Cockatoo
Coal Limited

BARALABA NORTH CONTINUED OPERATIONS PROJECT

REGIONAL INTERESTS DEVELOPMENT APPLICATION REPORT

DOCUMENT CONTROL

Current Revision

Revision	Date issued	Reviewed by	Approved by	Date approved	Rev Type
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Project:	Baralaba North Continued Operations Project
Document No:	
Document: Title	Regional Interests Development Application
Document Revision:	A
Author:	Brendan Dillon
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Revision History

Revision	Date issued	Reviewed by	Approved by	Date approved	Rev Type
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1. Contents

1. Introduction

1.1 PURPOSE OF REGIONAL INTEREST DEVELOPMENT ASSESSMENT APPLICATION REPORT

The purpose of this Regional Interest Development Assessment (RIDA) Application Report is to obtain approval under section 53 of the *Regional Planning Interest Act 2014* (Qld) (RPI Act), to undertake a resource activity specifically that of coal mining within an area of regional interest under the Central Queensland Regional Plan (CQ Regional Plan).

This RIDA Report also seeks to satisfy the requirements under section 29 (b) of the RPI Act which requires a RIDA application to be accompanied by a report –

i. Assessing the resource activity's impact on the area of regional interest; and
ii. Identifying any constraints on the configuration or operation of the activity.

The project title is the Baralaba North Continued Operations Project (referred to as the BNCOP) and it is the BNCOP which will be assessed in this RIDA Report against the relevant area of regional interest assessment criteria as required under the *Regional Planning Interest Regulation 2014* (Qld) (RPI Reg).

1.2 BACKGROUND INFORMATION

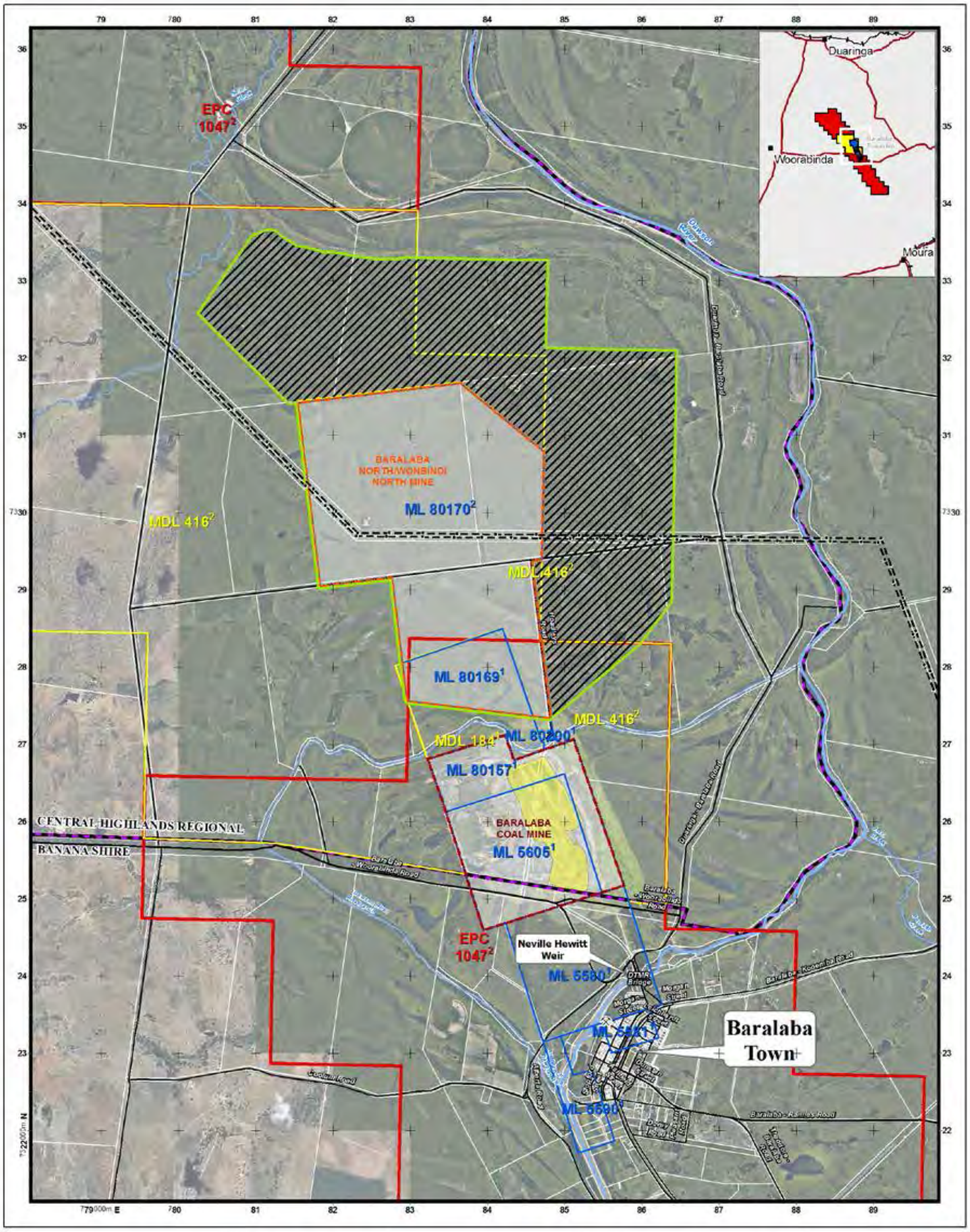
The BNCOP is located approximately 115 kilometres south-west of Rockhampton, in the lower (south-east) Bowen Basin region of Central Queensland (Qld).

The BNCOP provides for the continuation and expansion of open cut coal mining, and the introduction of processing activities at the existing Baralaba Coal Mine and the approved Baralaba North/Wonbindi North Mine (Figure 1-1). The BNCOP Disturbance Footprint is the area of additional land beyond the approved Baralaba North/Wonbindi North Mine footprint and is shown on Figure 1-1 within the green outline.

The BNCOP will produce 'greater than 2 million tonnes per annum of 'run-of-mine' (unprocessed) ore or coal', and therefore the preparation of an Environmental Impact Statement (EIS) was warranted in accordance with the Department of Environment and Heritage Protection's (DEHP) Triggers for Environmental Impact Statements under the *Environmental Protection Act 1994* (Qld) (EP Act) for mining, petroleum and gas activities (EM1128, Version 2a). Under section 72 of the EP Act, DEHP approved an application to voluntarily prepare an EIS on 5 November 2013. On 15 April 2014 the BNCOP EIS was lodged with DEHP and is currently on public notification with the submission period running from 26 May 2014 to 7 July 2014. A full version of the BNCOP EIS can be accessed at www.baralabacoal.net.au or alternatively Cockatoo Coal can provide the assessing agencies with a DVD copy of the BNCOP EIS.

Cockatoo Coal will lodge an application to amend an environmental authority following DEHP issuing an EIS Assessment Report for the BNCOP. The EA for the BNCOP would provide approvals for the Environmentally Relevant Activities (ERAs) (listed under the EP Regulation) proposed as part of the project.

A Mining Lease Application (MLA 80201) under the *Mineral Resources Act 1989* (Qld) was accepted by the Mining Register on 1 April 2014 over the area of the BNCOP Operational Land within MDL 416.



PROJECT **BCNOP REGIONAL INTERESTS DEVELOPMENT APPLICATION**	DISCLAIMER: Cockatoo Coal Ltd has exercised all due care in the production of this map. Cockatoo Coal Ltd makes no warranty or representation to the client or third parties (expressed or implied) in respect to the information conveyed on this map, particularly with regard to any commercial investment decision made on the basis of this map. Use of this map by the client or third parties shall be at their own risk, and extracts from this map may only be published with the permission of Cockatoo Coal Ltd.			0 500 1,000 1,500 2,000 Metres		
TITLE **Figure 1-1** **The BNCOP and other Existing/Approved Operations in the Immediate Vicinity**	REV	DESCRIPTION	DATE	SCALE 1:45,000	CURRENT ISSUE SIGNATURES	
	0	Original map output	12/06/14	SIZE A3	DRAWN	MJS
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Legend

- Road
- Watercourse
- Powerline & Power Pole
- Local Government Area
- Cadastre
- Cockatoo Coal ML
- Cockatoo Coal MDL
- Cockatoo Coal EPC
- Baralaba North/Wonbindi North Mine
- Baralaba Coal Mine
- Existing Operational Land
- Baralaba Central Pit
- BNCOP Area/Disturbance Footprint
- BNCOP Operational Land

STATUS **FINAL**

PROJECT NO	DRAWING NO
Baralaba Nth	BBN-117-01-00-140612

Path: N:\Baralaba\Baralaba_North\PROJECTS\140\BBN_117_140612_RIDA_Figures\BBN_117_01_00_140612_RIDA_CCL_Projects_at_Baralaba_A3P.mxd

The BNCOP was determined to be a ‘Controlled Action’ under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) on 12 December 2013. The relevant controlling provisions are:

- Listed threatened species and communities (sections 18 and 18A EPBC Act); and
- A water resource, in relation to coal seam gas development and large coal mining development (sections 24D and 24E).

The potential impacts of the BCNOP on the Matters of National Environmental Significance (MNES) protected by the EPBC Act have been assessed under DEHP’s EIS process. That process is accredited under the assessment bilateral agreement (section 45 of the EPBC Act) between the Commonwealth and Qld governments. Accordingly, assessment of the BNCOP under part 8 of the EPBC Act is not required.

