



**Mount Owen Continued
Operations Project**

SOIL ASSESSMENT

FINAL

October 2014

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Prepared by
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on behalf of
Mount Owen Continued Operations

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APPENDICES

1 Laboratory Test Results

1.0 Introduction

The Mount Owen Continued Operations Project (the Project) proposes to extend the life of the current Mount Owen open cut coal operation for 12 years from 2018 to 2030. This will involve an extension to the existing North Pit towards the south-east as well as upgrades to some rail and road infrastructure. The Project includes a Proposed Disturbance Area (**Figure 1.1**) covering a total of 485 hectares with three separate components. These include:

- an upgrade to the southern end of Hebden Road with a rail overpass over the existing Northern Rail Line and a two-way bridge across Bowmans Creek to improve safety for road users (13.1 hectares);
- an upgrade to the existing Mount Owen rail spur with an additional line and northern turnout to allow more efficient train storage and movements (91.4 hectares); and
- continuation of the existing mining operations within the North Pit to the south beyond the current approved North Pit shell (approximately 380.5 hectares).

The Project also includes two off-site biodiversity offset properties that are currently partially used for agricultural production. These are the property 'Esparanga' (303.2 hectares), located between Muswellbrook and Denman and the property 'Cross Creek' (367.4 hectares) located on the northern boundary of the Project Area (refer to **Figure 1.2**).

Umwelt (Australia) Pty Limited has undertaken a detailed assessment of the soils and the associated land and soil capability of the land directly affected by the Project (the Proposed Disturbance Area). This forms part of the Agricultural Impact Statement (AIS) which is an integrated component of the environmental impact assessment process required for the approval of the Project. The soils assessment included a review of past soil surveys and soil mapping undertaken within the existing mine lease as well as a detailed soil survey undertaken across the Proposed Disturbance Area.

The objectives of this detailed soil assessment of the Proposed Disturbance Area were to:

- describe, classify and map the soil types;
- assess the land and soil capability to determine the potential agricultural value and limitations;
- verify the mapping of Biophysical Strategic Agricultural Land (BSAL) identified in the *Strategic Regional Land Use Plan Upper Hunter* (Upper Hunter SRLUP) (DP&I 2012b) (refer to **Figure 1.3**);
- analyse the suitability of the soils for use in rehabilitation; and
- provide baseline data on the physical and chemical fertility of the soils for potential use in future rehabilitation monitoring.

This report describes the methodology of the soil survey and presents the results of the soil assessment of the Proposed Disturbance Area.

1.1 Offsets and Surrounding Areas

The biodiversity offset properties have been assessed in the main body of the AIS using existing regional scale mapping of soil type, fertility, slope and land and soil capability, as



FIGURE 1.1
Locality Plan

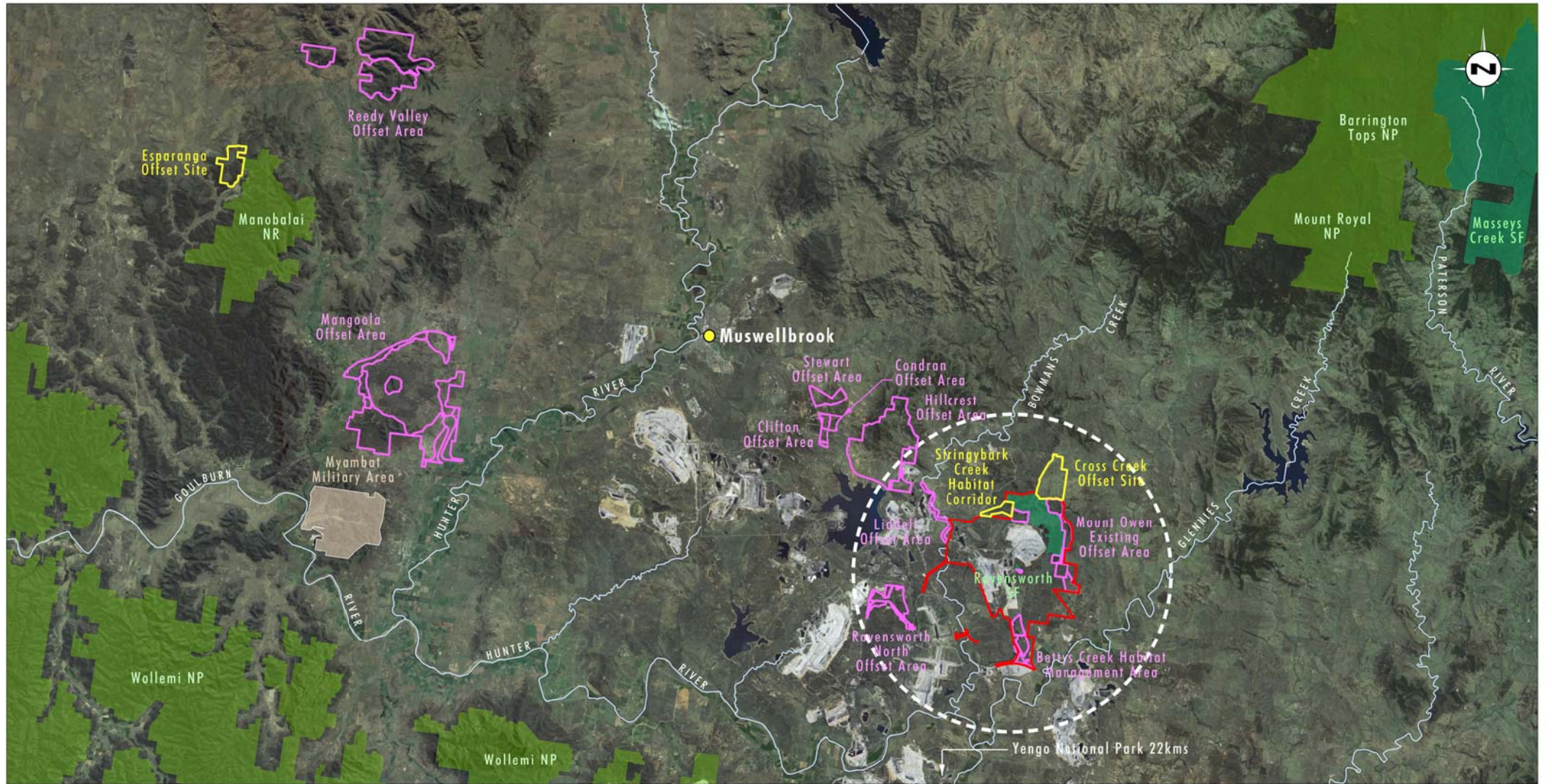
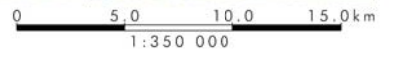


Image Source: Google Earth (2009)
 Data Source: Department of Lands (2003), LPI (2012), OEH (2013), State of NSW (2013), Mount Owen (2014)

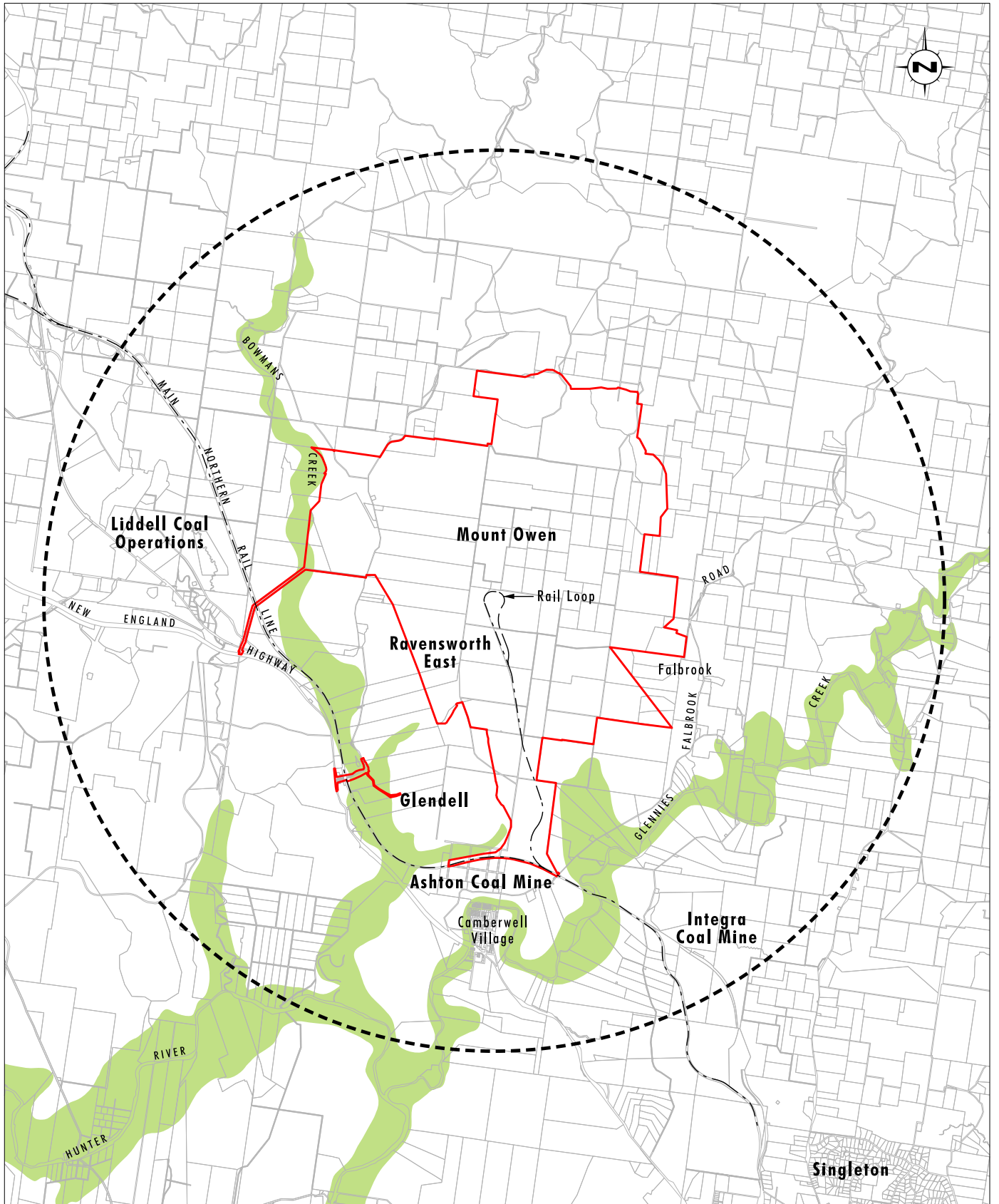


Legend

- Project Area
- Existing Glencore Offsets
- Proposed Mount Owen Offsets
- National Park/Nature Reserve (NP/NR)
- State Forest (SF)
- Crown Reserve
- Mount Owen Complex Locality (10km Radius from Rail Loop)

File Name (A4): R08/APP1/3109_929.dgn
 20140926 10.33

FIGURE 1.2
Mount Owen Complex Locality
Regional Setting



Data Source: Mount Owen (2014)
 BSAL: OEH (2011)
 Note: Absence of critical industry clusters is due to their not being mapped as occurring within the locality.

0 2.0 4.0 6.0km
 1:120 000

Legend

- Project Area
- Mount Owen Complex Locality (10km Radius from Rail Loop)
- Biophysical Strategic Agricultural Land (BSAL)

FIGURE 1.3

**Potential Biophysical Strategic
 Agricultural Land and Critical Industry
 Clusters - Upper Hunter SRLUP Mapping**

well as localised vegetation mapping, to determine potential agricultural value and/or limitations.

2.0 Soil Survey and Assessment Methodology

2.1 Personnel

The soil survey and assessment were prepared by Umwelt staff, Rachel Rummery and Pam Dean-Jones, qualified and experienced in natural resources, soils and agriculture. The survey design, field methods, soil recording and report were peer reviewed by Mr Peter Fogarty, Principal of Soil and Land Conservation Consulting, who is a Certified Practising Soil Scientist Level 3 with the Australian Society of Soil Science Australia.

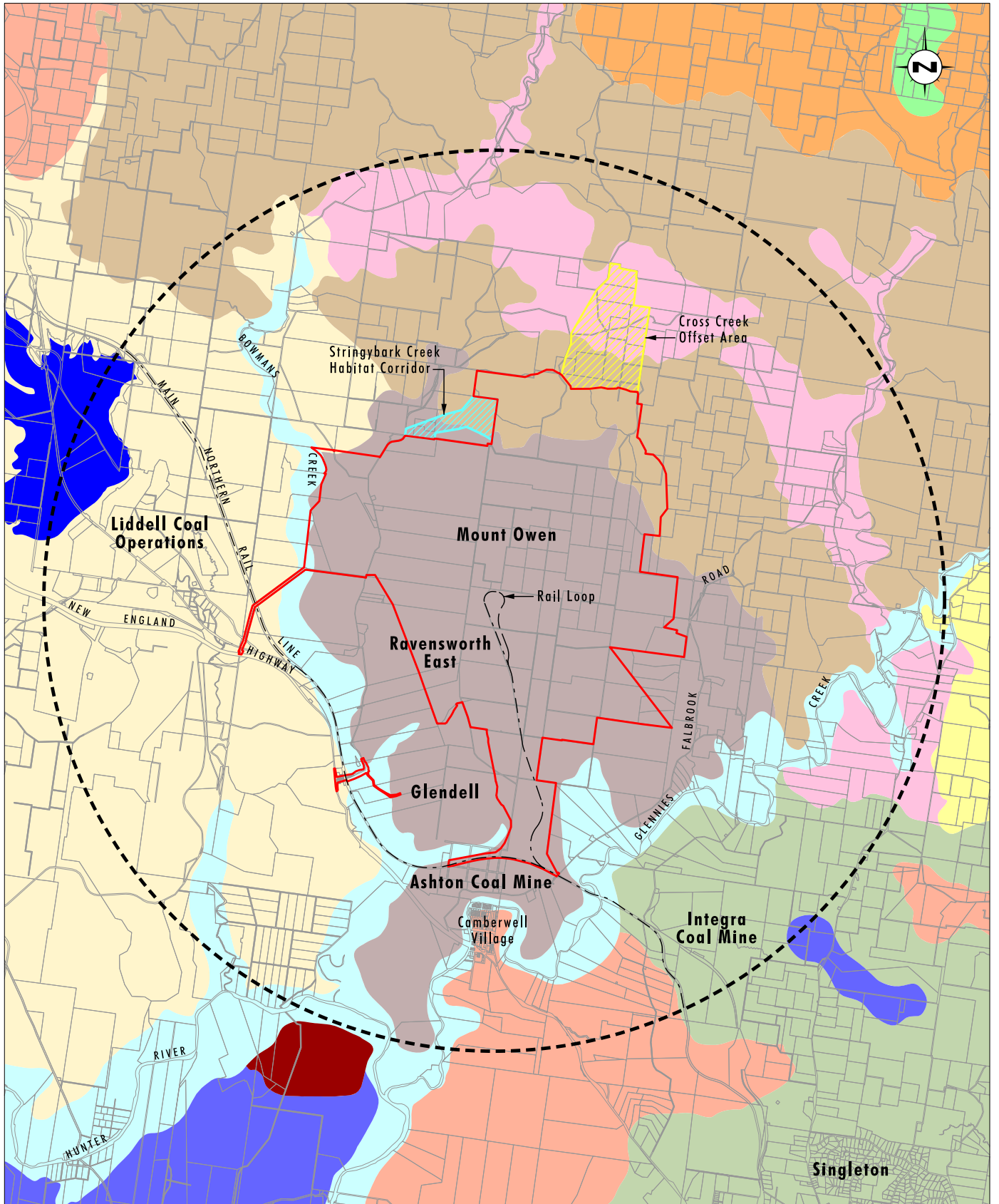
Mr Fogarty participated in part of the field survey and assisted with soil profile descriptions and soil identification.

