and Lot 5 on AB50 and largely along the eastern boundary within the Nullin” property, adjacent to Potters Flat Road																																							
Quaternary	Period of geological time including the Holocene and Pleistocene; up to approx. 2 million years BP																																							
Rill erosion	A narrow and shallow incision into topsoil layers resulting from erosion by overland flow or surface runoff																																							
Ripping	Deep cultivation with a tyned implement to a depth of >300 mm																																							
Scarifying	Shallow cultivation usually with a tyned implement to a depth of <300 mm																																							
Sheet erosion	The removal of a thin layer of soil by raindrop splash and runoff																																							
Silt	Fine soil particles in the size range 0.02-0.002 mm (NCST, 2009)																																							
Salinity	Salinity is the presence of soluble salts in soils, mainly Ca²⁺, Mg²⁺, Na⁺, Cl⁻, SO₄²⁻ and HCO₃. Salinity ratings (Rayment and Lyons, 2011) <table><tr><th rowspan="2">Soil salinity rating</th><th colspan="4">EC _{1:5} (dS/m)</th></tr><tr><th>10-20% clay</th><th>20-40% clay</th><th>40-60% clay</th><th>60-80% clay</th></tr><tr><td>Very low</td><td><0.07</td><td><0.09</td><td><0.12</td><td><0.15</td></tr><tr><td>Low</td><td>0.07-0.15</td><td>0.09-0.19</td><td>0.12-0.24</td><td>0.15-0.3</td></tr><tr><td>Medium</td><td>0.15-0.34</td><td>0.19-0.45</td><td>0.24-0.56</td><td>0.3-0.7</td></tr><tr><td>High</td><td>0.34-0.63</td><td>0.45-0.76</td><td>0.56-0.96</td><td>0.7-1.18</td></tr><tr><td>Very high</td><td>0.63-0.93</td><td>0.76-1.21</td><td>0.96-1.53</td><td>1.18-1.87</td></tr><tr><td>Extreme</td><td>>0.93</td><td>>1.21</td><td>>1.53</td><td>>1.87</td></tr></table>	Soil salinity rating	EC _{1:5} (dS/m)				10-20% clay	20-40% clay	40-60% clay	60-80% clay	Very low	<0.07	<0.09	<0.12	<0.15	Low	0.07-0.15	0.09-0.19	0.12-0.24	0.15-0.3	Medium	0.15-0.34	0.19-0.45	0.24-0.56	0.3-0.7	High	0.34-0.63	0.45-0.76	0.56-0.96	0.7-1.18	Very high	0.63-0.93	0.76-1.21	0.96-1.53	1.18-1.87	Extreme	>0.93	>1.21	>1.53	>1.87
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Sand	Fine soil particles in the size range 0.02-2.0 mm, where fine sand ranges from 0.02-0.2 mm and coarse sand ranges from 0.2-2.0 mm (NCST, 2009)																																							
Sodic soil/sodicity	Sodicity is a measure of exchangeable sodium (Na) in proportion to other exchangeable cations. Fine earth material with an exchangeable sodium percentage (ESP) of 6 or greater is defined as sodic. Sodicity/ESP ratings (Northcote and Skene, 1972) <table><tr><th>Sodicity rating</th><th>ESPs proposed for Australian soils (%)</th></tr><tr><td>Non-sodic</td><td>0-6</td></tr><tr><td>Sodic</td><td>6-15</td></tr><tr><td>Strongly sodic</td><td>>15</td></tr></table>	Sodicity rating	ESPs proposed for Australian soils (%)	Non-sodic	0-6	Sodic	6-15	Strongly sodic	>15																															
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Strongly sodic	>15																																							
Sodosols	ASC Soil Order – Soils with strong texture contrast between A horizons and sodic B horizons, which are not strongly acid (Isbell & NCST, 2016)																																							
Soil horizon	A soil horizon is a layer of soil, approximately parallel to the surface, with morphological properties different from layers below and/or above it																																							

Term	Definition																				
Soil pH (1:5 soil:water)	Soil pH can be used as an indicator of the chemical processes that occur in a soil – that is, can indicate certain nutrient deficiencies and toxic effects, which may have implications for soil management and rehabilitation measures. pH classification (Rayment and Lyons, 2011) <table> <tr> <th>pH (1:5 soil:water)</th><th>Rating</th></tr> <tr> <td>> 9.0</td><td>Very strongly alkaline</td></tr> <tr> <td>9.0 – 8.5</td><td>Strongly alkaline</td></tr> <tr> <td>8.4 – 7.9</td><td>Moderately alkaline</td></tr> <tr> <td>7.8 – 7.4</td><td>Mildly alkaline</td></tr> <tr> <td>7.3 – 6.6</td><td>Neutral</td></tr> <tr> <td>6.5 – 6.1</td><td>Slightly acid</td></tr> <tr> <td>6.0 – 5.6</td><td>Moderately acid</td></tr> <tr> <td>5.5 – 5.1</td><td>Strongly acid</td></tr> <tr> <td>5.0 – 4.5</td><td>Very strongly acid</td></tr> </table>	pH (1:5 soil:water)	Rating	> 9.0	Very strongly alkaline	9.0 – 8.5	Strongly alkaline	8.4 – 7.9	Moderately alkaline	7.8 – 7.4	Mildly alkaline	7.3 – 6.6	Neutral	6.5 – 6.1	Slightly acid	6.0 – 5.6	Moderately acid	5.5 – 5.1	Strongly acid	5.0 – 4.5	Very strongly acid
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7.3 – 6.6	Neutral																				
6.5 – 6.1	Slightly acid																				
6.0 – 5.6	Moderately acid																				
5.5 – 5.1	Strongly acid																				
5.0 – 4.5	Very strongly acid																				
Soil structure	Soil structure refers to the distinctness, size, and shape of natural soil aggregates																				
Soil texture (field)	The size distribution of particles finer than 2 mm as reflected in the behaviour of a small handful of soil when moistened and kneaded into a ball																				
Subsoil	Subsoil is a commonly used term used to identify soil material below the topsoil (A horizons) and is usually comprised of B horizons																				
Tenosols	ASC Soil Order – Soils with generally only weak pedologic organisation apart from the A horizons (Isbell & NCST, 2016)																				
Tertiary	Geological period approx. 65-2.0 Mya																				
Topsoil	Topsoil is a commonly used term to identify soil horizons designated as A horizon(s). It is described as the mineral horizon at or near the soil surface with some accumulation of humified organic matter. It is usually darker in colour than underlying horizons with maximum biologic activity for any given soil profile. For the purposes of this document, topsoil is defined as that proportion of the soil profile that is suitable for stockpiling and rehabilitation. Topsoil thickness classification (Maher, 1996) <table> <tr> <th>Horizon thickness (mm)</th><th>A horizon thickness rating</th></tr> <tr> <td><150</td><td>Thin</td></tr> <tr> <td>150-300</td><td>Medium</td></tr> <tr> <td>300-600</td><td>Thick</td></tr> <tr> <td>>600</td><td>Very thick</td></tr> </table>	Horizon thickness (mm)	A horizon thickness rating	<150	Thin	150-300	Medium	300-600	Thick	>600	Very thick										
Horizon thickness (mm)	A horizon thickness rating																				
<150	Thin																				
150-300	Medium																				
300-600	Thick																				
>600	Very thick																				
Vertosols	ASC Soil Order – Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates (Isbell & NCST, 2016)																				

APPENDIX B

Laboratory Certificates of Analysis

ASIA PACIFIC OFFICES

BRISBANE

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