The BNCOP is a component of the Baralaba Expansion Project which was declared to be a ‘Prescribed Project’ under to the *State Development and Public Works Organisation Act 1971* (Qld) on 31 July 2013 by the Minister for State Development, Infrastructure and Planning.

1.3 APPLICANT

The applicant for the BNCOP is Cockatoo Coal Limited (CCL) (ABN: 13 112 682 158).

The registered office for CCL is:

Cockatoo Coal Limited
Level 4, 10 Eagle St
Brisbane QLD 4000

CCL is listed on the Australian Stock Exchange (ASX) (ASX Code: COK) and is a metallurgical coal producer with projects in the Bowen and Surat Basins in Central Qld.

CCL is the owner of the Baralaba Coal Mine and the approved Baralaba North/Wonbindi North Mine, managed by its subsidiaries Baralaba Coal Pty Ltd (Suitable Operator Reference: 339270) and Wonbindi Coal Pty Ltd (Suitable Operator Reference: 558800).

2. Description of development

2.1 PROJECT TITLE & LOCATION

The BNCOP is located approximately 115 km south west of Rockhampton, in the lower (south east) Bowen Basin region of central Qld (Figure 2-1). The BNCOP is located approximately 45 km North of Moura, and 70 km North West of Biloela.

The BNCOP provides for the continuation and expansion of open cut coal mining and introduction of processing activities at the Baralaba Coal Mine and Baralaba North/Wonbindi North Mine. The BNCOP also incorporates the approved Baralaba Coal Mine Extension Project, including existing/approved operations within mining tenements at Baralaba Coal Mine and Baralaba North/Wonbindi North Mine up to 1 Mtpa product coal (Figure 1-1).

CCL is the owner of the Baralaba Coal Mine and Baralaba North/Wonbindi North Mine. The Baralaba North/Wonbindi North Mine is managed by CCL subsidiaries Baralaba Coal Pty Ltd (Suitable Operator Reference: 339270) and Wonbindi Coal Pty Ltd (Suitable Operator Reference: 558800) which hold or have applied for the following tenements of relevance (Figure 2-2):

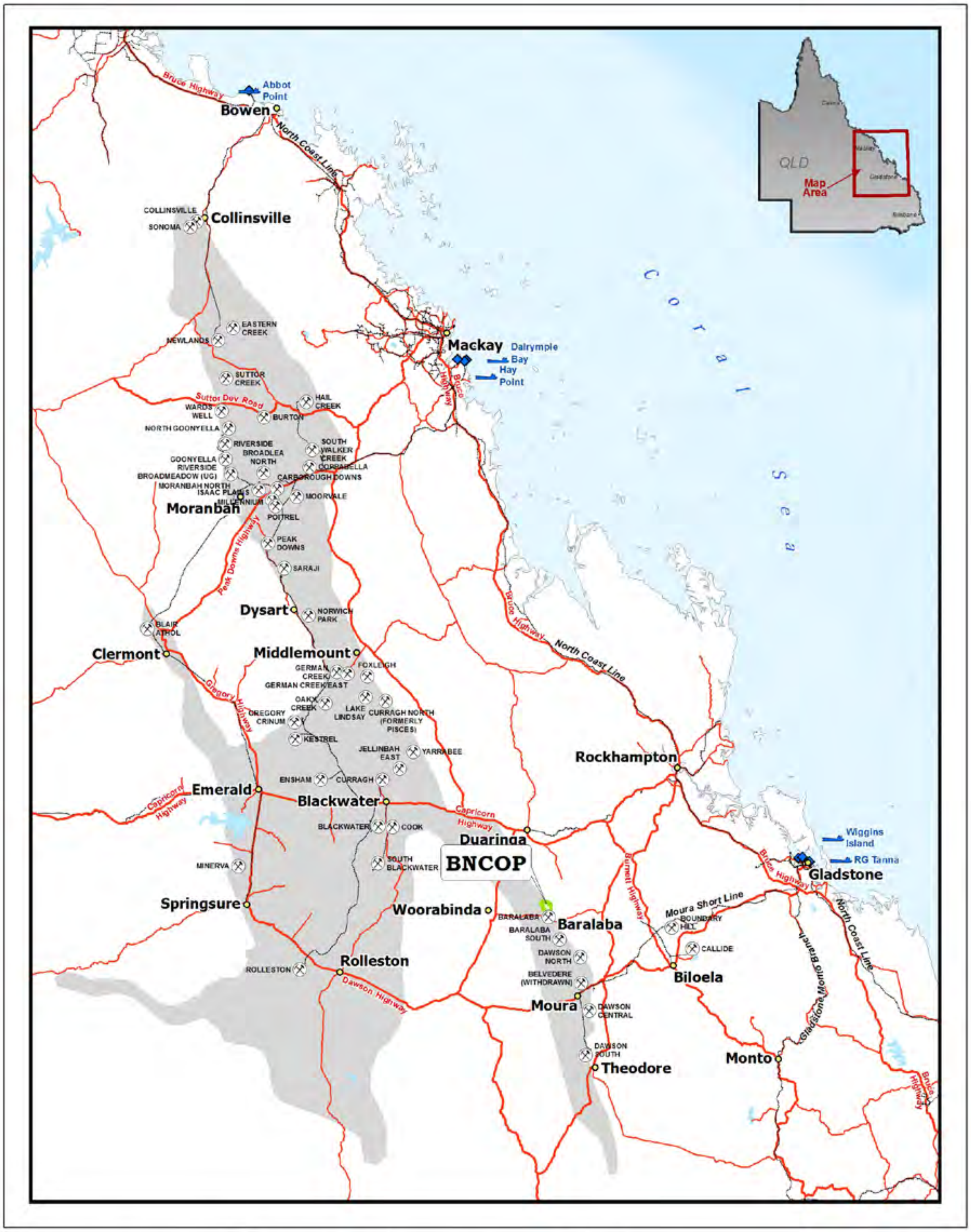
- Mining Lease (ML) 5580, ML 5581, ML 5590, ML 5605, ML 80157, ML 80169 and Mineral Development Licence (MDL) 184 (Baralaba Coal Pty Ltd); and
- ML 80170, MLA 80201, MDL 416 and Exploration Permit for Coal (EPC) 1047 (Wonbindi Coal Pty Ltd).

Relevant land ownership and tenement holder information including the proposed extent of ‘Operational Land’ for the BNCOP and adjoining lands is provided on Figures 2-2 and 2-3. CCL has also entered into a consent agreement with Queensland Coking Coal Pty Ltd on 16 August 2013 for sub-blocks C, D, J and O of CHAR142 within EPC 1237. These four sub-blocks are adjacent to and east of ML 80169, ML 80170 and MDL 416 (Figure 2-3).

The relevant details of the freehold land on which the BNCOP is proposed can be found below in Table 1.

Table 1 BNCOP Freehold Land

Lot & Plan	Owner
11KM46	Wonbindi Coal Pty Ltd
6KM44	Wonbindi Coal Pty Ltd
1SP235019	Baralaba Coal Pty Ltd
2SP235019	Baralaba Coal Pty Ltd
12SP256221	Baralaba Coal Pty Ltd
7KM44	Wonbindi Coal Pty Ltd
2RP618842	Baralaba Coal Pty Ltd
1RP618842	Baralaba Coal Pty Ltd
13KM182	GA & MJ Austin
14KM183	GA & MJ Austin



PROJECT

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Legend

Coal Terminal ◆
Coal Mine - Operating ⚒
Populated Place ○
Road
Rail
Watercourse
Bowen Coal Basin
BNCOP Operational Land ▭

TITLE

Figure 2-1
Regional Location

REV	DESCRIPTION	DATE
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3		

SCALE 1:2,000,000
SIZE A3
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PROJECTION MGA Zone 55

CURRENT ISSUE SIGNATURES	
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APPROVED	BJD

STATUS **FINAL**

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DRAWING NO BBN-117-02-00-140612