2.2 Reference Map and Desktop Review

Initially a desk top assessment of the soils and other features in the Project Area¹ was conducted using:

- aerial photos;
- topographic maps at 1:25,000 scale;
- the *Soil Landscapes of the Singleton 1:250,000 Sheet* (Kovac and Lawrie 1991) (refer to **Figure 2.1**);
- *Strategic Regional Land Use Policy: Guideline for Agricultural Impact Statements* (DP&I 2012a), the *Agricultural Impact Statement: Technical Notes* (DPI 2013) the *Upper Hunter Strategic Regional Land Use Plan* (Upper Hunter SRLUP) (DP&I 2012b), the *Land and Soil Capability Assessment Scheme; Second Approximation* (OEH 2012) and the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH and OASFS 2013) to define and explain information required about soils and soil landscapes to meet the NSW Government expectations for agricultural impact assessment and appropriate protocol for the identification and verification of strategic agricultural land;
- land and soil capability mapping and fertility mapping prepared by the NSW Office of Environment and Heritage (OEH) (OEH 2012, OEH and OASFS 2013);
- BSAL maps from the Upper Hunter SRLUP (DP&I 2012b); and
- soil survey, soil sampling and analysis technical references (refer to **Table 2.1**) as specified in the DPI guidelines and technical notes (noted above).

¹ For the purpose of the AIS, the Project Area is the area which will be covered by the Development Application. It encompasses the currently approved development consent areas for the Mount Owen Mine and Ravensworth East Mine as well as the Proposed Disturbance Area described in **Section 1.0**.



Data Source: Mount Owen (2014)
 Soil Landscapes: NSW Department of Environment,
 Climate Change and Water (DECCW) (2010)

0 2.0 4.0 6.0 km
 1:120 000

Legend

- | | | | |
|--|--|--|---|
| Project Area | Soil Landscapes: | Roxburgh | Jerrys Plains |
| Mount Owen Complex Locality
(10km Radius from Rail Loop) | Hunter | Sedgfield | |
| Cross Creek Offset Area | Rosevale | Water | |
| Stringybark Creek Habitat Corridor | Greenland | Branxton | |
| | Bayswater | Scrumlo | |
| | Lambs Valley | Lethbridge | |
| | Bridglands | | |

FIGURE 2.1

Regional Soil Landscapes

Table 2.1 - Soil Survey, Soil Sampling and Analysis Technical References

Aspect	Requirements Set Out in Reference
Soil sampling and survey	McKenzie, N.J., Grundy, M.J., Webster, R., Ringrose-Voase, A.J. (2008). <i>Guidelines for Surveying Soil and Land Resources</i> , 2nd ed. CSIRO Publishing, Victoria, Australia.
Soil classification	Isbell, R.F. (2002). <i>The Australian Soil Classification</i> . CSIRO Australia, Collingwood, VIC.
Soil physical measurements	McKenzie, N., Coughlan, K., & Resswell, H. (2002). <i>Soil physical measurement and interpretation for land evaluation</i> . Collingwood, Australia: CSIRO Publishing.
Soil chemical measurements	Rayment, G. E., and Lyons, D. J. (2011). <i>Soil Chemical Methods: Australasia</i>
Land and Soil Capability	Office of Environment and Heritage (OEH). (2012). <i>The Land and Soil Capability Assessment Scheme; Second Approximation</i> .
BSAL verification	OEH and OASFS, 2013

The review of mapping and documentation provided an overview of the land and soil characteristics of the Project Area and highlighted locations where detailed soil survey and verification assessment were required. It also informed the detailed survey design.

In developing the field survey plan, the following were also taken into account:

- a detailed LIDAR slope analysis, using 2012 data (refer to **Figure 2.2**) undertaken across the Project Area to identify correlations between landform elements and soil types to assist with land and soil capability mapping, BSAL verification and soil distribution;
- identification of areas of environmental and cultural significance. These were not physically sampled but observations of conditions were made in the field; and
- identification of significant areas of prior site disturbance or current infrastructure for exclusion from the soil survey.

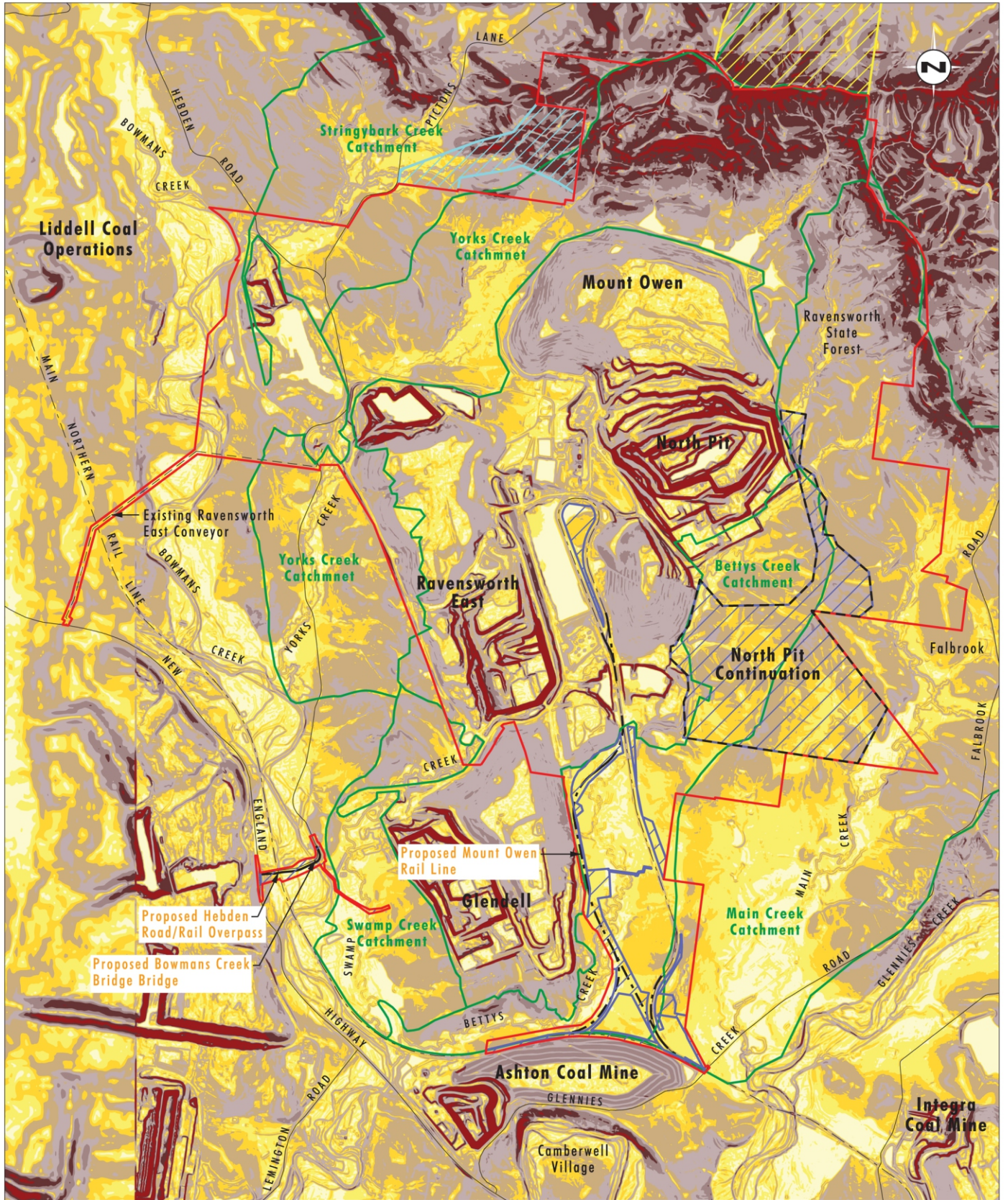
2.3 Field Survey

2.3.1 Survey Design

The field survey of the Proposed Disturbance Area was a comprehensive soil survey conducted in accordance with the *Guidelines for Surveying Soil and Land Resources* (McKenzie *et. al.* 2008). Detailed descriptions of full soil profiles, laboratory analyses of surface and subsoil samples and observations of sites were combined to provide an integrated quantitative soil survey of the Proposed Disturbance Area.

The soil survey was undertaken in September 2012, July 2013 and June 2014.

The soil survey was conducted at a scale of 1:25,000 with the location and type of samples and observations presented in **Figure 2.3** and summarised below in **Table 2.2**. A total of 41 sites were assessed. In addition, the three visits to the Proposed Disturbance Area involved significant driving between soil sampling sites which enabled observations of slopes, vegetation types and landform features to confirm soil mapping.



Data Source: Mount Owen (2014)

0 1 2 3km
1:60 000

Legend

- | | | |
|--|---|---|
| Project Area | Slope Class: | > 50% |
| Proposed North Pit Continuation | < 1% | 1-3% |
| Proposed Rail Upgrade Works | 3-5% | 5-10% |
| Proposed Hebden Road Upgrade Works | 10-20% | 20-33% |
| Proposed Disturbance Area | 33-50% | |
| Cross Creek Offset Area | | |
| Stringybark Creek Habitat Corridor | | |
| Catchment Boundary | | |

FIGURE 2.2
Existing Landforms and Slopes

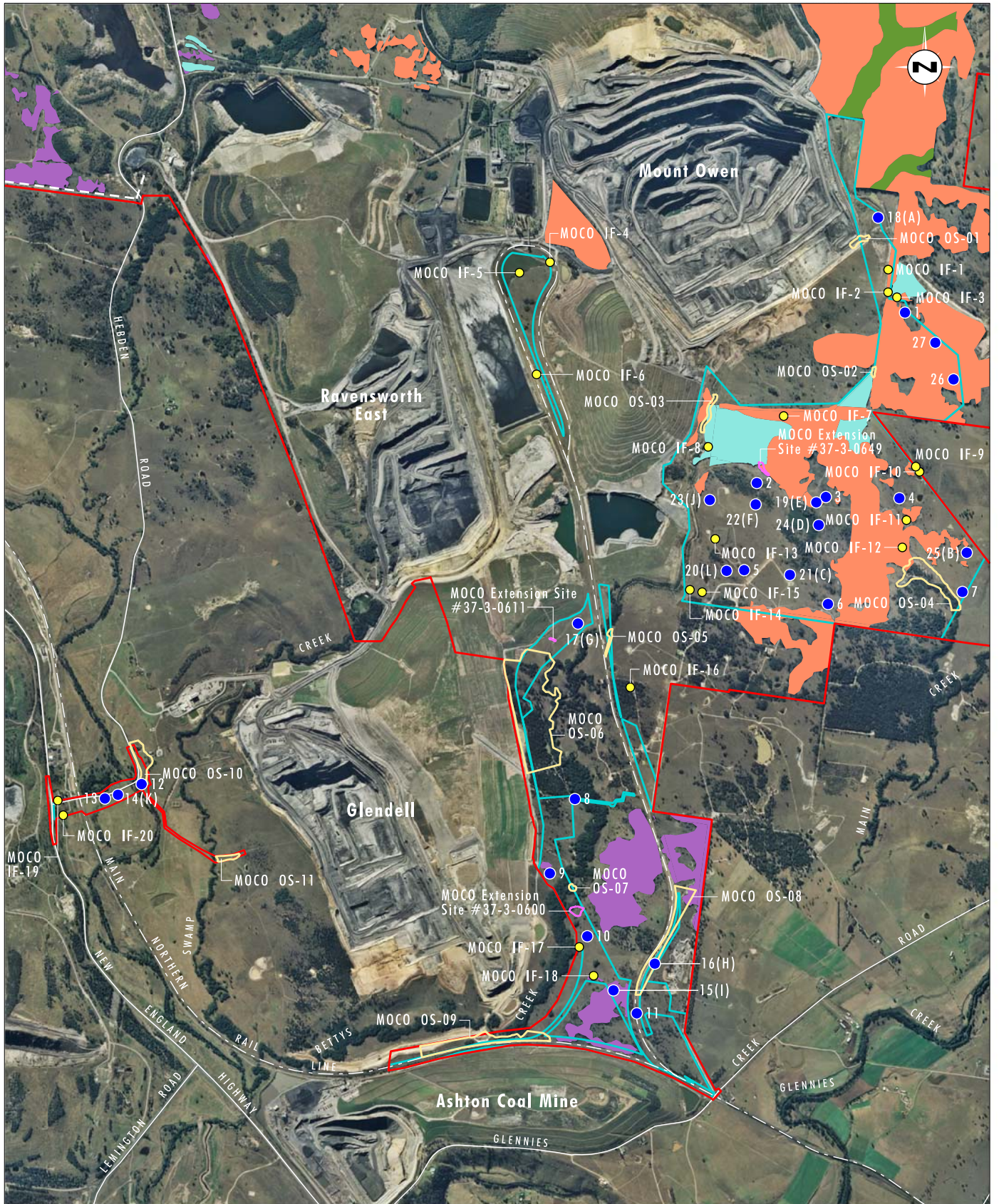


Image Source: Mount Owen (2013)
 Data Source: Mount Owen (2014), OzArk (2013)

0 0,5 1,0 2,0 km
 1:40 000

Legend

- ▭ Project Area
- ▭ Proposed Disturbance Area
- ▭ Artefact Scatter
- ▭ Extensions to Previously Recorded Sites
- Isolated Find
- Soil Sampling Site
- ▭ Central Hunter Grey Box - Ironbark Woodland (EEC)
- ▭ Hunter Lowlands Red Gum Forest (EEC)
- ▭ Planted Ironbark - Spotted Gum - Grey Box Forest (EEC)
- ▭ Central Hunter Ironbark - Spotted Gum - Grey Box Forest (EEC)

FIGURE 2.3

Soil Sampling Areas of Exclusion

The Proposed Disturbance Area covers three soil landscapes, the Hunter, Bayswater and Liddell Soil Landscapes (Kovac and Lawrie 1991). The small area of the Liddell Soil Landscape on the western edge of the Hebden Road upgrade site was excluded from sampling due to significant disturbance of the site in association with the New England Highway, the Main Northern Railway Line and the Ravensworth Village (refer to **Figure 2.3**).