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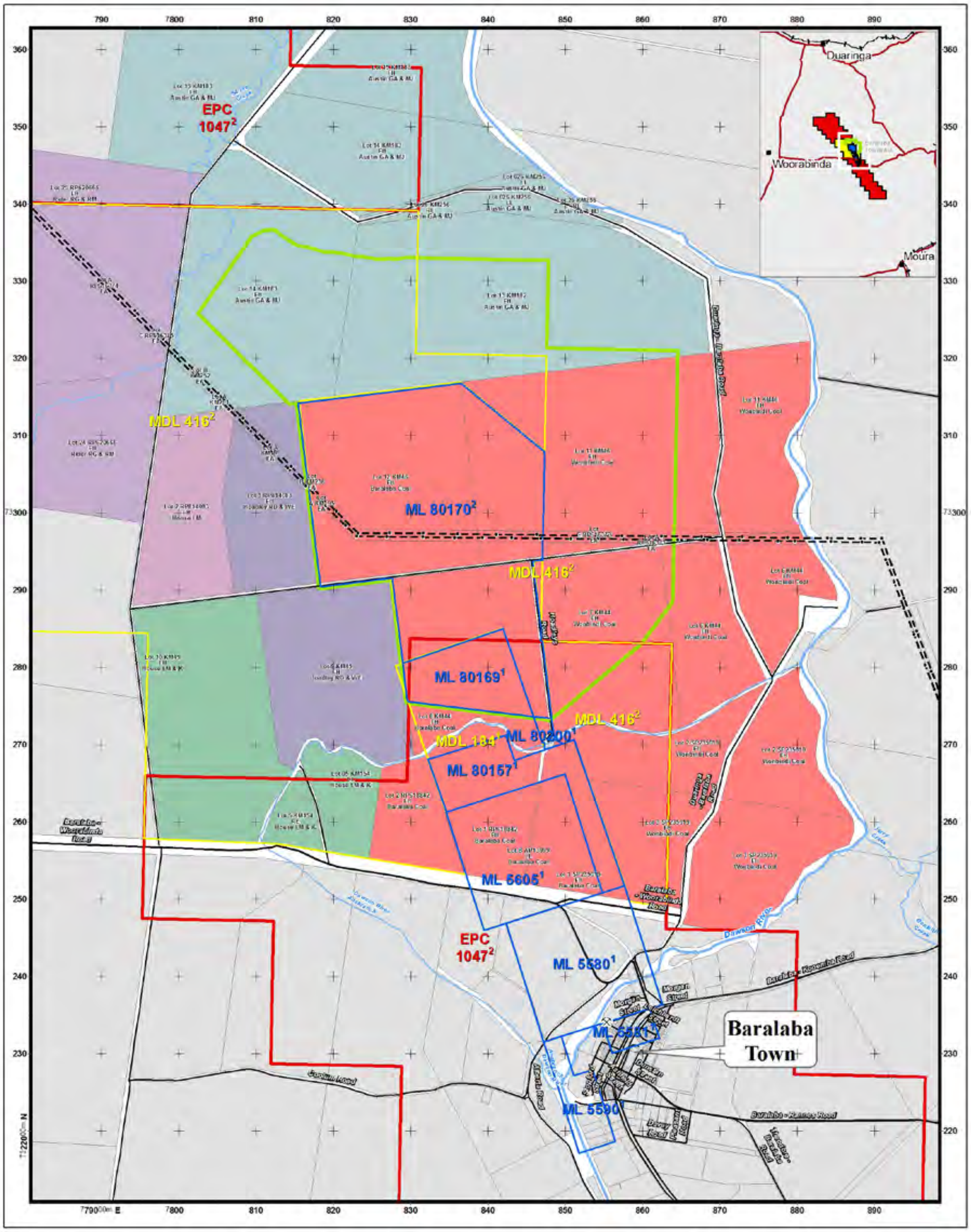

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**Figure 2-2
Land Ownership**

REV	DESCRIPTION	DATE			
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2			PROJECTION MGA Zone 55	APPROVED	BJD

Legend
Road
Watercourse
Cadastre
Cockatoo Coal ML
Cockatoo Coal MDL
Cockatoo Coal EPC
Powerline & Power Pole
BNCOP Operational Land

STATUS **FINAL**

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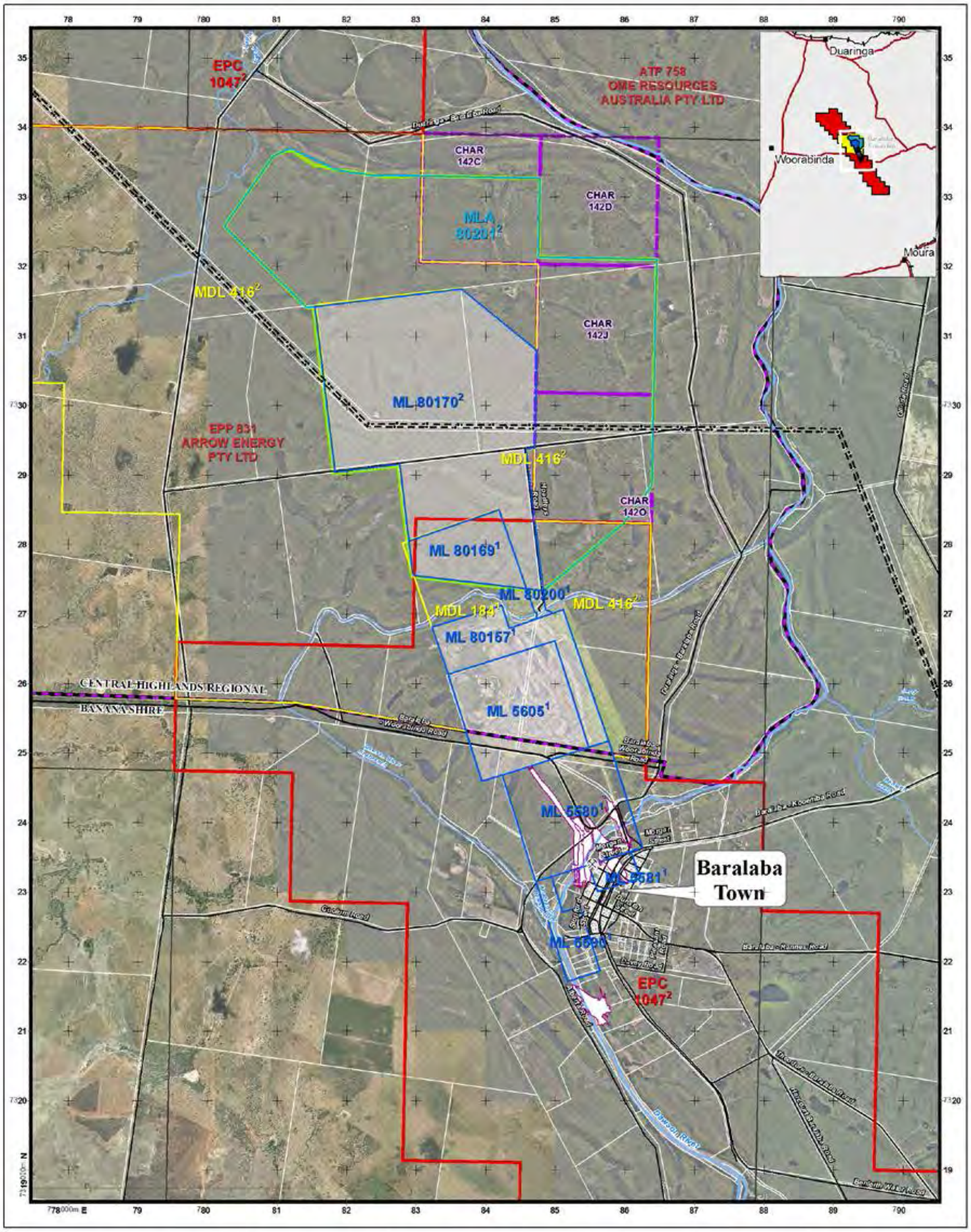

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Legend

Road		Powerline & Power Pole	
Watercourse		Local Government Area	
Cadastre		Existing Operational Land	
Cockatoo Coal ML		BNCOP Operational Land	
Cockatoo Coal MLA		EPC 1237 - Sub-blocks	
Cockatoo Coal MDL	🟨	Historic Mines Working	
Cockatoo Coal EPC	🟥	Authorities to Prospect for Petroleum	

TITLE

Figure 2-3
Resource Tenements

REV	DESCRIPTION	DATE		CURRENT ISSUE SIGNATURES	
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2			PROJECTION MGA Zone 55	APPROVED	BJD

STATUS **FINAL**

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Other land within the BNCOP area is listed below in Table 2.

Table 2 BNCOP Easements

Easement	Owner
AKM195	Powerlink Queensland
ARP616373	Powerlink Queensland
CRP616373	Powerlink Queensland
BKM238	Powerlink Queensland
Hoadleys Road	Central Highlands Regional Council
Other Minor Roads/Laneways	Central Highlands Regional Council
Dawson River Anabranch	Central Highlands Regional Council

2.2 PROJECT OBJECTIVES AND RATIONALE

CCL is a user in the Stage One development of the Wiggins Island Coal Export Terminal (WICET) with a 3 Mtpa allocation in addition to CCL's existing export rate of 0.5 Mtpa through the RG Tanna Coal Terminal (RGTCT) at the Port of Gladstone (Figure 2-1).

The existing target resource at the Baralaba Coal Mine (Baralaba Central pit) has limited economic mining life (anticipated to be completed by the end of 2014). Accordingly, CCL has been conducting an active exploration program to the North and South of the current Baralaba Coal Mine.

CCL has optimised the 3.5 Mtpa product coal Baralaba Expansion Project, examining all the options to secure the long-term future of the Baralaba Coal Mine, including reevaluating the feasibility of the Baralaba South Project. A supplementary bankable feasibility study conducted by CCL has concluded that the BNCOP is favoured over the Baralaba South Project.

Whilst the Baralaba Coal Mine Extension Project was approved during 2013 to increase production from the Baralaba Coal Mine and Baralaba North/Wonbindi North Mine up to 1 Mtpa of product coal for at least 15 years, expansion to increase production from the Baralaba North pit to 3.5 Mtpa product coal is now required to meet "take or pay" commitments (dated 27 September 2011) at WICET.

The BNCOP would mean job security for the 135 people currently employed at the Baralaba Coal Mine, and also allow CCL to continue to support local suppliers of the operations, providing additional security and longevity of employment within the Central Qld Region. The proposed future workforce for the BNCOP is up to approximately 430 people at peak [including construction].

2.3 NATURE AND SCALE OF THE BNCOP

The Baralaba Coal Mine is an existing open cut mining operation (i.e. a brownfield site). Initial development works at the Baralaba North/Wonbindi North Mine commenced in 2013 and coal production started in May 2014.

Operations and activities at the Baralaba Coal Mine and Baralaba North/Wonbindi North Mine are conducted 24 hours per day, seven days per week in accordance with the requirements of Environmental Authority (EA) (Mining Activities) Non Code Compliant Level 1 Mining Project Permit Numbers:

- EPML00223213 – Baralaba Coal Mine; and
- EPML00617113 – Baralaba North/Wonbindi North Mine.

It is acknowledged that the open cut mining operations on ML 80169 (held by Baralaba Coal Pty Ltd) and ML 80170 (held by Wonbindi Coal Pty Ltd) will be operated as a single open cut mining operation by way of the “Baralaba North Mine Project Cooperation Deed”. The open cut mining operations are jointly referred to as the Baralaba North/Wonbindi North Mine.

In accordance with EA EPML00223213 and EA EPML00617113, up to 1 Mtpa of ROM coal is currently approved for extraction from the Baralaba North/Wonbindi North Mine (ML 80169 and ML 80170 combined) and up to 750,000 tpa of ROM coal from Baralaba Coal Mine (ML 5605 and ML 80157 combined), with total production averaging 1 Mtpa product coal from Baralaba Coal Mine and Baralaba North/Wonbindi North Mine.

Up to 3.5 Mtpa of product coal would need to be produced at the BNCOP to meet CCL’s full “take or pay” allocation requirement at the Port of Gladstone (i.e. RGTCT and WICET) (Figure 2-1).

The approximate extent of the open cut mining area for the BNCOP is approximately 2,498 hectares (ha), including surface development areas in support of the operations and areas already approved for disturbance on ML 80169 and ML 80170 in accordance with EPML00223213 – Baralaba Coal Mine and EPML00617113 – Baralaba North/Wonbindi North Mine.

2.4 PROJECT GENERAL ARRANGEMENT

The general arrangement of the BNCOP uses existing infrastructure and services facilities at the Baralaba Coal Mine and integrates with the development of the approved Baralaba North/Wonbindi North Mine.

The main activities associated with the development of the BNCOP include (Figure 2-2):

- ROM coal production up to 4.1 Mtpa for an additional 15 years (commencing approximately 1 April 2015 subject to obtaining all required approvals), including mining operations associated with:
    - continued development of the Baralaba North pit;
    - extension of the Baralaba North pit further North within MLA80201; and
    - spoil dump to the east of the Baralaba North pit within MLA80201.
- exploration activities;
- progressive backfilling of the mine void with waste rock behind the advancing open cut mining operations at the Baralaba North/Wonbindi North Mine and/or within the Baralaba Central void;
- continued and expanded placement of waste rock in spoil dumps adjacent to the pit extents;
- progressive development of new haul roads and internal roads;
- construction and operation of a CHPP at the Baralaba North/Wonbindi North Mine ;
- disposal of CHPP rejects on-site within the mine void behind the advancing open cut mining operations and/or within the Baralaba Central void;
- progressive development of sediment dams and storage dams, pumps, pipelines and other water management equipment and structures (including levees);
- continued development of soil stockpiles, laydown areas and borrow areas;
- use of upgraded administration and maintenance facilities at the Baralaba Coal Mine and establishment of new mine infrastructure areas at the Baralaba North/Wonbindi North Mine;

- other associated minor infrastructure, plant, equipment and activities, including minor modifications and alterations to existing infrastructure as required to accommodate the increased throughput;
- continued road transport of product coal (using AB triple and AAB quad road-trains) along the existing product coal road transport route (a network of public roads including Theodore-Baralaba Road) to new product coal stockpiles and TLO facility (subject to separate approvals being in place); and
- use of new product coal stockpiles and TLO facility for loading of product coal to trains for transport by rail and export via Gladstone.

Based on the planned maximum production rate, approximately 52 (Mt) of product coal would be produced during the 15 years of the BNCOP.

Indicative general arrangements for Year 3, Year 7, Year 8, Year 11 and Year 15 are shown on Figures 2-3 to 2-7. These indicative general arrangements are based on planned maximum production and mine progression. The mining layout and sequence may vary to take account of localised geological features (Figure 2-8), coal market volume and quality requirements, mining economics and BNCOP detailed engineering design.

2.4.1 Project Justification

A description of the need for and objectives of the BNCOP and a justification of the carrying out of the BNCOP in the manner proposed is provided below. This is provided having regard to biophysical, economic and social considerations, including consideration of alternatives and the consistency of the BNCOP with the objects of the EP Act.

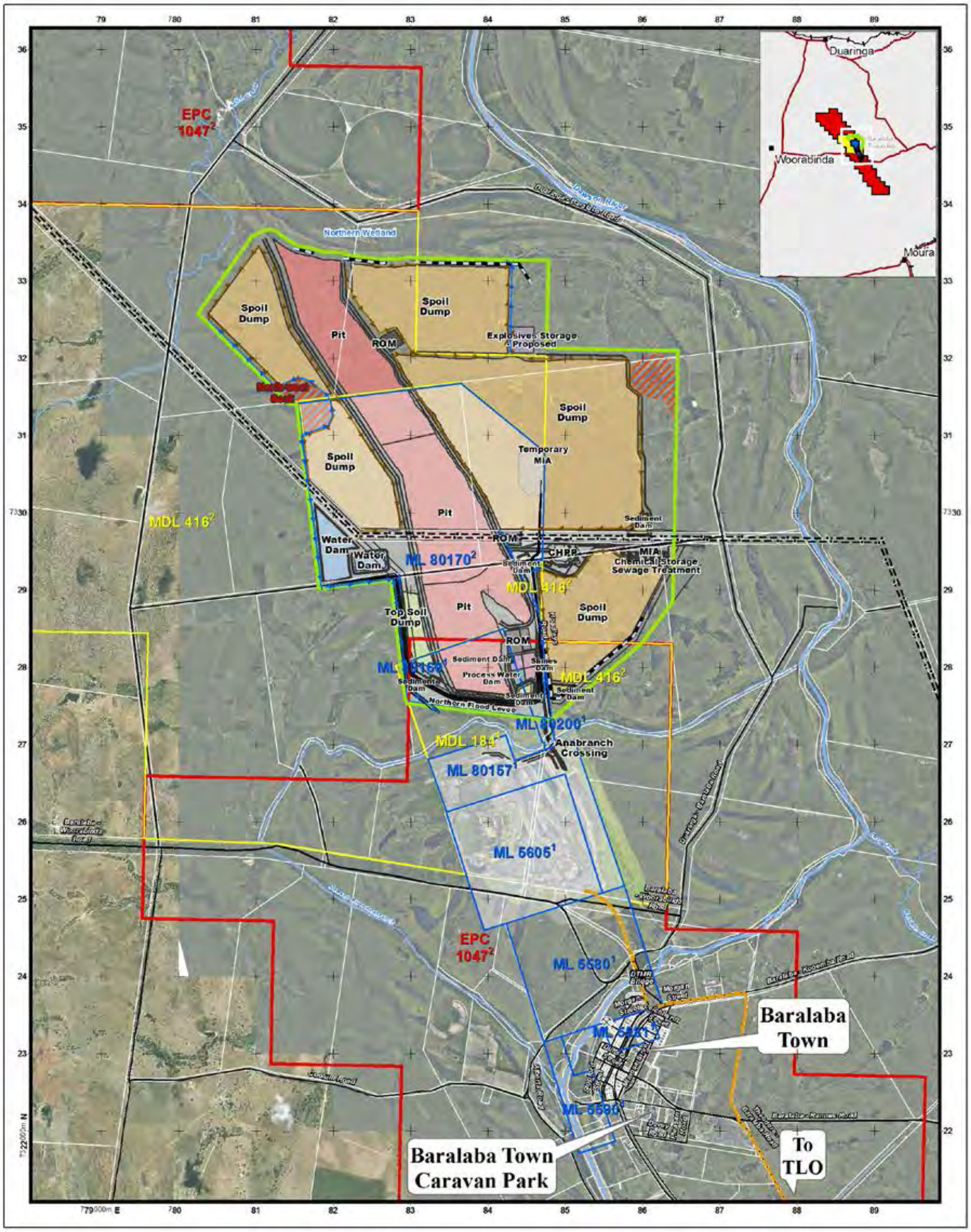
Need for the BNCOP

The BNCOP provides for the continuation and extension of open cut coal mining and the introduction of processing activities at the Baralaba Coal Mine and Baralaba North/Wonbindi North Mine to approximately 2030. The mining of the Baralaba Central pit at the Baralaba Coal Mine is scheduled for completion in 2014. While the approved Baralaba North/Wonbindi North Mine will continue beyond 2015, the mining rate is not sufficient to meet the “take or pay” commitments made by CCL (dated 27 September 2011) at the WICET.

At full development, the BNCOP provides for an operational workforce in the order of 380 on-site personnel, including a mixture of direct CCL employees and contractors. Short-term construction/development activities would require an additional construction workforce for short periods, resulting in a total workforce of approximately 430 people (peak).

The BNCOP would involve the production of up to 4.1 Mtpa of ROM coal with approximately 52 Mt of coal extracted over the life of the project. Based on the planned maximum production rate and processing of ROM coal mined from the BNCOP, the total product coal available to the Australian and World market would be up to 3.5 Mtpa. BNCOP coal production would contribute to Qld export income, State royalties and Commonwealth tax revenue, as well as contributing to electricity supply and manufacturing in Australia and other countries that purchase BNCOP coal.