Table 2.2 – Soil Survey Observations and Density

Proposed Disturbance Area	Area (ha)	Soil Landscape, Land and Soil Capability (LSC) Class (Desktop)	Shallow Shovel Pit Sites	Number of Soil Auger Sites	Number of Laboratory Analysis Sites (includes samples from auger sites and shallow shovel pits)	Number of Mapping Observation Sites
Hebden Road Upgrade	13.1	Hunter, Liddell LSC Class 3	2 12, 13	1 Site 14 (K)	3 Sites 12 to 14 (K)	3
Rail Spur Extension	91.4	Bayswater LSC Class 4 and 5	4 8, 9, 10, 11	3 Sites 15 (I) - 17 (G)	5 Sites 8-11, 17 (G)	3
North Pit Continuation	380.5	Bayswater LSC Class 4 to 7	7 1-7	10 Sites 18 (A) - 27	13 Sites 1-7, 22 (F) - 27	4
TOTAL	485	-	13	14	21	9

2.3.2 Detailed Soil Profile Descriptions

Soil cores were dug with a 100 millimetre hand auger to approximately 750 millimetres, or to bedrock if shallower, and were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST 2009). Detailed soil profile morphological descriptions recorded the parameters specified in **Table 2.3**. All soil profiles were recorded on standard Soil and Land Information System (SALIS)² forms and have been submitted to the SALIS database. Copies of all soil record forms can be provided if required.

² SALIS provides descriptions of soils, landscapes and other geographic features and is used to improve planning and decision-making related to land management.

Table 2.3 – Soil Profile Description Parameters

Descriptor	Application
Horizon depth	Weathering characteristics, soil development, fertility
Field colour	Permeability, aeration, susceptibility to dispersion / erosion
Mottles – presence, colour	Permeability, aeration
Field texture – A and B horizon	Erodibility, hydraulic conductivity, permeability, water holding capacity, root penetration
Horizon boundary distinctness	Erosional/depositional status, textural grade, identification of Australian Soil Classification
Consistence force	Structural stability, dispersion, ped formation
Structural pedality grade	Soil structure, root penetration, permeability, aeration
Ped type and size	Soil structure, root penetration, permeability, aeration
Gravel – presence, quantity, size	Water holding capacity, erosional/depositional character, permeability, root penetration
Field pH – A and B horizon	Identification of Australian Soil Classification
Roots – presence, depth	Effective rooting depth

2.3.3 Soil Laboratory Assessment

A total of 21 topsoil samples (0 to 10 centimetres) and 19 subsoil samples (approx 20 to 30 centimetres) were collected for analysis by the NATA accredited Soil Conservation Service Laboratory at the Scone Research Centre. A range of physical and chemical tests to characterise the inherent fertility, stability/erodibility, salinity and pH of the soils were undertaken.

The tests conducted are outlined in **Table 2.4**. These tests have also informed the classification of the soils based on the Australian Soil Classification which requires characterisation of both the A and B horizons of the soil, particularly in the case of duplex soil types. The samples chosen for laboratory analysis were representative of the different soil types encountered while soil coring.

Table 2.4 – Laboratory Analysis Tests

A Horizon (0-10 cm) – Sites 1 to 13	B Horizon (10-20cm) – Sites 1 to 11 and 13
pH (water and CaCl ₂)	pH (water and CaCl ₂)
Cation Exchange Capacity (me/100g)	
Exchangeable Sodium, Potassium, Calcium, Magnesium, Aluminium (me/100g)	
Available Phosphorus (mg/kg)	
Emerson Aggregate Test	Emerson Aggregate Test
Texture	Texture
A Horizon (0-10cm) – Sites 14 (K), 17 (G), 18 (A), 22 (F), 23 (J), 24 (D), 25 (B), 26 and 27	B2 Horizon (approx 20-30 cm) – Sites 14 (K), 17 (G), 18 (A), 22 (F), 23 (J), 24 (D), 26 and 27
All tests as above plus:	All tests as above plus:
Organic Carbon (Walkley Black)	Cation Exchange Capacity and Exchangeable Cations (me/100g)

NB: The Walkley Black test for Organic Carbon was used following consultation with staff of DPI.

The Certified Analyses of the soil samples are provided in **Appendix AA**. The Exchangeable Sodium Percentage (ESP) and the Calcium:Magnesium Ratio were calculated from the test results also provided in **Appendix AA**.

2.3.4 Mapping Observations

Mapping observations consisted of:

- examining existing exposed cuttings of soil profiles including eroded gullies, track cuts and pipeline cuts; and
- surface observations located between full profile description sites.

In addition, observations of landform, vegetation and rock outcrops were made to confirm soil mapping boundaries.

2.4 Soil Classification

The Australian Soil Classification (ASC) system (Isbell 1996) and nomenclature was used for identifying and naming the soils in this survey.

3.0 Soil Survey Results

Four different soil types were identified in the Proposed Disturbance Area. **Figures 3.1, 3.2 and 3.3** illustrate the distribution of the three soil types across the Proposed Disturbance Area.

Rudosols associated with the Hunter soil landscape are the dominant soil type in the Hebden Road upgrade section of the Proposed Disturbance Area. Rudosols also occur in the south-eastern part of the Proposed Disturbance Area associated with the tributaries of Main Creek. Sodosols associated with the Bayswater Soil Landscape are the dominant soil types in the Rail Spur extension and North Pit extension Proposed Disturbance Areas. There is also an area of Kurosols along the eastern edge of the North Pit Continuation area. **Table 3.1** summarises the areas occupied by each soil type. Overall, the Proposed Disturbance Area is dominated by Brown Sodosol soils.

Table 3.1 – Overview of Soil Types in the Proposed Disturbance Area

Soil Type		Soil Landscape	Land Area	
			Hectares	Percentage (%)
1	Stratic Rudosol	Hunter, Bayswater	15.8	3.2
2	Clastic Rudosol	Hunter, Bayswater	2.7	0.6
3	Brown Sodosol	Bayswater	461.8	95.2
4	Brown Kurosol	Bayswater	4.7	1.0
Total			485	100

Representative soil samples for each soil type are described in **Sections 3.1, 3.2, 3.3 and 3.4**.

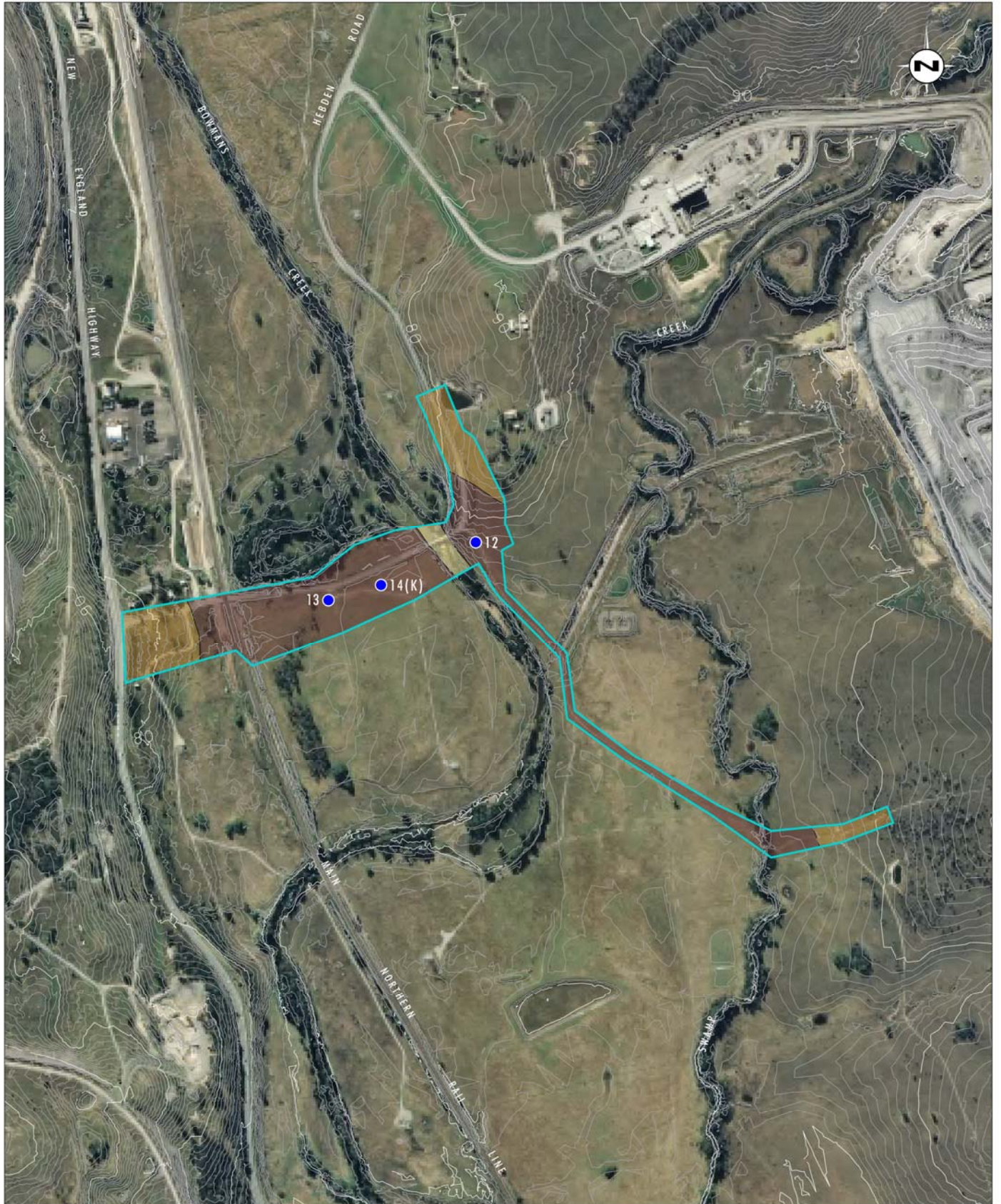


Image Source: Mount Owen (2013)
 Data Source: Mount Owen (2014)
 Note: Contour Interval 1m

0 100 250 500m
 1:10 000

Legend

- Proposed Disturbance Area
- Brown Sodosol
- Clastic Rudosol
- Stratic Rudosol
- Soil Sampling Site

FIGURE 3.1

Proposed Hebden Road Upgrade Works Area - Soil Types

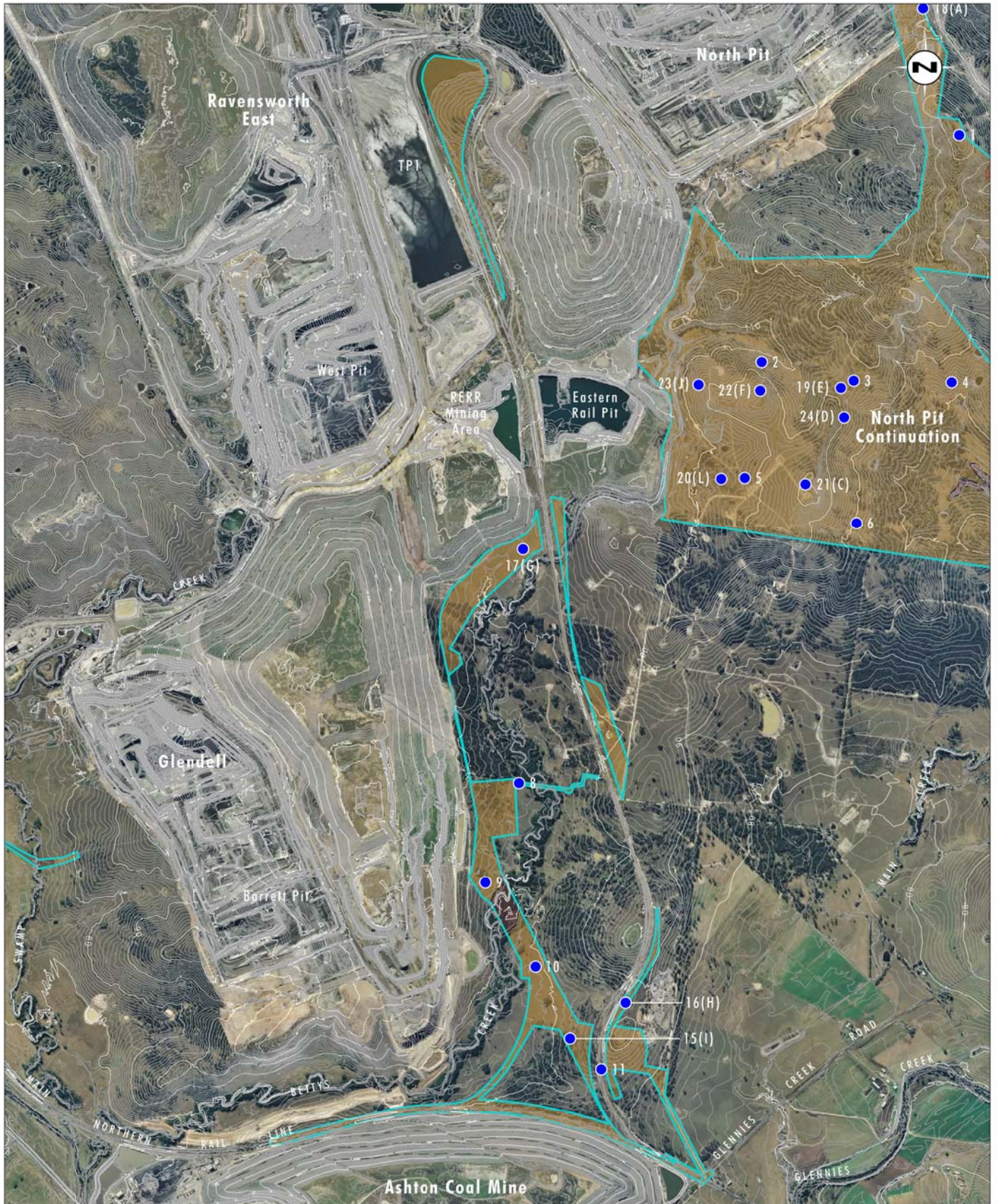


Image Source: Mount Owen (2013)
 Data Source: Mount Owen (2014)
 Note: Contour Interval 1m

0 0.5 1.0 1.5 km
 1:30 000

Legend

- Proposed Disturbance Area
- Brown Kurosol
- Brown Sodosol
- Stratic Rudosol
- Soil Sampling Site

FIGURE 3.2
Proposed Rail Upgrade
Works Area - Soil Types

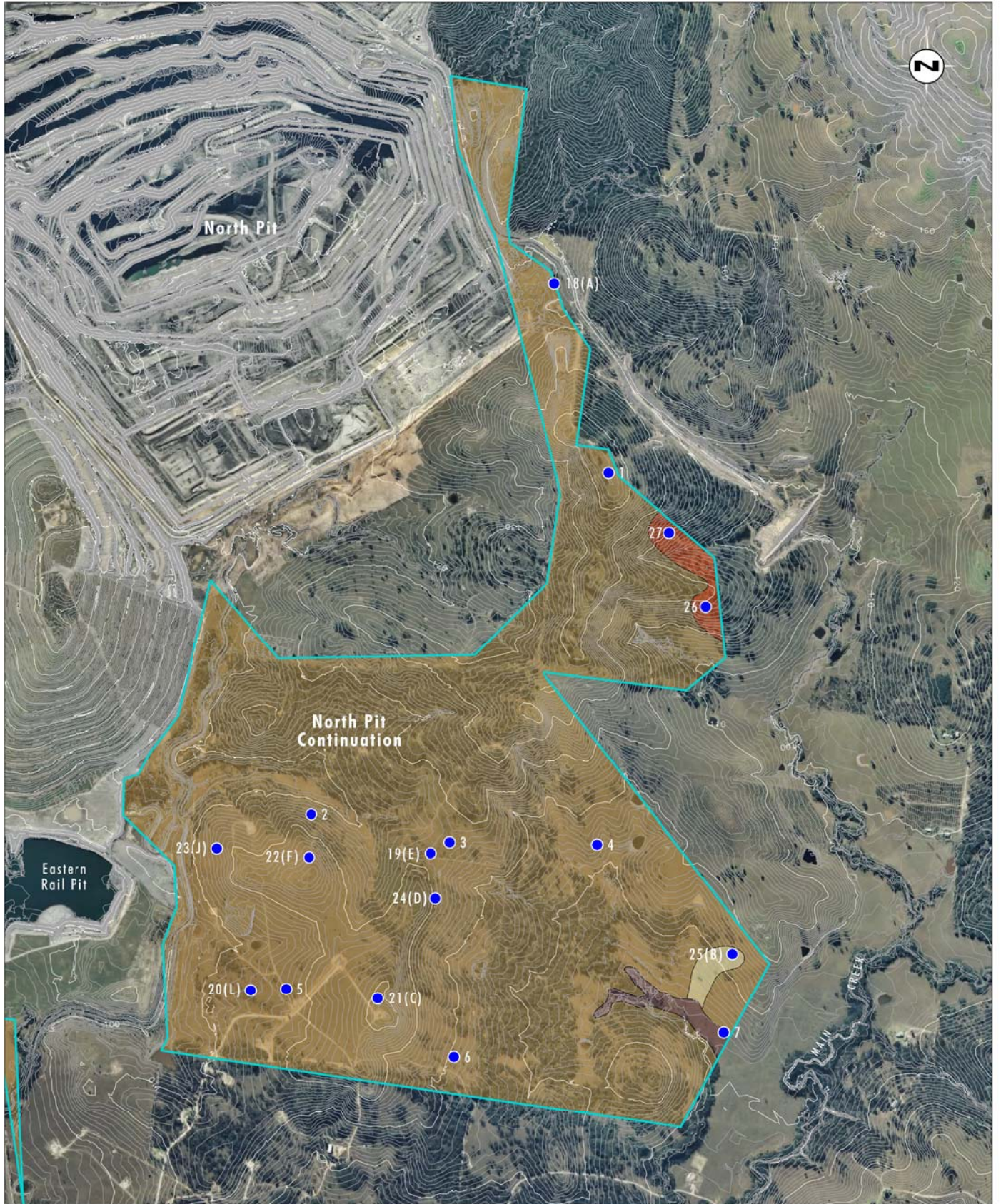


Image Source: Mount Owen (2013)
 Data Source: Mount Owen (2014)
 Note: Contour Interval 1m

0 0.25 0.5 1.0km
 1:20 000

Legend

- Proposed Disturbance Area
- Brown Kurosol
- Brown Sodosol
- Clastic Rudosol
- Stratic Rudosol
- Soil Sampling Site

FIGURE 3.3

Proposed North Pit Continuation Area - Soil Types

3.1 Soil Type 1 – Stratic Rudosol

Table 3.2 summarises the profile characteristics of Stratic Rudosol soils in the Proposed Disturbance Area. Stratic Rudosols cover approximately 15.8 hectares of the Proposed Disturbance Area. These soils are young depositional alluvial soils associated with the Bowmans Creek terrace in the west of the Proposed Disturbance Area (Hebden Road upgrade) and the drainage lines draining into Main Creek in the south-eastern part of the Proposed Disturbance Area (North Pit extension).

The soil profile is characterised by well drained, weakly structured fine sandy loam topsoil with little differentiation through to the subsoil. The pH is neutral throughout the soil depth, the topsoil is non-saline, non-sodic and has a low to moderate Cation Exchange Capacity. The Land and Soil Capability Class is 4 (refer to **Section 4.0**). This is because the pH of the profile meets the criteria for Class 4 with the local rainfall and soil texture, with the most limiting hazard being soil acidity.

From other observations on the Bowmans Creek terraces, stratified gravels occur at depth in the alluvial deposits.

Plate 3.1 illustrates the soil forming materials in the Stratic Rudosol soil type at Site 14 (K).

Plate 3.2 illustrates the landscape context of this soil type at Site 14 as an example. **Figure 2.3** illustrates the location of Site 14 (K).

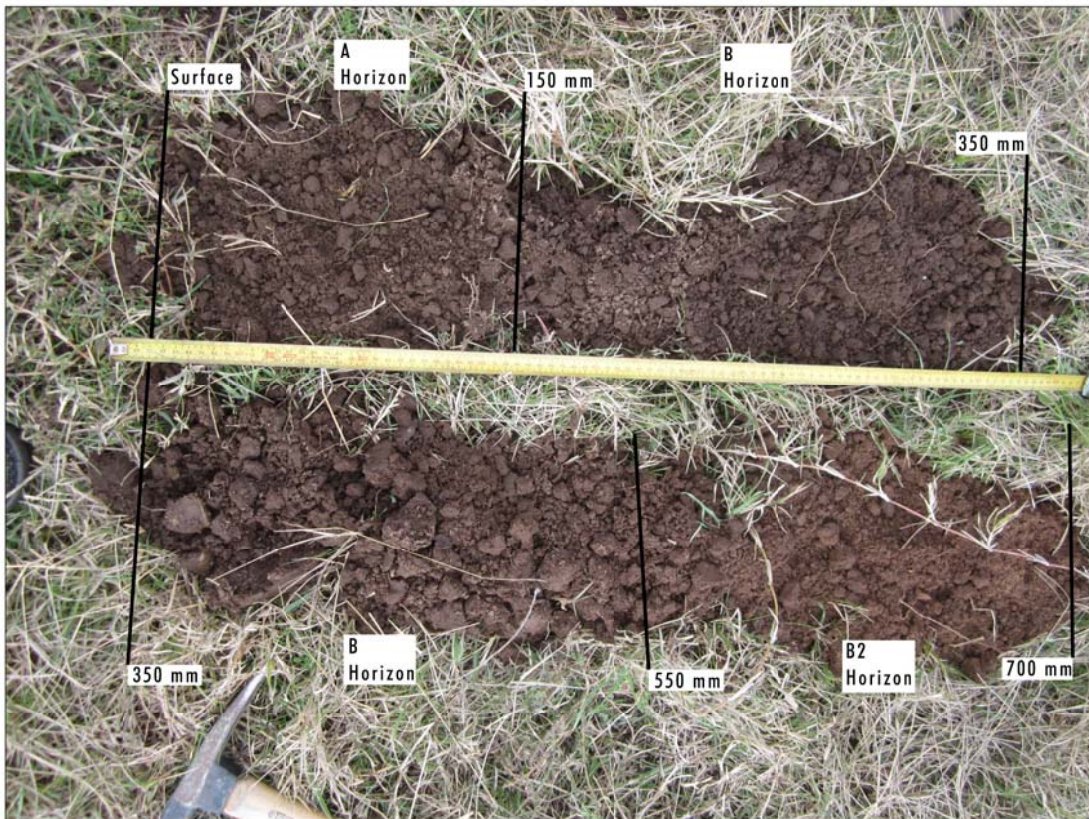


PLATE 3.1
Soil Forming Materials in the Stratic Rudosol Soil at Site 14 (K)



PLATE 3.2
Landscape Context of the Stratic Rudosol Soil at the Site 14 (K)

Table 3.2 – Stratic Rudosol description from the Proposed Disturbance Area

Typical Site Description											
Australian Soil Classification Order and Suborder		Stratic Rudosol									
Soil Landscape Unit		Hunter									
Slope Class		0 – 5 %									
Landscape position		Flat Creek Terrace									
Field sites		7, 13, 14 (K)									
LSC Class		Class 4; Refer to LSC Guidelines - Table 12. pH in CaCl ₂ with Hunter rainfall and site surface texture is within the range for Class 4.									
Physical Characteristics Site 14 (K)											
Horizon	Depth (m)	Description									
A1	0 - 0.15	Brown fine sandy loam; weak structure; 2-5 mm crumb peds with moderately weak consistence; neutral pH (6.5); rapidly drained; no gravel; no mottles; diffuse boundary; few fine roots present.									
B1	0.15 – 0.55	Brown fine sandy loam; weak structure; 5-10 mm sub- angular blocky peds with moderately weak consistence; neutral pH (6.5), rapidly drained, no gravel; no mottles, gradual boundary, few medium roots.									
B2	0.55 - >0.75	Brown fine sandy loam; weak structure; 5-10 mm sub-angular blocky peds with moderately weak consistence; neutral pH (6.5); rapidly drained, no gravel; no mottles; no roots. Based on other studies on these terraces, stratified creek gravels are known to occur at depth in the alluvial deposit.									
Soil Chemical Characteristics:											
Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)					C8A/3	C6A/2	
Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)
Site 14 (K) Horizon A	0.03	6.9	5.8	11.0	0.3	0.8	5.2	2.2	<0.3	4	2.89
Site 14 (K) Horizon B	0.01	7.1	5.7	12.4	0.4	0.2	6.6	2.9	nt	nt	nt
Method	P9B/2	P7B/2 Particle Size Analysis (%)									
Sample Id	EAT	clay	silt	f sand	c sand	gravel	Texture				
Site 14 (K) Horizon A	3(1)	13	15	48	22	2	sandy loam				
Site 14 (K) Horizon B	3(1)	nt	nt	nt	nt	nt	sandy loam				

3.2 Soil Type 2 – Clastic Rudosol

Table 3.3 summarises the characteristics of Clastic Rudosol soils in the Proposed Disturbance Area. Clastic Rudosols cover 2.7 hectares of the Proposed Disturbance Area and are young depositional soils associated with Bowman's Creek and tributaries of the Main Creek. The soil profile is characterised by well drained, moderately structured sandy loam topsoil overlying a gravel layer which is overlying a massive clay.

The pH is neutral to slightly acid throughout the soil depth, the topsoil is non-saline, non-sodic and has a moderately low Cation Exchange Capacity. The Land and Soil Capability Class is 7 with the most limiting hazard being soil depth due to the gravel layer (refer to **Section 4.0**).

Plate 3.3 illustrates the soil forming materials in a Clastic Rudosol in the Proposed Disturbance Area at Site 25 (B).

Plate 3.4 illustrates the landscape context of the Clastic Rudosol, based on the example at Site 25 (B). **Figure 2.3** shows the location of Site 25 (B).

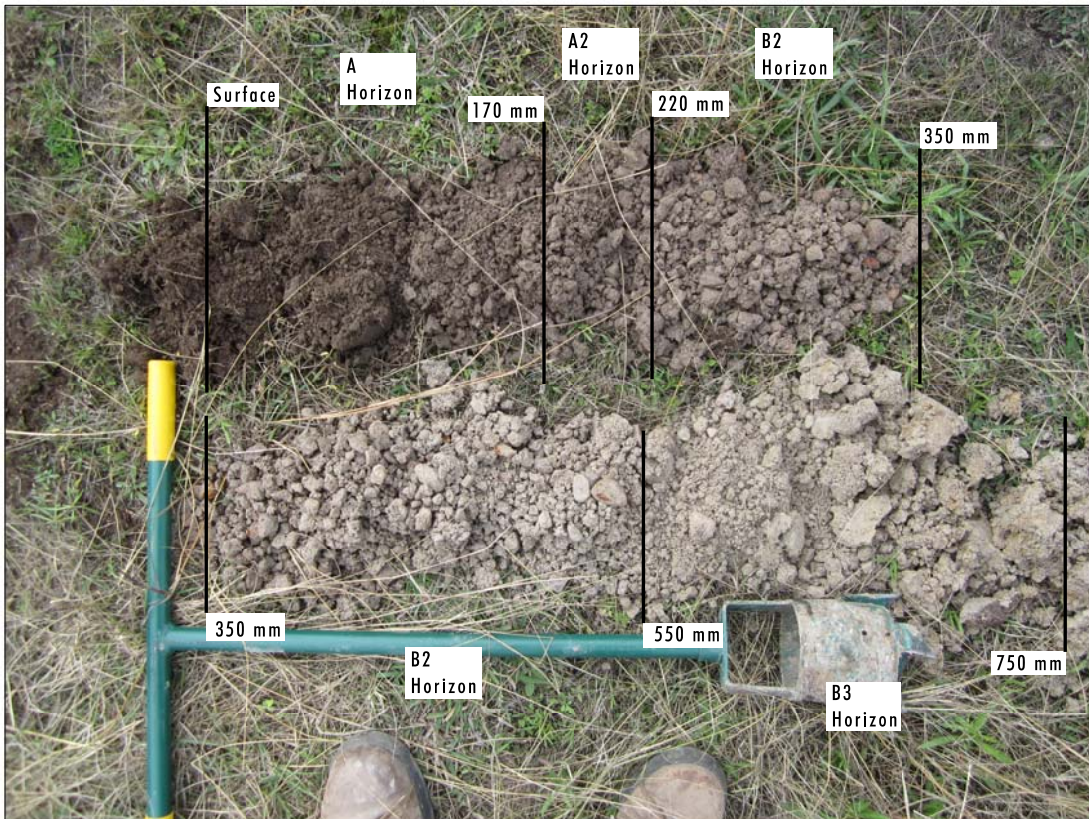


PLATE 3.3
Soil Forming Materials in the Clastic Rudosol Soil at Site 25 (B)