The Qld Government (2008) anticipates Qld’s coal exports could almost double by 2030, generating significant economic growth in the State. In recognition of the BNCOP’s potential contribution to this growth, the Baralaba Expansion Project was declared a ‘Prescribed Project’ pursuant to section 76E of the SDPWO Act.



PROJECT

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Legend

- Road
- Watercourse
- Cadastre
- Cockatoo Coal ML
- Cockatoo Coal MDL
- Cockatoo Coal EPC
- Area of Exclusion of Mining Activities
- Product Road Transport Route
- Powerline & Power Pole
- BNCOP Operational Land
- Clean Water Drain
- Dirty Water Drain
- Proposed Flood/Erosion Protection Levee

TITLE

Figure 2-4
Indicative Project Layout

REV	DESCRIPTION	DATE
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SCALE 1:45,000	CURRENT ISSUE SIGNATURES	
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PROJECTION MGA Zone 55	APPROVED	BJD

STATUS **FINAL**

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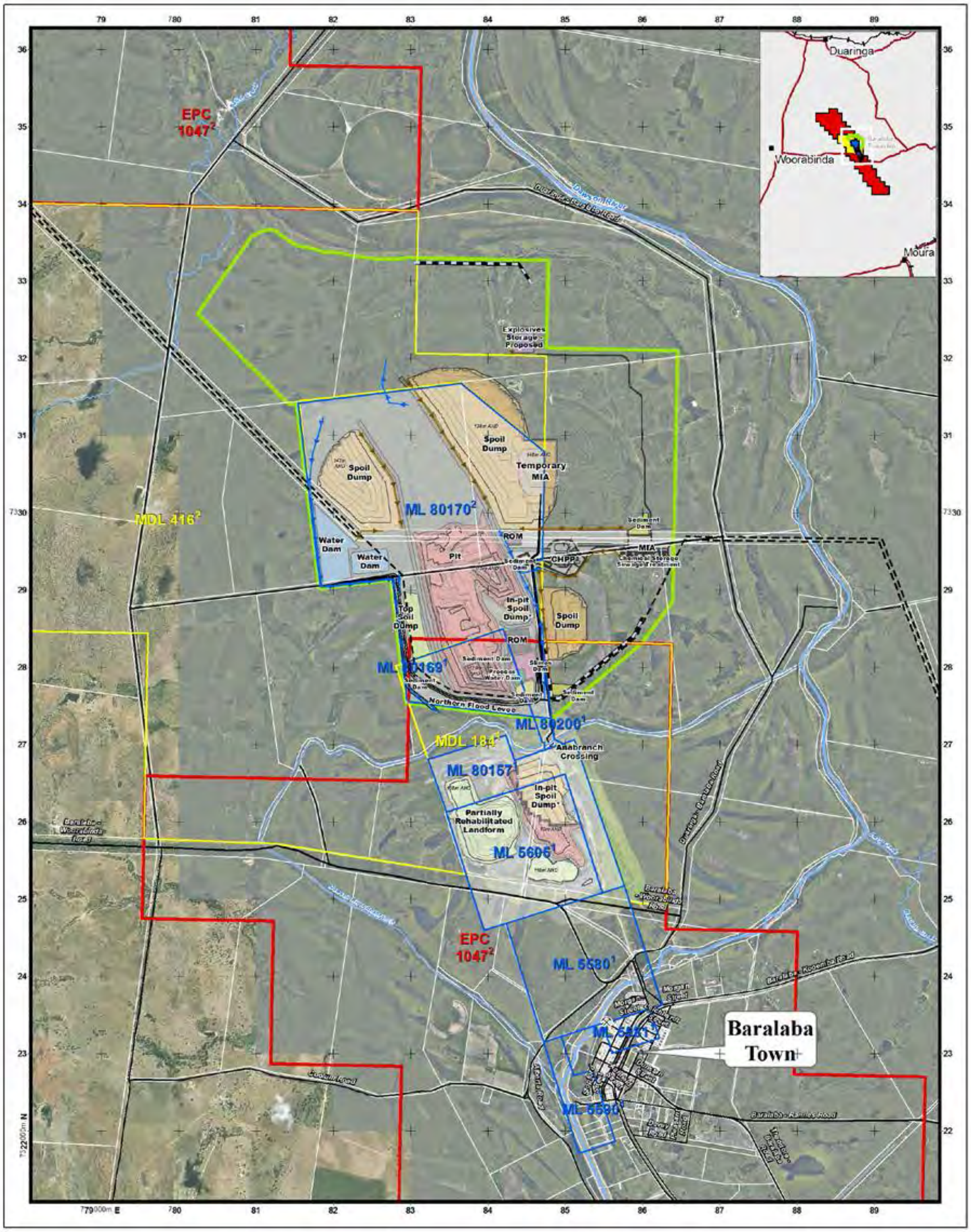

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* INCLUDING CHPP REJECTS CO-DISPOSAL

TITLE

Figure 2-5
Indicative Project Layout
Year 3

REV	DESCRIPTION	DATE
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SCALE 1:45,000	CURRENT ISSUE SIGNATURES	
SIZE A3	DRAWN	MJS
DATUM GDA 94	CHECKED	BJD
PROJECTION MGA Zone 55	APPROVED	BJD

Legend

Road		Pipeline & Power Pole	
Watercourse		BNOOP Operational Land	🟩
Cadastre		Clean Water Drain	
Cockatoo Coal ML	🟦	Dirty Water Drain	
Cockatoo Coal MDL	🟨	Proposed Flood/Erosion Protection Levee	
Cockatoo Coal EPC	🟥		

STATUS
FINAL

PROJECT NO	DRAWING NO
Baralaba Nth	BBN-117-06-00-140612

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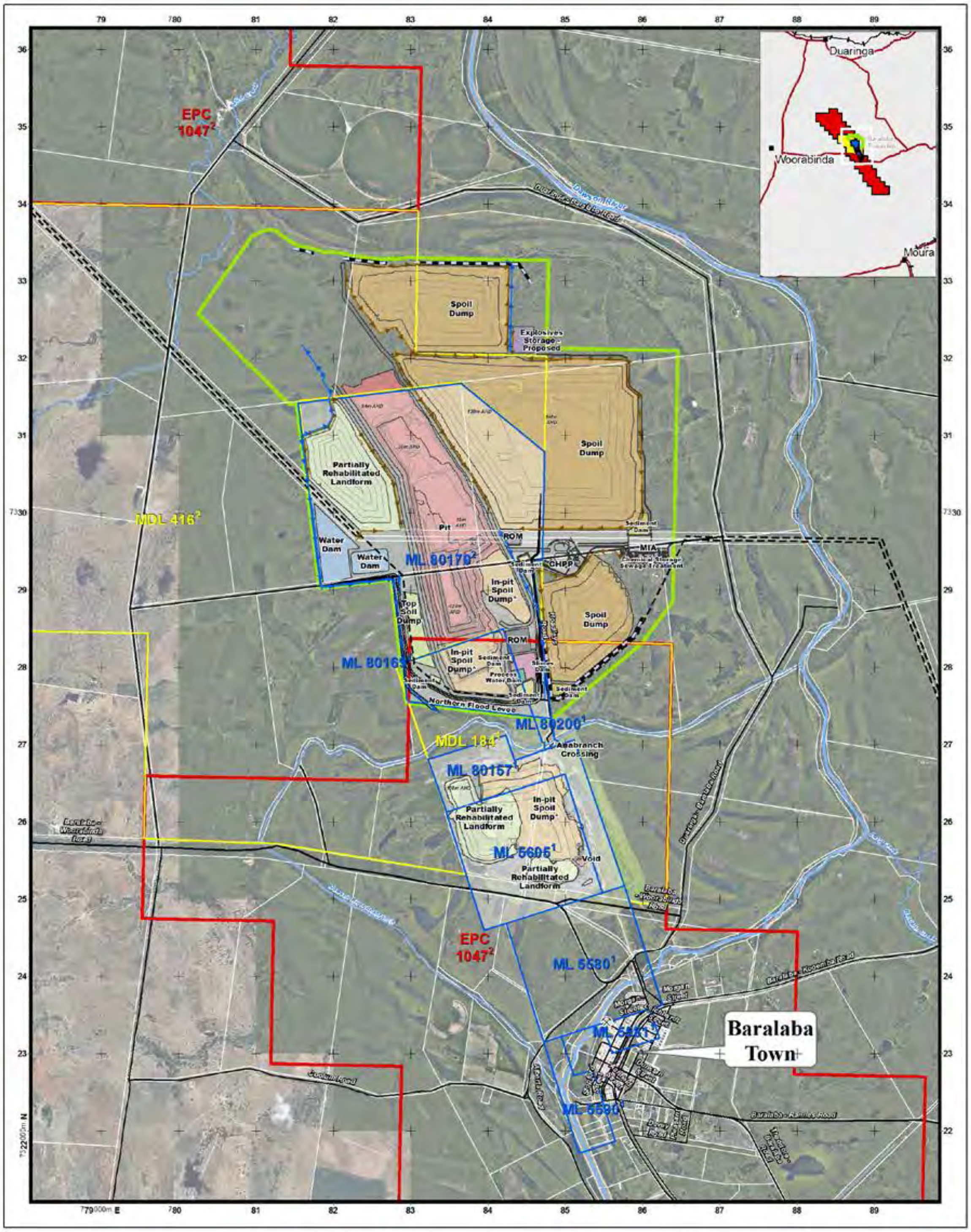

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BCNOP
REGIONAL INTERESTS
DEVELOPMENT APPLICATION

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Legend

Road	⟋	Pipeline & Power Pole	⟋
Watercourse	⟋	BNCOP Operational Land	🟩
Cadastre	⟋	Clean Water Drain	➚
Cockatoo Coal ML	▭	Dirty Water Drain	➚
Cockatoo Coal MDL	🟨	Proposed Flood/Erosion Protection Levee	⟋
Cockatoo Coal EPC	🟥		

TITLE

Figure 2-6
Indicative Project Layout
Year 7

REV	DESCRIPTION	DATE		CURRENT ISSUE SIGNATURES	
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2			PROJECTION MGA Zone 55	APPROVED	BJD

STATUS **FINAL**

PROJECT NO	DRAWING NO
Baralaba Nth	BBN-117-07-00-140012

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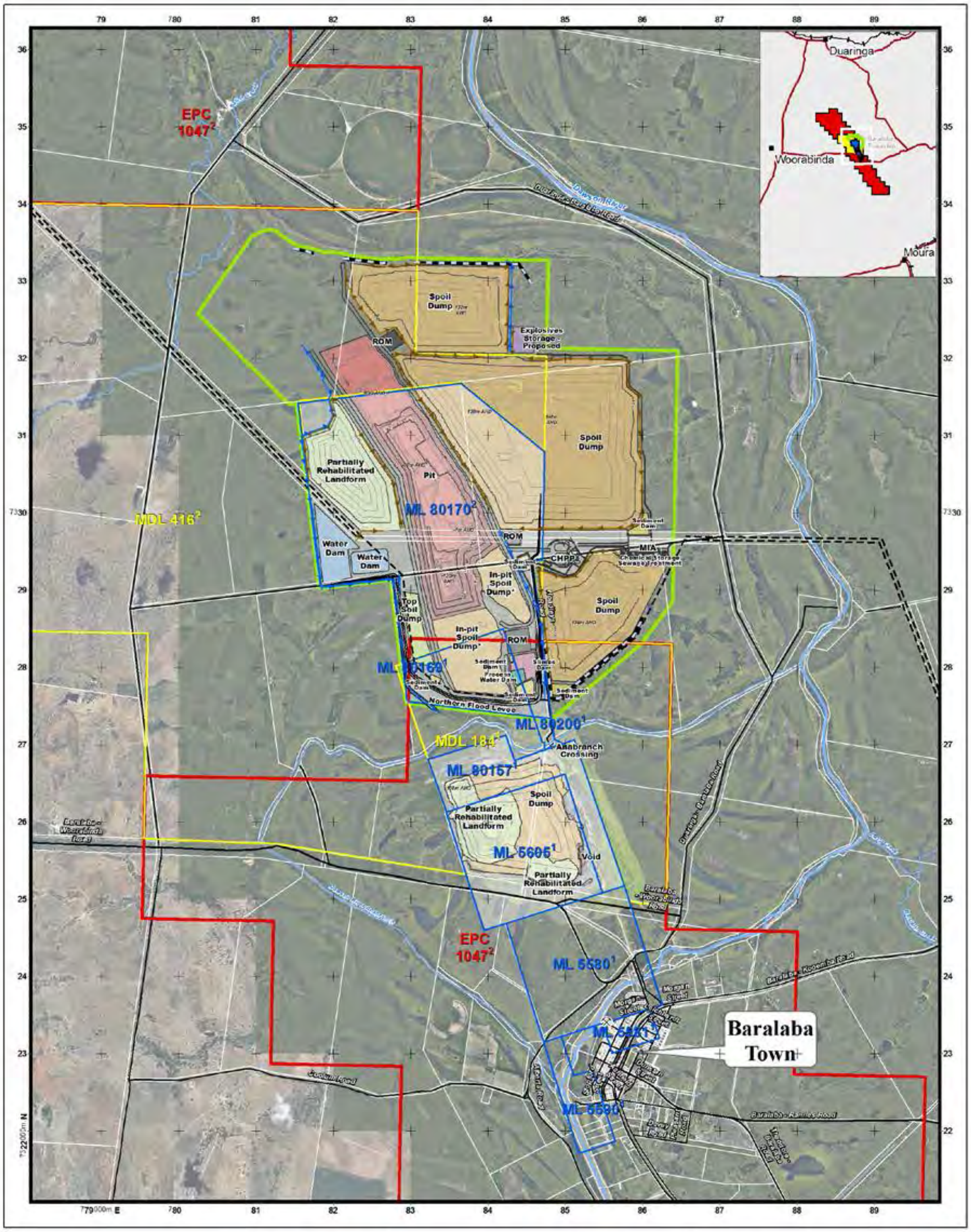

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TITLE

Figure 2-7
Indicative Project Layout
Year 8

REV	DESCRIPTION	DATE
0	Original map output	12/06/14
1		
2		

SCALE 1:45,000	CURRENT ISSUE SIGNATURES	
SIZE A3	DRAWN	MJS
DATUM GDA 94	CHECKED	BJD
PROJECTION MGA Zone 55	APPROVED	BJD

Legend

Road	Pipeline & Power Pole
Watercourse	BNCOP Operational Land
Cadastre	Clean Water Drain
Cockatoo Coal ML	Dirty Water Drain
Cockatoo Coal MDL	Proposed Flood/Erosion Protection Levee
Cockatoo Coal EPC	

STATUS
FINAL

PROJECT NO:	DRAWING NO:
Baralaba Nth	BBN-117-08-00-140612

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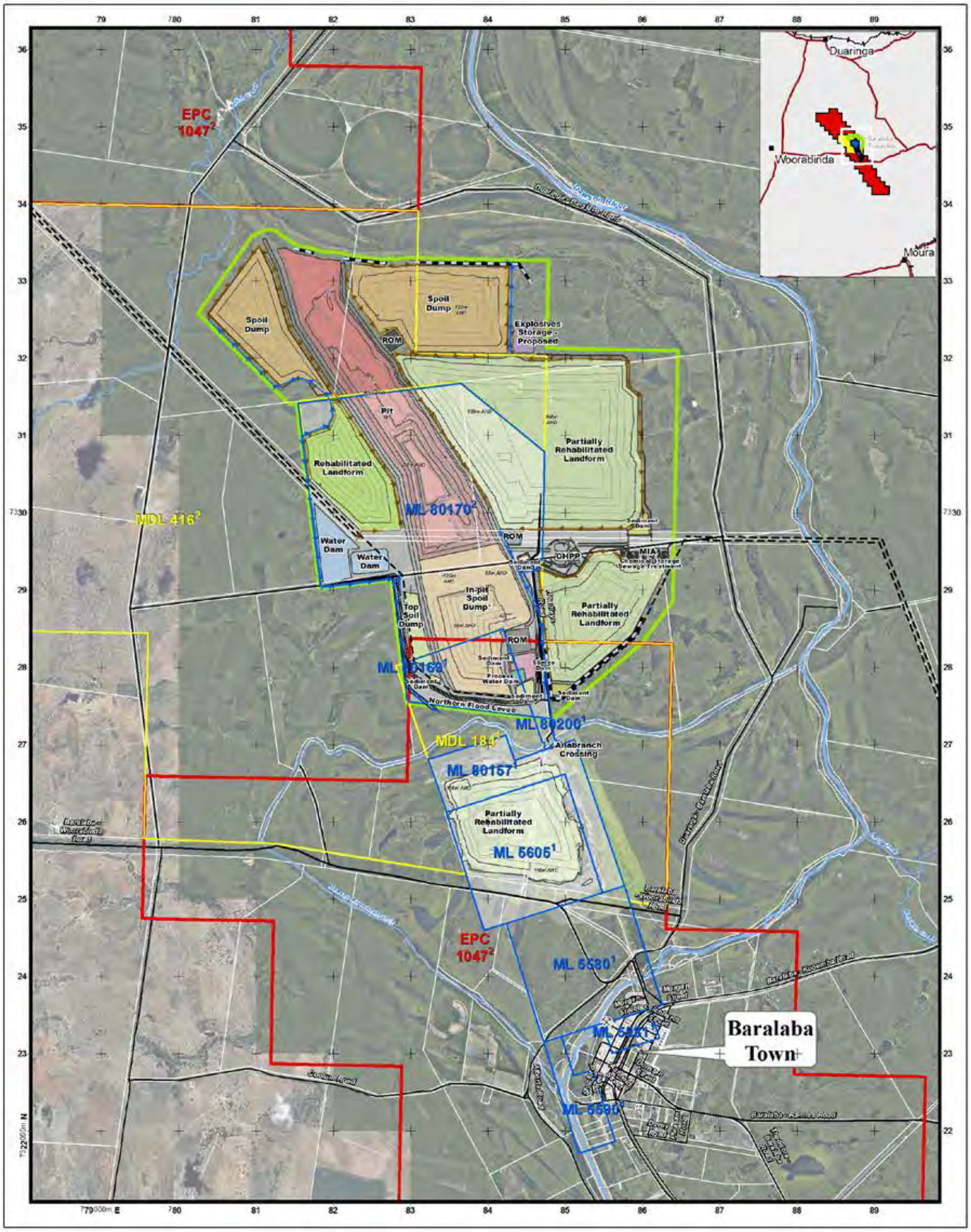

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TITLE

Figure 2-8
Indicative Project Layout
Year 11

REV	DESCRIPTION	DATE
0	Original map output	12/06/14
1		
2		

SCALE 1:45,000	CURRENT ISSUE SIGNATURES		
SIZE A3	DRAWN	MJS
DATUM GDA 94	CHECKED	BJD
PROJECTION MGA Zone 55	APPROVED	BJD

Legend
Road
Watercourse
Cadastre
Cockatoo Coal ML
Cockatoo Coal MDL
Cockatoo Coal EPC
Pipeline & Power Pole
BNCOP Operational Land
Clean Water Drain
Dirty Water Drain
Proposed Flood/Erosion Protection Levees

STATUS **FINAL**

PROJECT NO	DRAWING NO
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The BNCOP Economic Assessment (Appendix A) indicates that operation of the BNCOP is likely to result in an incremental average annual stimulus of up to approximately 472 direct and indirect jobs in the Banana and Central Highlands local government areas (LGAs) and some 2,460 direct and indirect jobs in Qld. The BNCOP would also make contributions to regional and Qld output or business turnover and household income

The benefit cost analysis in Appendix A indicates a net benefit of $856M would be forgone if the BNCOP is not implemented.