PLATE 3.4
Landscape Context of the Clastic Rudosol Soil at Site 25 (B)

Table 3.3 – Clastic Rudosol description from the Proposed Disturbance Area

Typical Site Description											
Australian Soil Classification Order and Suborder				Clastic Rudosol							
Soil Landscape Units				Hunter, Bayswater							
Slope Class				0 – 5 %							
Landscape position				Flat floodplain (exposed in the bank), colluvial deposit on lower slope							
Field sites				12, 25(B)							
LSC Class				Class 7; main limitation – soil depth due to gravel layer							
Physical Characteristics Site 25 (B)											
Horizon	Depth (m)	Description									
A1	0 - 0.17	Brown loam; moderate structure; 2-5 mm sub-angular blocky peds with moderately firm consistence; neutral pH (6.0); rapidly drained; no gravel; no mottles; abrupt boundary; common fine roots present.									
A2	0.17 – 0.22	Brown fine sandy loam; moderate structure; 2-5 mm sub- angular blocky peds with moderately firm consistence; slightly acid pH (5.5), rapidly drained; 20–50% sub-rounded gravel (6-20mm); no mottles, gradual boundary, common fine roots.									
Gravel layer	0.22 – 0.55	Brown medium clay; slightly acid pH (5.5); rapidly drained; 50-90% sub-rounded gravel (20-60mm); no mottles; gradual boundary; no roots.									
B2/B3	0.55 - >0.75	Grey heavy clay; massive structure; slightly acid pH (5.5); very slow drainage; <2% gravel; 2-10% distinct orange mottles; no roots.									
Soil Chemical Characteristics											
Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)						C8A/3	C6A/2
Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)
Site 25 (B) Horizon A	0.02	5.9	4.9	7.2	0.2	0.1	3.5	1.3	0.4	3	1.91
Method	P9B/2	P7B/2 Particle Size Analysis (%)									
Sample Id	EAT	clay	silt	f sand	c sand	gravel	Texture				
Site 25 (B) Horizon A	5	10	17	31	30	12	sandy loam				

3.3 Soil Type 3 – Brown Sodosol

Table 3.4 summarises the characteristics of Sodosol soils in the Proposed Disturbance Area. Sodosols cover 461.8 hectares of the Proposed Disturbance Area and are associated with the undulating Bayswater Soil Landscape.

These soils have well drained sandy loam to loam topsoils with a strong texture contrast at 0.2 to 0.35 metres to a poorly drained, strongly structured sodic clay B horizon which is not strongly acidic. The soils are neutral to slightly acidic throughout the profile, the cation exchange capacity is low to moderate, the soils are non-saline and slightly to extremely sodic in the topsoil and strongly sodic in the subsoil.

The Emerson Aggregate tests indicate the soils (both topsoils and subsoils) are dispersible and hence prone to water erosion, with the hazard increasing in the subsoil. The Land and Soil Capability Classes range from 4 to 7 depending on the site. The main hazards are soil structure decline, soil acidity (low pH in the topsoil and subsoil) and soil depth.

Plate 3.5 illustrates the soil materials in the Brown Sodosol profile at Site 24 (D).

Plate 3.6 illustrates the landscape context of the Brown Sodosol soil at Site 24 (D). **Figure 2.3** illustrates the location of site 24 (D).

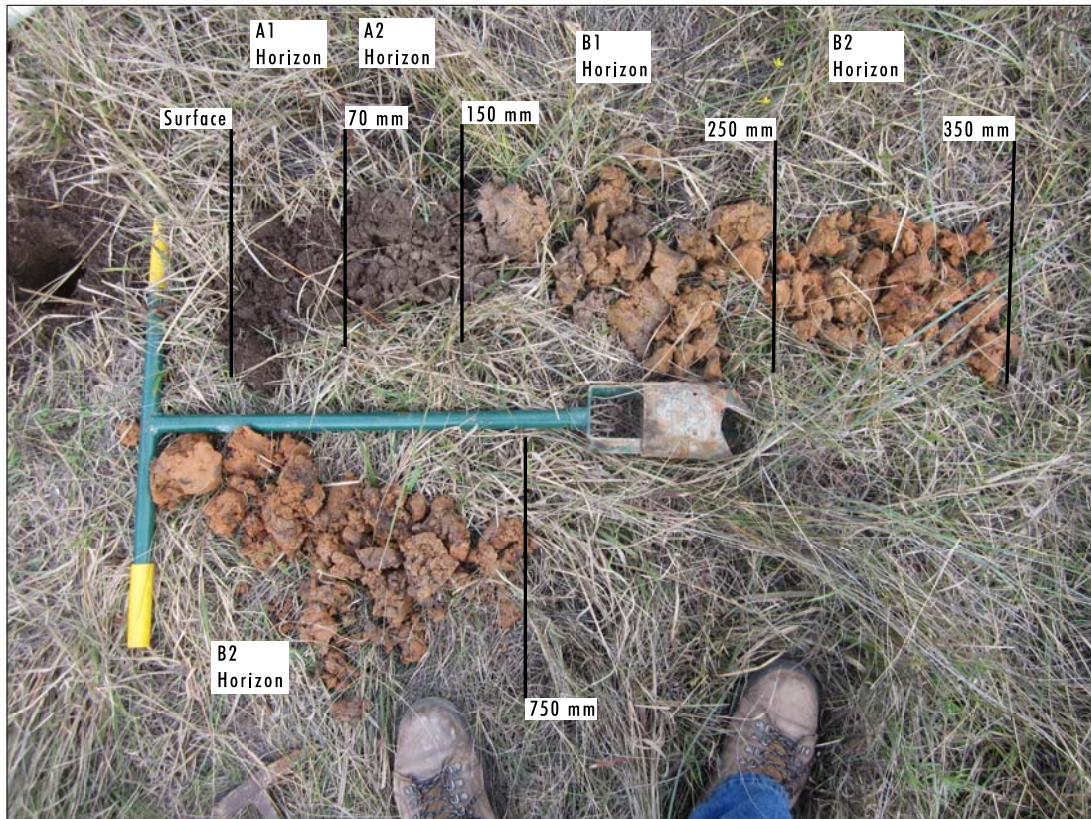


PLATE 3.5
Soil Forming Materials in the Brown Sodosol Soil at Site 24 (D)



PLATE 3.6
Landscape Context of the Brown Sodosol Soil at Site 24 (D)

Table 3.4 – Brown Sodosol description from the Proposed Disturbance Area

Typical Site Description												
Australian Soil Classification Order and Suborder		Brown Sodosol										
Soil Landscape Unit		Bayswater										
Slope Class		0–5 %, 5-10%										
Landscape position		Undulating, ranging from crest to lower slope										
Field sites		1-6, 8-11, 15 (I), 16 (H), 17 (G), 18 (A), 19 (E), 20 (L), 21 (C), 22 (F), 23 (J), and 24 (D)										
LSC Classes		Class 4-7; main limitations – soil structure decline, soil acidification and soil depth in some locations										
Physical Characteristics Site 24 (D)												
Horizon	Depth (m)	Description										
A1	0 - 0.07	Black /brown loam; moderate structure; 2-5 mm sub-angular blocky peds with moderately firm consistence; slightly acid pH (5.5); rapidly drained; no gravel; no mottles; sharp boundary; common fine roots and few medium roots present.										
A2	0.07 – 0.15	Grey fine sandy clay loam; moderate structure; 2-5 mm sub-angular blocky peds with moderately firm consistence; slightly acid pH (5.5), rapidly drained; common sub-rounded coarse gravel; no mottles; clear boundary, common fine roots and medium roots present.										
B1	0.15 – 0.25	Brown heavy clay; massive structure with moderately strong consistence; slightly acid pH (5.5); very slow drainage; no gravel; 2-5% distinct dark mottles; few fine roots and no medium roots.										
B2	0.25 - >0.75	Brown heavy clay; massive structure with moderately strong consistence; very slightly acid pH (6.0); very slow drainage; no gravel; 20-50% distinct dark mottles; no roots										
Soil Chemical Characteristics												
Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)					C8A/3	C6A/2		
Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)	
Site 24 (D) Horizon A	0.04	5.7	4.7	10.5	<0.1	0.6	3.7	3.3	0.4	1	2.72	
Site 24 (D) Horizon B	0.28	5.9	4.8	25.7	3.4	0.6	2.1	17.0	<0.3	nt	nt	
Method	P9B/2	P7B/2 Particle Size Analysis (%)										
Sample Id	EAT	clay	silt	f sand	c sand	gravel	Texture					
Site 24 (D) Horizon A	5	14	20	40	20	6	sandy loam					
Site 24 (D) Horizon B	2(3)	nt	nt	nt	nt	nt	medium clay					

3.4 Soil Type 4 – Brown Kurosol

Table 3.5 summarises the characteristics of Kurosol soils in the Proposed Disturbance Area. Kurosols cover approximately 4.7 hectares of the Proposed Disturbance Area and are associated with the undulating Bayswater Soil Landscape.

These soils have reasonably well drained sandy loam to clay loam topsoils, including a bleached and weakly structured fine sand A2 horizon, with a strong texture contrast at 0.05 to 0.25 metres to a poorly drained, strongly structured sodic clay B horizon which is also strongly acidic. The soils are moderately to strongly acidic at the surface becoming more acid with depth with high Aluminium levels, the cation exchange capacity is moderate, increasing with depth as the clay content increases. The soils are non-saline and moderately sodic in the topsoil increasing to strongly sodic in the subsoil. It is noted that there is very little difference between the Brown Sodosol and Brown Kurosol soil types, with Sites 26 and 27 being determined Brown Kurosol due their having a slightly more acidic B-horizon.

The Emerson Aggregate tests indicate the soils (both topsoils and subsoils) are either stable or mildly dispersible when wet, with the hazard increasing in the subsoil. The high aluminium is likely to offset the impact of the high sodium levels in the subsoils. The Land and Soil Capability Classes range from 4 to 5 depending on the site. The main hazards are water erosion, soil acidity (low pH in the topsoil and subsoil), waterlogging and soil depth.

Plate 3.7 illustrates the soil materials in the Brown Kurosol profile at Site 26.

Plate 3.8 illustrates the landscape context of the Brown Kurosol soil at Site 26. **Figure 2.3** illustrates the location of site 26.

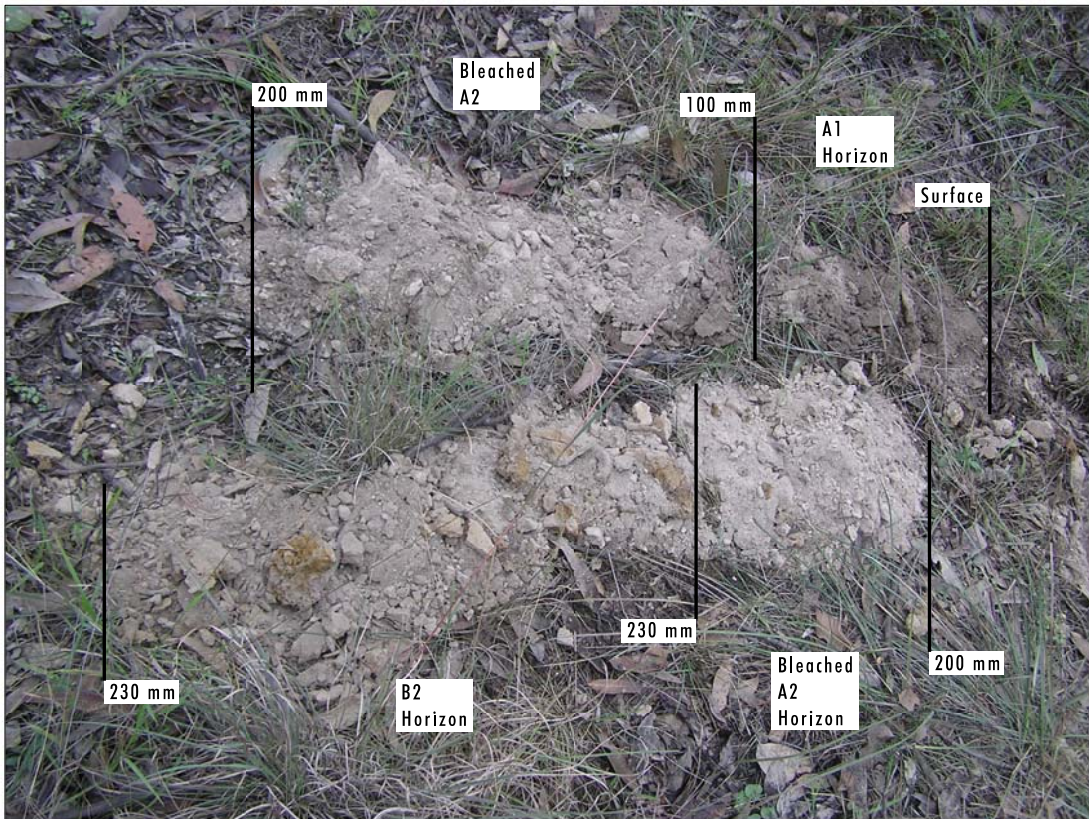


PLATE 3.7
Soil Forming Materials in the Brown Kurosol Soil at Site 26



PLATE 3.8
Landscape Context of the Brown Kurosol Soil at the Site 26

Table 3.5 – Brown Kurosol description from the Proposed Disturbance Area

Typical Site Description											
Australian Soil Classification Order and Suborder		Brown Kurosol									
Soil Landscape Unit		Bayswater									
Slope Class		0–5 %, 5-10%									
Landscape position		Undulating, ranging from crest to lower slope									
Field sites		26, 27									
LSC Classes		Class 4-5; main limitations – water erosion, soil acidification, waterlogging and soil depth in some locations									
Physical Characteristics Site 24 (D)											
Horizon	Depth (m)	Description									
A1	0 - 0.1	Brown sandy loam; weak structure; 1-2 mm sub-angular blocky peds with moderately weak consistence; moderately acid pH (5.0); rapidly drained; no gravel; no mottles; abrupt boundary; common fine and medium roots present.									
A2	0.1 – 0.23	Pale fine sand; moderate structure; 10-20 mm sub-angular blocky peds with moderately firm consistence; rapidly drained; no gravel; no mottles; abrupt boundary, few fine and medium roots present.									
B1	0.23 – 0.30 Profile continued deeper but too dry to sample	Brown heavy clay; moderate structure: 20-50mm sub angular blocky peds with firm consistence; strongly acid pH (4.5); very slow drainage; no gravel; 2-10% distinct orange mottles; few fine and medium roots.									
Soil Chemical Characteristics											
Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)					C8A/3	C6A/2	
Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)
Site 26 Horizon A	0.06	6.1	5	9.6	0.3	0.4	4.6	3	1.8	2	2.07
Site 26 Horizon B	0.19	5.5	4.5	14.2	1.9	0.3	2.5	8.4	2.6	nt	nt
Method	P9B/2	P7B/2 Particle Size Analysis (%)									
Sample Id	EAT	clay	silt	f sand	c sand	gravel	Texture				
Site 26 Horizon A	8	10	15	46	29	<1	sandy loam				
Site 26 Horizon B	2(1)	nt	nt	nt	nt	nt	heavy clay				

4.0 Land and Soil Capability Assessment

Land capability is the inherent physical capacity of the land to sustain a range of land uses and management activities in the long term without degradation to soil, land, air and water resources. The OEH have developed a system to assess land and soil capability (LSC) in NSW described in the *Land and Soil Capability Assessment Scheme, Second Approximation* (OEH 2012) known as the LSC Guideline.

The scheme uses biophysical features of the land as well as the management inputs required to manage the land sustainably to classify land into one of eight classes. The LSC classes are described in **Table 4.1**. Eight hazards are assessed for each land type and the overall LSC class is the most limiting hazard.

Table 4.1 - Land and Soil Capability Classes – General Definitions

LSC Class	General Description
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)	
LSC Class 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.
LSC Class 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.
LSC 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. 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)	
LSC Class 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.
LSC 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.

Table 4.1 - Land and Soil Capability Classes – General Definitions (cont.)

LSC Class	General Description
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
LSC Class 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.
LSC Class 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.
LSC Class 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.

4.1 Land and Soil Capability Methodology

This section reviews the LSC class of soils in the Proposed Disturbance Area, using the results of field and laboratory tests. The LSC classes derived from this assessment are relevant at the Project scale, rather than the regional scale.

The biophysical features of landform position, slope, drainage, climate, soil type and characteristics have been used to identify the eight hazards that are assessed by the LSC scheme. The hazards are:

- water erosion;
- wind erosion;
- soil structure decline;
- soil acidification;
- salinity;
- waterlogging;
- shallow soils; and
- mass movement.

Each hazard is assessed against set criteria described in the LSC Guideline and ranked from 1 (least limiting) to 8 (most limiting) to determine the overall LSC ranking as the most limiting hazard.

The LSC classification has been applied to the Proposed Disturbance Area in accordance with the LSC Guideline. **Table 4.2** outlines the criteria for assessing each hazard considered.

The LSC classes for each soil sampling site are detailed in **Table 4.3**.

Table 4.2 – Criteria for assessing LSC Class

Hazard	Criteria
Hazard 1: Water Erosion	<p>The water erosion hazard is largely based on the location of the site and slope. The presence of sodic/dispersible soils or gully erosion influences the LSC class on 10 to 20 per cent slopes. The Proposed Disturbance Area is in the Eastern and Central Division of NSW. Slopes across the Proposed Disturbance Area range from 0 to 5 per cent, 5 to 10 per cent and > 10 per cent and are less than 500 metres long. Water erosion is a low risk hazard across the majority of the Proposed Disturbance Area.</p>
Hazard 2: Wind Erosion	<p>There are four factors used to determine the level of wind erosion hazard. Three of these factors were assessed to be consistent across the Proposed Disturbance Area.</p> <ul style="list-style-type: none"> • The wind erosive power has been mapped as 'moderate' (The NSW Wind Atlas). • The average annual rainfall of the Project Area is in the >500 millimetres class. • The exposure of the Project site was determined to be 'moderate' across the Proposed Disturbance Area. <p>The determining factor with regard to the wind erosion hazard was the surface soil texture according to the LSC Guideline.</p>
Hazard 3: Soil Structure Decline	<p>To assess the structure, stability and resilience of the soil, the LSC classification assesses the soil structure decline hazard using the criteria of:</p> <ul style="list-style-type: none"> • surface soil texture; • surface soil sodicity; and • degree of self mulching. <p>The calculated Exchangeable Sodium Percentage (ESP) (refer to Appendix 1) has been used to assess the surface soil sodicity according to the LSC guidelines where:</p> <ul style="list-style-type: none"> • ESP < 3 per cent is very low, • ESP 3 to 5 per cent is low; • ESP 5 to 8 per cent is moderate; • ESP 8 to 15 per cent is high; and • ESP >15 per cent is very high.
Hazard 4: Soil Acidification Hazard	<p>The soil acidification hazard is assessed using three criteria:</p> <ul style="list-style-type: none"> • soil buffering capacity (based on Great Soil Groups, surface soil texture or geology of parent material); • pH of the surface soil; and • mean annual rainfall. <p>The Great Soil Groups were used to determine soil buffering capacity and the Project site falls in the 550 to 700 millimetres mean annual rainfall category. The pH of the surface soils was measured in the laboratory.</p>
Hazard 5: Salinity	<p>The salinity hazard requires an estimation of the recharge potential, the discharge potential and the soil salt store for the site. At the Project site the mean annual evaporation rate is over twice as high as the mean annual rainfall (BOM 2013) which indicates that the recharge potential of the site was low. The discharge potential varies depending on the landscape position and was assessed as moderate. The soil salt store is mapped as low and this is confirmed by laboratory EC measurements of the soil samples.</p>

Table 4.2 – Criteria for assessing LSC Class (cont.)

Hazard	Criteria
Hazard 6: Waterlogging hazard	Waterlogging hazard is assessed on the drainage potential of the soil as well as the duration and return period of waterlogging events. Field evidence of drainage and waterlogging including soil texture, presence of mottles and vegetation features such as the presence of wet area plants (e.g. rushes) were assessed.
Hazard 7: Shallow Soils and Rockiness	The shallow soils hazard is assessed on the level of rock outcropping in combination with the depth of soil. Gravel layers at some sites limited the effective rooting depth.
Hazard 8: Mass Movement	The mass movement hazard is assessed through a combination of three criteria: <ul style="list-style-type: none"> • mean annual rainfall; • presence of mass movement; and • slope class.

4.2 Land and Soil Capability Assessment

The Proposed Disturbance Area has been assessed in detail for the Land and Soil Capability of each soil sampling point (refer to **Table 4.3**). The classes are mapped on **Figure 4.1, 4.2** and **4.3**. The LSC was assessed on a site basis rather than a soil type basis as there were site specific differences in factors such as slope, landscape position and soil characteristics that impacted on LSC Classes. In **Table 4.3**, the orange shading indicates the most limiting factor, which defines overall LSC class.

Table 4.3 – Land and Soil Capability for Sampled Sites

Site No.	Soil type	Hazard Criteria								Overall class
		Water erosion	Wind erosion	Structure	Acidity	Salinity	Water-logging	Soil depth	Mass movement	
1	Sodosol	2	2	3	4	1	2	6	1	6
2	Sodosol	3	2	6	4	1	3	7	1	7
3	Sodosol	2	2	6	4	1	3	3	1	6
4	Sodosol	2	3	3	4	1	3	3	1	4
5	Sodosol	3	2	6	4	1	3	3	1	6
6	Sodosol	3	2	6	4	1	3	3	1	6
7	Rudosol	2	3	3	4	1	1	3	1	4
8	Sodosol	2	2	6	4	1	3	2	1	6
9	Sodosol	1	2	7	4	1	3	2	1	7
10	Sodosol	1	3	7	4	1	3	3	1	7
11	Sodosol	1	2	6	4	1	3	3	1	6
12	Rudosol	2	2	3	4	1	1	7	1	7
13	Rudosol	1	3	3	4	1	1	1	1	4



Image Source: Mount Owen (2013)
 Data Source: Mount Owen (2014)
 Note: Contour Interval 1m

0 100 250 500m
 1:10 000

Legend

- Proposed Disturbance Area
- Infrastructure Not Assessed
- LSC Class 4
- LSC Class 6
- LSC Class 7
- Soil Sampling Site

FIGURE 4.1
 Proposed Hebden Road Upgrade Works Area
 Land and Soil Capability

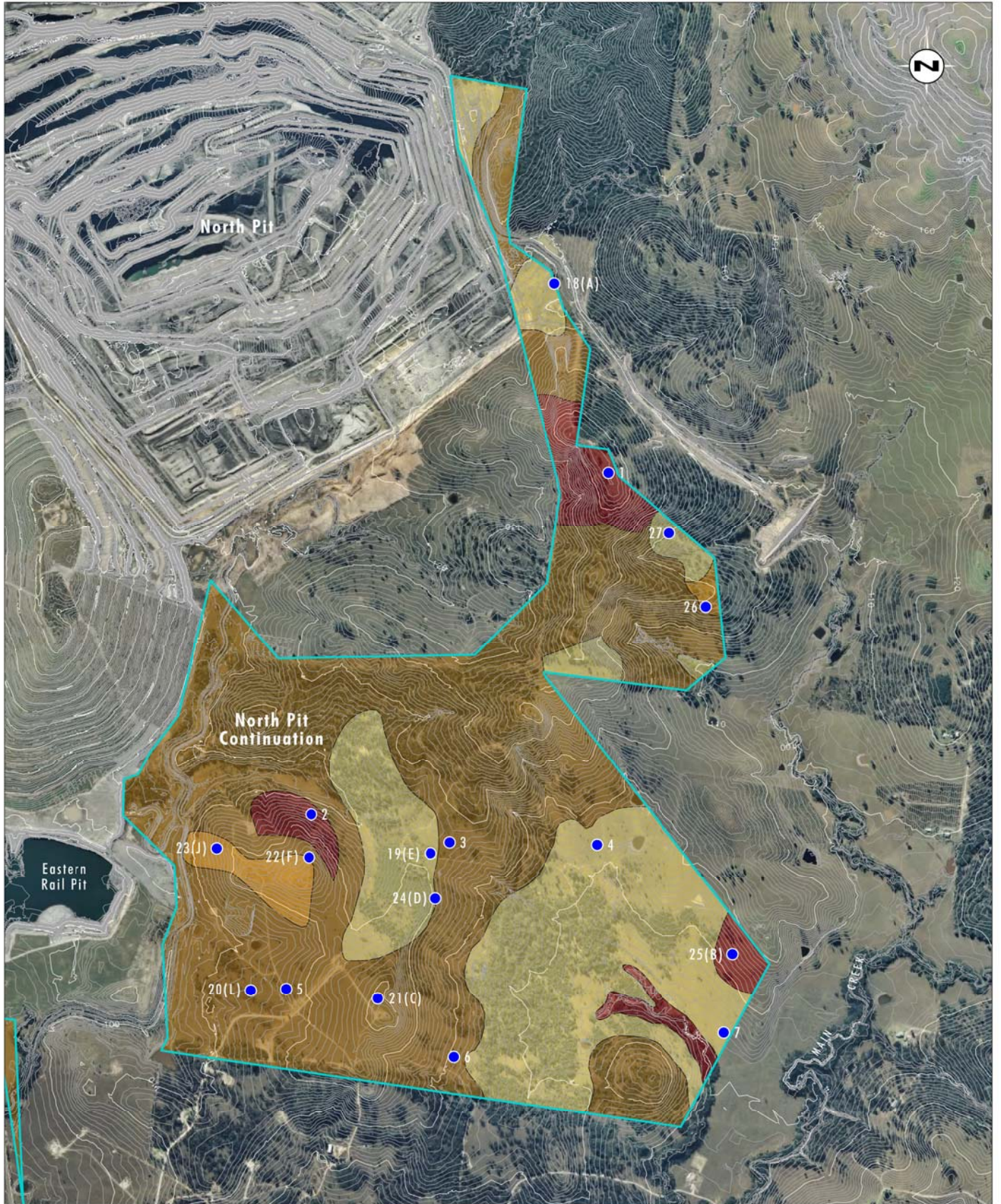


Image Source: Mount Owen (2013)
 Data Source: Mount Owen (2014)
 Note: Contour Interval 1m

0 0.25 0.5 1.0km
 1:20 000

Legend

- Proposed Disturbance Area
- LSC Class 4
- LSC Class 5
- LSC Class 6
- LSC Class 7
- Soil Sampling Site

FIGURE 4.2
 Proposed North Pit Continuation Area
 Land and Soil Capability

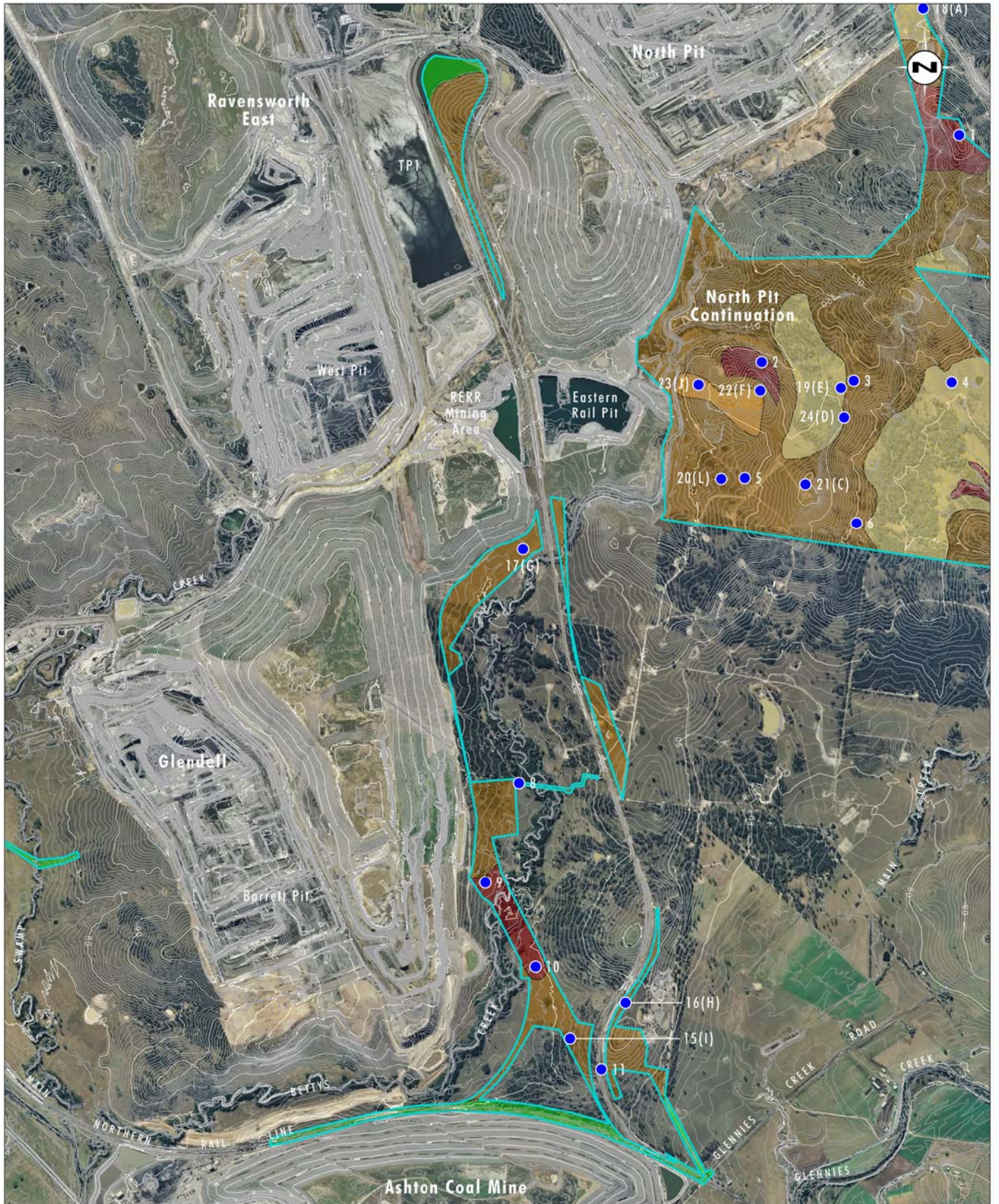


Image Source: Mount Owen (2013)
 Data Source: Mount Owen (2014)
 Note: Contour Interval 1m

0 0.5 1.0 1.5 km
 1:30 000

Legend

- Proposed Disturbance Area
- Infrastructure Not Assessed
- LSC Class 4
- LSC Class 5
- LSC Class 6
- LSC Class 7
- Soil Sampling Site

FIGURE 4.3
Proposed Rail Upgrade Works Area
Land and Soil Capability

Table 4.3 – Land and Soil Capability for Sampled Sites (cont.)