Project Alternatives considered

A number of alternatives to the BNCOP assessed in the EIS were considered by CCL in the development of the BNCOP project description, including further consideration of alternatives following lodgement of the Project Description in September 2013. A description of key alternatives considered by CCL is described below.

Location

The location for the BNCOP is determined by the presence of coal seams that are amenable to be economically mined in the vicinity of the existing Baralaba Coal Mine and Baralaba North/Wonbindi North Mine. The BNCOP involves an extension to an existing open cut in the Permian Baralaba Coal Measures.

The continued development of coal resources in close proximity to CCL's existing facilities allows utilisation of existing infrastructure and associated returns on existing financial investments. It also provides opportunities to minimise the additional land disturbance area associated with the BNCOP, as described further below.

Mining Operations

The relative scale, rate and nature of the proposed mining operation is determined by the optimum resource recovery and production rate that maximises value to CCL and demonstrates ongoing viability in consideration of mine planning constraints and CCL's "take or pay" commitments at WICET.

Mine planning is a process that takes into account the range of key variables that may influence a potential mining operation and its viability. Aspects considered in the mine planning process include safety, resource recovery, potential environmental impacts (e.g. noise, air quality, water), community issues, risks to the operation, mining methods and rates, equipment requirements, infrastructure capacity, development timeframes and economics (i.e. capital and operating costs).

Mining Method

The key alternatives with respect to the proposed mining operations are:.

- underground methods (whereby the coal is accessed via a small surface opening leading to sub-surface excavations which expose the coal); or
- open cut methods (whereby mining occurs from the surface downwards to progressively expose the coal).

Due to the proximity of the coal to the surface, the presence of faulting and the dipping nature of the coal seams in the BNCOP area (i.e. the seams are not flat or gently sloping and have dip angles of up to approximately 55^{o}), CCL has not identified any economically viable underground mining method for extraction of coal in the BNCOP area to date.

Accordingly, the BNCOP has no alternative but to utilise open cut mining methods to recover approximately 52 Mt of coal over the life of the project.

Minimising the Additional Project Surface Development Area

CCL has evaluated the relative costs and environmental benefits of a number of alternative mechanisms to reduce the potential additional disturbance area associated with the BNCOP.

The following refinements to the mine design have resulted in minimising additional land disturbance and related impacts to flora, fauna and associated habitats:

- optimising the backfilling of the open cut to minimise the overall mine footprint;
- extending the height and extent of the existing spoil dumps where possible (i.e. dumping over and extending the existing mine landforms) rather than establishing new spoil dumps;
- use of existing open cut void if required (e.g. for water storage to reduce the need for specifically constructed storages); and
- adjusting the proposed general arrangement to specifically avoid clearance of three key areas of surrounding wetlands (Figure 2-2), specifically the:
    - North-west Soak;
    - large Palustrine wetland to the north of the BNCOP Operational Land; and
    - wetland protection area in the north-east of the BNCOP Operational Land.

3. Application Justification

3.1 STATE PLANNING FRAMEWORK

3.1.1 State Planning Policy

The Queensland Government established the single State Planning Policy (SPP) in December 2013 to simplify and clarify matters of state interest in land use planning and development. The SPP, which replaced multiple planning policies, is a key component of Queensland's land use planning system that enables development, protects our natural environment and allows communities to grow and prosper.

The SPP provides clarity to local governments when making and amending local planning instruments and assessing development applications and assists developers in preparing development applications. The comprehensive presentation of the State's interests makes it easier for local governments to reflect and balance state interests 'up front' in local planning schemes, ensuring the right developments are approved in the right locations without undue delays.

Through the SPP, the state sets out the interests that must be addressed through local government planning schemes, regional plans and when making decisions about the designation of land for community infrastructure.

Rather than mandate prescriptive processes, the SPP has a strong emphasis on finding solutions which are regionally, locally and site appropriate. It does this by outlining what outcomes must be achieved in relation to state interests, while enabling local government to determine how best to do this for their particular community. It encourages flexible and locally appropriate approaches to planning that reflect the state’s interests while meeting the needs and priorities of local government and their communities.

The BNCOP is not inconsistent with the intent of the SPP as CCL strongly believes that the BNCOP strikes the right balance between the State interests of agriculture, mining and liveable communities. Section 3.2.2 of the RIDA Report provides detailed discussion on the BNCOP’s consistency with the SPP.

3.1.2 Central Queensland Regional Plan

The CQ Regional Plan has a strong focus on resolving land use competition between the agricultural and the resource sectors and driving economic development.

The policies contained in the CQ Regional Plan contribute towards the protection of strategic areas of Priority Agricultural Land Use (PALU) from potentially incompatible resource activities and maximise opportunities for co-existence of resources and agricultural land use.

The CQ Regional Plan also safeguards areas required for the growth of towns in the region through the establishment of Priority Living Areas. Resource activities may locate within these areas marked for residential expansion where doing so meets communities' expectations as determined by the relevant local government.

The regional outcomes and policies contained in Chapter 4 of the CQ Regional Plan align with and advance the achievement of the state’s interest in relation to:

- supporting the long-term viability and growth of the agricultural sector
- maximising the productive use of key mining resources
- providing for liveable communities.

The CQ Regional Plan provides additional protection for both the region's highly productive agricultural uses and towns by providing regional outcomes and policies which aim to:

- protect PALUs while supporting co-existence opportunities for the resources sector
- provide certainty for the future growth of towns.

The CQ Regional Plan outcomes and policies are as listed below:

Table 3 Priority Agriculture Areas - Regional Outcomes & Policies

Protecting Priority Agricultural Land Uses while supporting co-existence opportunities for the resources sector
Regional outcome Agriculture and resources industries within the Central Queensland region continue to grow with certainty and investor confidence.
Regional policy 1 Protect Priority Agricultural Land Uses within Priority Agricultural Areas.
Regional policy 2 Maximise opportunities for co-existence of resource and agricultural land uses within Priority Agricultural Areas.

Table 4 Priority Living Areas - Regional Outcomes & Policies

Providing certainty for the future of towns
Regional outcome The growth potential of towns within the Central Queensland region is enabled through the establishment of Priority Living Areas. Compatible resource activities within these areas which are in the communities' interest can be supported by local governments.
Regional policy 3 Safeguard the areas required for the growth of towns through the establishment of Priority Living Areas
Regional policy 4 Provide for resource activities to locate within a Priority Living Area where it meets the communities' expectations as determined by the relevant local government.

The BNCOP has considered the above regional outcomes and regional policies of the CQ Regional Plan throughout all stages of Project development - from mine planning through to employment policies and accommodation strategies. In doing so the BNCOP has achieved the two key regional outcomes of the CQ Regional Plan, with the first being coexistence between the agricultural and resource sectors and the second being providing certainty for future towns. The specifics of how the BNCOP achieves these regional outcomes can be found below in section 3.2.2.

3.2 REGIONAL PLANNING LEGISLATIVE FRAMEWORK

3.2.1 Regional Planning Interests Act 2014

The purposes of the RPI Act as defined under section 3(1) are to:

a) Identify areas of Queensland that are of regional interest because they contribute, or are likely to contribute, to Queensland's economic, social and environmental prosperity; and
b) Give effect to the policies about matter of State interest stated in regional plans; and
c) Manage, including in ways identified in regional plans –
  i. The impact of resource activities and other regulated activities on areas or regional interest; and
  ii. The coexistence, in areas of regional interest, of resource activities and other regulated activities including, for example, highly productive agricultural activities.

Section 7 of the RPI Act states that each of the following is an area of regional interest:

a) a priority agricultural area;
b) a priority living area;
c) the strategic cropping area;
d) a strategic environmental area.

Under section 12(1) of the RPI Act a resource Act is any of the following—

(a) Geothermal Energy Act 2010;

(b) Greenhouse Gas Storage Act 2009;

(c) Mineral Resources Act 1989;

(d) Petroleum Act 1923;

(e) Petroleum and Gas (Production and Safety) Act 2004.