Site No.	Soil type	Hazard Criteria								Overall class
		Water erosion	Wind erosion	Structure	Acidity	Salinity	Water-logging	Soil depth	Mass movement	
14 (K)	Rudosol	1	3	3	4	1	1	3	1	4
15 (I)	Sodosol	2	2	6	4	1	3	3	1	6
16 (H)	Sodosol	2	2	6	4	1	3	3	1	6
17 (G)	Sodosol	2	2	6	4	1	3	3	1	6
18 (A)	Sodosol	2	2	3	4	1	3	3	1	4
19 (E)	Sodosol	2	2	3	4	1	3	3	1	4
20 (L)	Sodosol	2	2	6	4	1	3	3	1	6
21 (C)	Sodosol	2	2	6	4	1	3	3	1	6
22 (F)	Sodosol	2	5	3	4	1	2	3	1	5
23 (J)	Sodosol	2	4	3	5	1	4	3	1	5
24 (D)	Sodosol	2	2	3	4	1	3	3	1	4
25 (B)	Rudosol	2	2	3	4	1	2	7	1	7
26	Kurosol	3	2	3	5	2	4	3	1	5
27	Kurosol	4	2	3	4	2	4	4	1	4

Land and Soil Capability Classes 4 to 7 occur in the Proposed Disturbance Area. The Proposed Disturbance Area is assessed as containing moderate through to very low capability land. The most common limitations were soil structure decline and soil acidification.

Overall, the verified LSC classes at the project scale are lower than the regional scale mapping of LSC indicated. LSC Class 6 is the most common in the Proposed Disturbance Area, but LSC Class 4 is also relatively common.

Table 4.4 presents the area and percentage of LSCS in each component of the Project Disturbance Area. **Figure 3.1, 3.2** and **3.3** illustrate these locations.

Table 4.4 - Land and Soil Capability Classes across the Proposed Disturbance Area

Proposed Disturbance Area Site	LSC Class	Area (ha)	Percentage of Site (%)
Hebden Rd Upgrade Sites 12, 13 and 14 (K)	4	4.0	30.5
	6	1.3	9.9
	7	0.5	3.8
	Infrastructure - not assessed	7.3	55.7
	TOTAL	13.1	100
Rail Spur Extension Sites 8, 9, 10, 11, 15 (I), 16 (H), 17 (G)	6	64.3	70.4
	7	8.7	9.6
	Infrastructure - not assessed	18.4	20
	TOTAL	91.4	100
North Pit Continuation Sites 1, 2, 3, 4, 5, 6, 7, 18 (A), 19 (E), 20 (L), 21 (C), 22 (F), 23 (J), 24 (D), 25 (B), 26 and 27	4	111.9	29.4
	5	8.9	2.3
	6	235.9	62.0
	7	23.8	6.3
	TOTAL	380.5	100

Further information regarding the capabilities and limitations of soil classes in the Proposed Disturbance Area is provided below.

Class 4 – This land is moderately capable of a range of land uses including grazing with pasture improvement, limited cropping with restricted cultivation and some horticulture. It has moderate to severe limitations that require specialist management practices or inputs to overcome and maintain sustainable productivity. There is widespread potential for soil acidification across the Proposed Disturbance Area due to soils with low buffering capacity and low surface pH. This limitation could be managed with the use of acid tolerant perennial pastures and/or the use of lime.

Class 5 – This land is moderate to low capability and can be used for grazing and permanent horticulture such as orchards. There are severe limitations for high impact agricultural practices.

Class 6 – This land is low capability and can be used for limited land uses such as grazing, forestry and nature conservation. There is widespread risk of soil structure decline across many of the Sodosol soils of the Proposed Disturbance Area. The majority of sites recorded moderate surface soil sodicity which would require maintenance of surface soil vegetation cover to prevent erosion and inputs of gypsum to effectively manage the sodium levels. The subsoils were also strongly sodic and prone to dispersion adding to the limitations of these soils.

Class 7 – This land is very low capability and should be used for conservation or selective forestry. The Class 7 land only occupies limited areas of the Proposed Disturbance Area where there are localised soil depth issues, including a gravel layer inhibiting rooting depth, and two sites, sites 9 and 10, with very high surface ESP levels that may have been affected by previous land management activities that has caused the topsoil to have been lost through sheet erosion.

5.0 Biophysical Strategic Agricultural Land

The Upper Hunter SRLUP (DP&I 2012b) has identified approximately 11 hectares of BSAL within the Project Area (refer to **Figure 1.3**). This land is mapped in association with the floodplain and low terraces along Bowman's Creek which will be impacted by the proposed upgrade of the Hebden Road. There are no Critical Industry Clusters within the locality of the Project.

Verification of the BSAL mapping was conducted across the entire Proposed Disturbance Area by assessing all soil sampling sites in accordance with both the criteria outlined in the Upper Hunter SRLUP. **Table 5.1** presents the criteria from the Upper Hunter SRLUP and the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH and OASFS 2013).

Table 5.1 – Biophysical Strategic Agricultural Land Criteria Upper Hunter SRLUP and Interim OEH Protocol

Upper Hunter SRLUP Criteria
<ul style="list-style-type: none"> land that falls under soil fertility classes 'high' or 'moderately high' under the <i>Draft Inherent General Fertility of NSW</i> (OEH),
<ul style="list-style-type: none"> land capability classes I, II or III under the Land and Soil Capability Mapping of NSW (OEH),
<ul style="list-style-type: none"> reliable water of suitable quality, characterised by having rainfall of 350mm or more per annum (9 out of 10 years); or properties within 150m of a regulated river, or unregulated rivers where there are flows for at least 95% of the time (i.e. the 95th percentile flow of each month of the year is greater than zero) or 5th order and higher rivers; or groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5L/s and total dissolved solids of less than 1,500mg/L.
<ul style="list-style-type: none"> OEH Interim Protocol
<ul style="list-style-type: none"> land that falls under soil fertility classes 'moderate' under the <i>Draft Inherent General Fertility of NSW</i> (OEH),
<ul style="list-style-type: none"> land capability classes I or II under the Land and Soil Capability Mapping of NSW (OEH),
<ul style="list-style-type: none"> reliable water of suitable quality, characterised by having rainfall of 350mm or more per annum (9 out of 10 years); or properties within 150m of a regulated river, or unregulated rivers where there are flows for at least 95% of the time (i.e. the 95th percentile flow of each month of the year is greater than zero) or 5th order and higher rivers; or groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5L/s and total dissolved solids of less than 1,500mg/L.

Sections 5.1 and **5.2**, below, present the assessment against each. Both assessments determined there is no BSAL within the Project Disturbance Area

5.1 Biophysical Strategic Agricultural Land Assessment – Upper Hunter SRLUP

The minimum requirement for reliable rainfall was met across the Project site where mean annual rainfall is greater than 600 millimetres (BOM), therefore the LSC Class and the soil fertility were assessed for each soil type identified within the Proposed Disturbance Area. Results are presented in **Table 5.2**.

Table 5.2 – Applied BSAL Criteria- SRLUP Upper Hunter

Soil Type	LSC Class	Fertility*	BSAL	BSAL Limitation
Stratic Rudosol	4	Moderately low	No	LSC Class and fertility
Clastic Rudosol	7	Low	No	LSC Class and fertility
Brown Sodosol	4 to 7	Moderately low	No	LSC Class and fertility
Brown Kurosol	4 to 5	Moderately low	No	LSC Class and fertility

* Fertility correlated with ASC classes (OEH and OASFS2013).

Under the criteria of the Upper Hunter SRLUP the fertility classes and LSC classification failed to meet the criteria for BSAL across the Proposed Disturbance Area.

5.1.1 Verified Soil Fertility in the Proposed Disturbance Area

Each soil type was assessed on the basis of soil fertility factors as classified by the ASC. The Stratic Rudosol soils associated with the Bowman's Creek floodplain and terraces are classified as moderately low fertility and yet are mapped at a regional scale as probable BSAL. Soil testing undertaken in the field and the laboratory at Sites 13 and 14 (K) show the typical indicators of inherent soil fertility, including Cation Exchange Capacity (CEC), Particle Size Analysis/Texture, and Organic Carbon, reinforce the ASC classification. Cation Exchange Capacity is moderately low (10-11 meq/100g), Particle size analysis identifies a relatively low clay percentage (13 per cent) in a fine loamy sand and Organic Carbon (Walkley Black) is moderate (2.89 per cent). The surface pH (Ca Cl₂) is 5.6–5.8 and in combination with a low buffering capacity and mean annual rainfall between 550 and 700 millimetres indicates a potential acidification risk which is identified as LSC Class 4.

The Clastic Rudosols are classified as low fertility under the ASC. This is also reinforced by laboratory testing of Sites 12 and 25 (B) which measured a low CEC (7.2-7.4 meq/100gm), a low clay percentage (10 per cent) and a moderately low Organic Carbon (1.91 per cent). The surface pH (CaCl₂) is 4.9-5.0 and the buffering capacity of the soil is low, indicating a potential soil acidification risk. Further these soils are constrained by a 30 centimetres thick gravel layer within the root zone which effectively limits the depth of the soil and placing these soils in LSC Class 7.

The Brown Sodosols and Kurosols are classified as moderately low fertility under the ASC. The sites tested with the Proposed Disturbance Area had Cation Exchange Capacities ranging from low (2.8 meq/100gm) to high (35.6 meq/100gm) where the high values had high sodium levels and low Calcium to Magnesium ratios associated with them. Surface pH (CaCl₂) was generally below 5, surface soils had low clay percentages, low buffering capacity and moderately low Organic Carbon levels. LSC Classes ranged from 4 to 7 with the constraints relating to potential acidification and soil structural limitations.

The fertility classes and LSC classification fail to meet the criteria for BSAL across the Proposed Disturbance Area.

5.2 BSAL Assessment – Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land

This methodology identifies access to a reliable water supply and then uses a 12 step BSAL verification process, summarised in **Table 5.3**.

The site must meet all 12 criteria including being greater than 20 hectares in area to be assessed as BSAL. That is, if any of the conditions are not met, the site is rejected as BSAL and the remaining conditions are not assessed.

Table 5.3 – 12 Step Process for BSAL Verification

Step	Criteria	BSAL Definition
-	Reliable water supply	Reliable water of suitable quality, characterised by having rainfall of 350 millimetres or more per annum (9 out of 10 years)
1	Slope	Slope less than or equal to 10%
2	Rock outcropping	Less than 30% rock outcrop
3	Unattached rock fragments	Less than or equal to 20% of site has unattached rock fragments > 60 millimetres diameter
4	Gilgais	Less than or equal to 50% of the site has gilgais > 500 metre deep
5	Slope	Slope < 5% (If yes, go to 6, if no go to 7b)
6	Rock outcrop	Nil rock outcrop (if yes, go to 7a, if no got to 7b)
7a	Fertility	Soil has moderate fertility
7b	Fertility	Soil has moderately high or high fertility
8	Soil depth	Effective rooting depth to a physical barrier > 750 millimetres
9	Drainage	Drainage better than poor
10	pH	PH range from 4.5 to 8 in Calcium chloride in upper 600 millimetres
11	Salinity	Salinity less than or equal to 4 dS/m
12	Effective rooting depth	Depth to chemical barrier > 750 millimetres
13	Minimum area	Area greater than or equal to 20 hectares.

Under the interim protocol all soil types across the Proposed Disturbance Area failed to meet the criteria for BSAL based on soil fertility being low to moderately low.

Soil fertility is based on the relative fertility of the Australian Soil Classification classes listed in Appendix 2 of the Interim Protocol for the Site Verification and Mapping of Biophysical Strategic Agricultural Land (OEH and OASFS 2013). Based on laboratory testing the fertility classes and LSC classification fail to meet the criteria for BSAL across the Proposed Disturbance Area (refer to **Section 5.1.1**).

6.0 Soil Use for Rehabilitation

All surface soils within the Proposed Disturbance Area are suitable for harvesting for later use in rehabilitation of the Project Area. The depth of suitable soil varies from 10 to 20 centimetres. The surface soils across the Proposed Disturbance Area have potential issues with soil acidity, soil sodicity, low to moderate Cation Exchange Capacity and moderate Organic Carbon (DSNR n.d.).

The soils are also relatively high in Magnesium compared with Calcium. Throughout rehabilitation the topsoil materials should be tested for pH and Exchangeable Sodium Percentage and appropriate amounts of lime and gypsum applied to ensure sustainable rehabilitation success.

7.0 Summary of Assessment Findings

This soil survey, LSC assessment and BSAL verification have been undertaken in accordance with the Guidelines for Surveying Soil and Land Resources (McKenzie *et al.* 2008) in addition to recent NSW government protocols. The key findings of this assessment are as follows:

- three soil types have been identified across the Proposed Disturbance Area:
 - Brown Sodosols, moderately low fertility duplex soils, occupy 461.8 hectares or 95.2 per cent of the Proposed Disturbance Area and correspond to the Bayswater Soil Landscape;
 - Brown Kurosols, moderately low fertility duplex soils, occupy 4.7 hectares or 1 per cent of the Proposed Disturbance Area and correspond to the Bayswater Soil Landscape;
 - Stratic Rudosols, young weakly structured moderately low fertility alluvial soils, cover 15.8 hectares (3.2 per cent) of the Proposed Disturbance Area and correspond to the Hunter Soil Landscape and isolated patches of the Bayswater Soil Landscape; and
 - Clastic Rudosols, low fertility alluvial soils overlying gravel, occupy 2.7 hectares (0.6 per cent) and are associated with the current Bowmans Creek and past tributaries of Main Creek.
- LSC assessment identified land Classes 4 to 7 across the Proposed Disturbance Area. The majority of the Proposed Disturbance Area is Class 6 (301.5 hectares, 62 per cent of the assessed land). These classes are suited to grazing operations, limited cropping with minimal cultivation, permanent horticulture, forestry and conservation. The main hazards associated with the identified soil types were soil acidification, soil structure decline, and soil depth in some areas.
- BSAL verification using both the Upper Hunter SRLUP assessment methodology and the OEH *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* identified there was no BSAL within the Proposed Disturbance Area. All soils failed to meet the criteria of adequate soil fertility.
- Topsoils to a depth of 20 centimetres would be suitable for rehabilitation with some management inputs to correct pH and sodicity.

8.0 References

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Kovac, M. and Lawrie, J.M. 1991. *Soil Landscapes of the Singleton 1:250,000 Sheet*, Soil Conservation Service of NSW.

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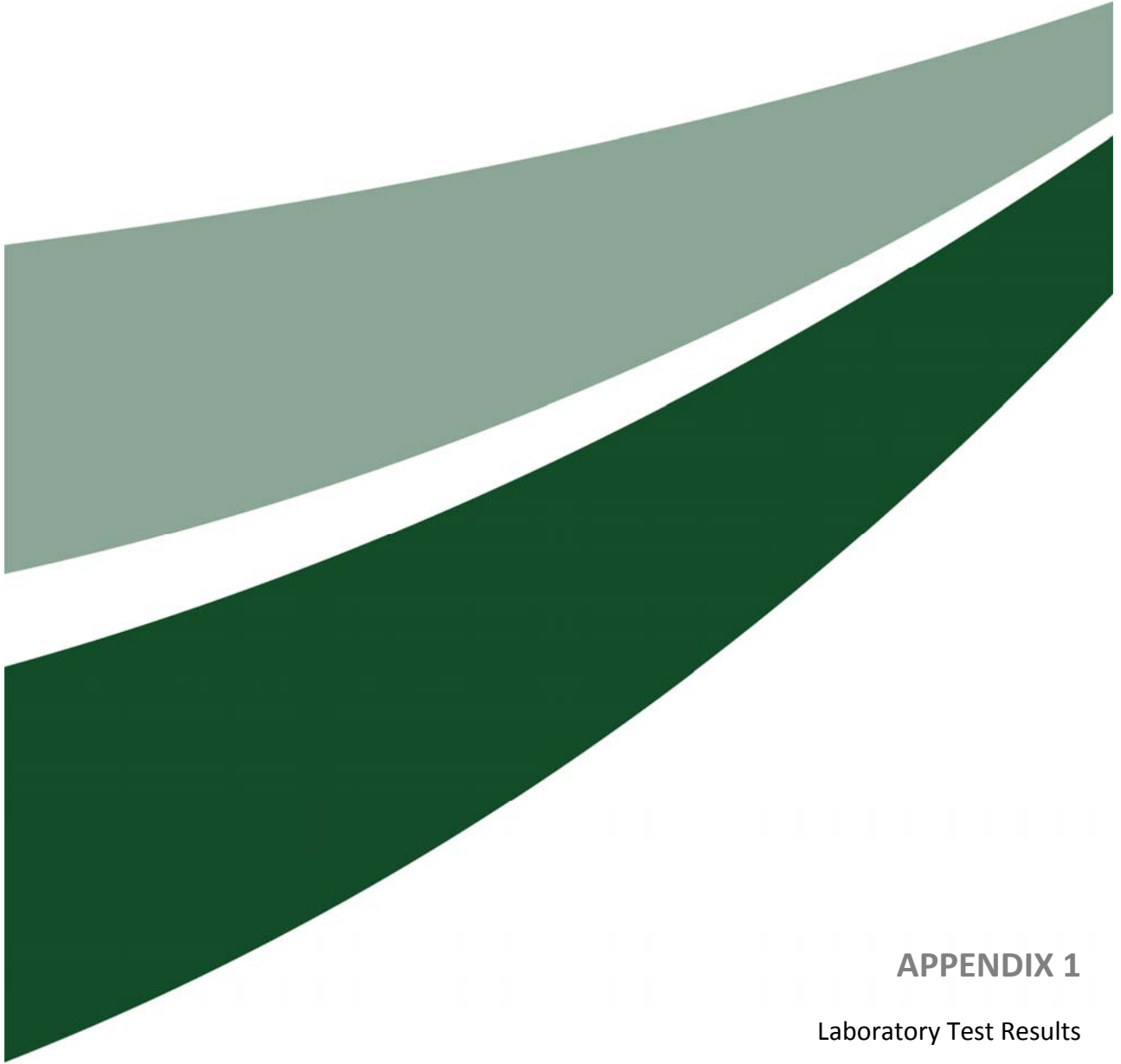
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(Accessed 12 Aug 2013)



APPENDIX 1

Laboratory Test Results



SOIL TEST REPORT

Page 1 of 2

Scone Research Centre

REPORT NO: SCO14/113R1

REPORT TO: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2283

REPORT ON: Four soil samples
Your ref: MGA 56

PRELIMINARY RESULTS
ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 26 June 2014

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

A handwritten signature in blue ink, appearing to read 'SR Young'.

SR Young
(Laboratory Manager)

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO14/113R1
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2283

Lab No	Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)					C8A/3	P9B/2	Texture	
		EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)		EAT
1	Site 26 A 0-10cm	0.06	6.1	5.0	9.6	0.3	0.4	4.6	3.0	1.8	2	8	Sandy loam
2	Site 26 B >23cm	0.19	5.5	4.5	14.2	1.9	0.3	2.5	8.4	2.6	nt	2(1)	Heavy clay
3	Site 27 A 0-5cm	0.05	5.7	4.5	16.1	0.7	0.8	4.4	9.6	3.0	3	3(2)	Clay loam
4	Site 27 B >15cm	0.07	5.4	4.2	19.0	1.2	0.6	2.0	12.0	5.1	nt	3(3)	Heavy clay

nt=not tested

Lab No	Method	P7B/2 Particle Size Analysis (%)					C6A/2
		clay	silt	f sand	c sand	gravel	OC %
1	Site 26 A 0-10cm	10	15	46	29	<1	2.07
2	Site 26 B >23cm	nt	nt	nt	nt	nt	nt
3	Site 27 A 0-5cm	28	23	34	15	<1	3.83
4	Site 27 B >15cm	nt	nt	nt	nt	nt	nt

nt=not tested



END OF TEST REPORT

SOIL TEST REPORT

Page 1 of 3

Scone Research Centre

REPORT NO: SCO13/220R1

REPORT TO: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2284

REPORT ON: Thirteen soil samples
Ref: Mount Owen (MOCO) Project

PRELIMINARY RESULTS
ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 26 August 2013

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL



SR Young
(Laboratory Manager)

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO13/220R1
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2284

Lab No	Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)						C8A/3	C6A/2
	Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)
1	Site K (14) A	0.03	6.9	5.8	11.0	0.3	0.8	5.2	2.2	<0.3	4	2.89
2	Site K (14) B	0.01	7.1	5.7	12.4	0.4	0.2	6.6	2.9	nt	nt	nt
3	Site G (17) A	0.05	6.1	4.9	11.3	0.7	0.5	3.1	4.5	<0.3	3	2.01
4	Site G (17) B	0.23	6.1	4.9	25.8	3.9	0.1	5.1	12.6	<0.3	nt	nt
5	Site A (18) A	0.10	6.1	5.3	14.5	0.4	0.7	6.9	4.8	<0.3	3	5.07
6	Site A (18) B	0.07	6.1	4.6	15.8	1.2	0.1	1.6	7.9	<0.3	nt	nt
7	Site F (22) A	0.02	5.9	4.7	7.1	<0.1	0.2	2.1	1.5	<0.3	7	1.96
8	Site F (22) B	0.01	6.3	4.7	7.7	0.2	0.2	1.8	3.6	<0.3	nt	nt
9	Site J (23) A	0.06	5.7	4.7	8.3	<0.1	0.8	3.5	2.1	<0.3	3	2.16
10	Site J (23) B	0.33	5.5	4.5	35.6	4.2	0.7	2.0	23.5	0.7	nt	nt
11	Site D (24) A	0.04	5.7	4.7	10.5	<0.1	0.6	3.7	3.3	0.4	1	2.72
12	Site D (24) B	0.28	5.9	4.8	25.7	3.4	0.6	2.1	17.0	<0.3	nt	nt
13	Site B (25) A	0.02	5.9	4.9	7.2	0.2	0.1	3.5	1.3	0.4	3	1.91

S.R. Young

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO13/220R1
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2284

Lab No	Method	P9B/2	P7B/2 Particle Size Analysis (%)					Texture
	Sample Id	EAT	clay	silt	f sand	c sand	gravel	
1	Site K (14) A	3(1)	13	15	48	22	2	sandy loam
2	Site K (14) B	3(1)	nt	nt	nt	nt	nt	sandy loam
3	Site G (17) A	3(1)	14	25	36	13	12	silty loam
4	Site G (17) B	2(3)	nt	nt	nt	nt	nt	heavy clay
5	Site A (18) A	8	is	is	is	is	3	sandy clay
6	Site A (18) B	2(3)	nt	nt	nt	nt	nt	medium clay
7	Site F (22) A	5	4	11	21	20	44	loamy sand
8	Site F (22) B	2(1)	nt	nt	nt	nt	nt	coarse sandy clay loam
9	Site J (23) A	5	6	14	26	36	18	loamy sand
10	Site J (23) B	2(2)	nt	nt	nt	nt	nt	heavy clay
11	Site D (24) A	5	14	20	40	20	6	sandy loam
12	Site D (24) B	2(3)	nt	nt	nt	nt	nt	medium clay
13	Site B (25) A	5	10	17	31	30	12	sandy loam

is = insufficient sample: nt = not tested



END OF TEST REPORT



SOIL TEST REPORT

Page 1 of 3

Scone Research Centre

REPORT NO: SCO12/320R1

REPORT TO: Rachel Rummery
Umwelt Australia
PO Box 768
Bendemeer NSW 2355

REPORT ON: Twenty five soil samples
Mt Owen

PRELIMINARY RESULTS
ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 17 October 2012

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
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A handwritten signature in blue ink, appearing to read "SR Young".

SR Young
(Laboratory Manager)

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO12/320R1
Client Reference: Rachel Rummery
Umwelt Australia
PO Box 768
Bendemeer NSW 2355

Lab No	Method	C1A/4	C2A/3	C2B/3	C5A/4 CEC & exchangeable cations (me/100g)						C8A/2	P9B/2	Texture
	Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	EAT	
1	Site 1 10cm	0.03	6.1	5.0	10.2	0.4	0.9	3.6	3.6	0.2	2	3(1)	sandy clay loam
2	Site 2 10cm	0.04	6.0	4.8	7.1	0.5	0.6	3.4	3.8	0.4	2	3(1)	clay loam sandy
3	Site 3 10cm	0.03	6.1	4.8	8.7	0.5	0.6	2.4	5.5	0.5	1	2(1)	light clay
4	Site 4 10cm	0.03	6.0	4.9	5.1	0.4	0.3	2.7	2.6	0.4	1	5	sandy loam
5	Site 5 10cm	0.03	6.2	4.9	9.3	0.6	0.6	3.5	5.2	0.4	1	3(1)	light clay
6	Site 6 10cm	0.03	6.1	4.8	6.3	0.4	0.3	2.6	3.4	0.5	1	3(1)	sandy clay loam
7	Site 7 10cm	0.02	5.7	4.7	2.8	0.2	0.2	1.7	1.3	0.1	2	7	loamy sand
8	Site 8 10cm	0.06	6.2	4.9	14.2	1.1	0.6	4.7	7.6	0.3	1	2(1)	light medium clay
9	Site 9 10cm	0.11	6.9	5.4	9.7	2.2	0.5	3.0	4.4	0.3	2	2(1)	silty clay
10	Site 10 10cm	0.05	5.8	4.5	3.6	0.6	0.1	1.8	2.0	0.4	1	3(1)	fine sandy clay loam
11	Site 11 10cm	0.03	6.1	4.9	13.1	0.7	0.6	4.7	6.5	0.2	1	2(1)	silty clay
12	Site 12 10cm	0.11	5.8	5.0	7.4	0.4	0.9	4.2	2.9	0.4	6	3(1)	fine sandy loam
13	Site 13 10cm	0.06	6.5	5.6	10.7	0.2	1.6	6.7	2.5	0.4	34	3(1)	fine loamy sand



SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO12/320R1
Client Reference: Rachel Rummery
Umwelt Australia
PO Box 768
Bendemeer NSW 2355

Lab No	Method	C1A/4	C2A/3	C2B/3	P9B/2	
	Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	EAT	Texture
14	Site 1 10-20cm	0.03	6.1	4.9	3(1)	sandy clay
15	Site 2 10-20cm	0.04	6.3	5.0	2(1)	sandy clay
16	Site 3 10-20cm	0.04	6.4	5.0	2(1)	medium heavy clay
17	Site 4 10-20cm	0.01	6.3	4.9	3(1)	coarse loamy sand
18	Site 5 10-20cm	0.04	6.8	5.3	2(1)	medium clay
19	Site 6 10-20cm	0.03	6.7	5.1	2(1)	sandy clay
20	Site 7 10-20cm	<0.01	6.1	4.8	2(1)	coarse loamy sand
21	Site 8 10-20cm	0.10	6.4	5.2	2(1)	heavy clay
22	Site 9 10-20cm	0.06	6.9	5.4	2(1)	clay loam
23	Site 10 10-20cm	0.10	6.8	5.4	2(2)	sandy clay loam
24	Site 11 10-20cm	0.06	6.7	5.3	2(1)	medium clay
25	Site 13 10-20cm	0.03	6.5	5.5	7	fine sandy loam



END OF TEST REPORT



Newcastle

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