In addition to the above section 12(2) of the RPI Act a resource activity is—

(a) an activity for which a resource authority is required to lawfully carry out; or

(b) for a provision about a resource authority or proposed resource authority—an authorised activity for the authority or proposed authority (if granted) under the relevant resource Act.

Finally under section 13 of the RPI Act a resource authority is any of the following—

(a) a geothermal tenure under the Geothermal Energy Act 2010;

(b) a GHG permit or GHG lease under the Greenhouse Gas Storage Act 2009;

(c) each of the following under the Mineral Resources Act 1989—

  (i) a mining tenement other than a prospecting permit;

  (ii) an approval that grants rights over land;

  (d) a 1923 Act petroleum tenure under the Petroleum Act 1923;

The BNCOP falls within the definition of a resource activity as the BNCOP mining lease (MLA80201) will be approved under the *Mineral Resources Act 1989* (Qld), a resource Act. Section 3.2.1.1 through to section 3.2.1.4 below explore the four areas of regional interest as defined under section 7 of the RPI Act and the relevance of each to the BNCOP.

3.2.1.1 Priority Agricultural Area

Under section 8(1) of the RPI Act, a priority agricultural area is an area that*:*

i. Includes 1 or more areas used for a PALU, whether it also includes other areas or features, including, for example, a regionally significant water source; and
ii. Is either –
    (1) Shown on a map in a regional plan as a priority agricultural area; or
    (2) Prescribed under a regulation.

Figure 3-1 illustrates that the BNCOP is located within a Priority Agricultural Area in the regional context and Figure 3-2 illustrates the BNCOP is located within a Priority Agricultural Area in its local context also. Figure 3-2 also illustrates the locations of various PALUs (as mapped under the Australian Land Use and Management Classification Version 7, May 2010 published by the Department of Agriculture, Fisheries and Forestry ABARES) within and surrounding the BCNOP operational land. As such, the BNCOP will be assessed against the criteria for Priority Agricultural Areas.

Assessment against the relevant assessment criteria for Priority Agricultural Areas can be found below in section 3.2.2.1

3.2.1.2 Priority Living Area

Under section 9 of the RPI Act a priority living area is an area –

a) Shown on a map in a regional plan as a priority living area; and
b) That includes the existing settled area of a city, town or other community and other areas necessary or desirable –
    i. For the future growth of the existing settled area; and
    ii. As a buffer between the existing or a future settled area and resource activities.

Figure 3-3 illustrates that the part of the BNCOP (specifically the existing ML 5605) is located within the 2km buffer zone which forms the basis of the priority living area surrounding Baralaba. ML 5605 forms part of the Cockatoo Coal's active Baralaba Coal Mine. Activities which currently take place on ML 5605 are each a pre-existing resource activity under section 24 of the RPI Act. ML 5580, ML 5590 and ML 5581 are historical mining leases under which Cockatoo Coal only possess surface infrastructure and underground mining rights, which also satisfy exemption requirements for pre-existing resource activity under section 24 of the RPI Act.

The BNCOP does not propose to introduce new activities (i.e. not currently authorized) to these areas. Accordingly, the BNCOP is an exempt resource activity for the priority living area.

For completeness, an assessment against the relevant assessment criteria for Priority Living Areas can be found below in section 3.2.2.2

3.2.1.3 Strategic Cropping Areas

Under section 10(1) of the RPI Act the strategic cropping area consists of the areas shown as the SCL trigger map as strategic cropping land. Section 10(2) states –

> Strategic cropping land means land that is, or is likely to be, highly suitable for cropping because of a combination of the land's soil, climate and landscape features.

Figure 3-4 illustrates that the BNCOP is located within a Strategic Cropping Area in a regional context and Figure 3-5 illustrates the BNCOP is located within a Strategic Cropping Area in a local context. More specifically, Figure 3-6 illustrates the soil types within the BNCOP Operational Land which were mapped as part of the Soil and Land Suitability Assessment completed for the BNCOP. As such the BNCOP requires assessment against the criteria for the Strategic Cropping Area.

A Soil and Land Suitability Assessment was completed in order to satisfy the BNCOP EIS terms of reference and can be found in Appendix A. As part of the Soil and Land Suitability Assessment a Strategic Cropping Land Assessment was undertaken.

By way of background, it should be noted that strategic cropping areas that overlap ML 80169, ML 80170, MDL 184 and ML 80200 have been previously assessed and dealt with under the now repealed *Strategic Cropping Land Act 2011* (Qld). SCL Protection Decision SCLRD2013/000161 (Appendix B) was issued as a result of this previous assessment and the required mitigation fee has subsequently been paid by Cockatoo Coal. The RPI Act transitions this protection decision to be a RIDA for the SCA in respect of this area of overlap.

Strategic Cropping Area Assessment

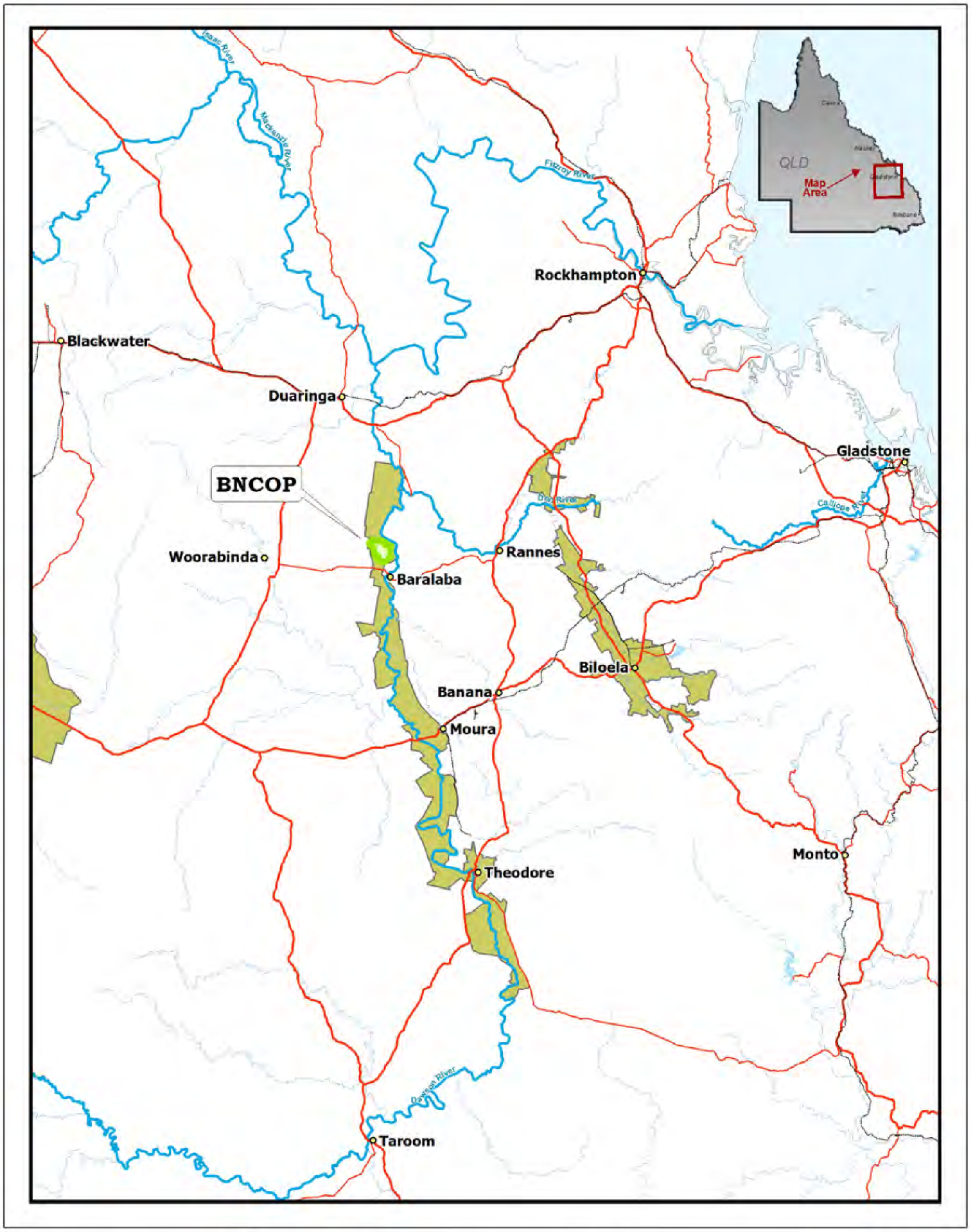
The SCL Assessment which formed part of the Soil and Land Suitability Assessment (as a contributing baseline study to the BNCOP Operational Area EIS) was concerned only with newly triggered areas external to ML 80169, ML 80170, MDL 184 and ML 80200. This effectively limited the current SCL assessment to lands within the BNCOP Disturbance Footprint (as illustrated in Figure 3-5). The complete and detailed BNCOP SCL assessment including the SCL Assessment Methodology can be found in Section 11 of the BNCOP Soil and Land Suitability Assessment (Appendix B).

As part of the SCL Assessment, the 118 ha of mapped SCL was considered against the Western Cropping Zone SCL Zonal Criteria 1-8 as defined under Schedule 3, Part 2 of the RPI Reg and minimum size requirements. This assessment concluded that 66.1ha or approximately 56% of the triggered land is compliant and qualifies as part of the SCA**.** The SCL assessment also concluded that within the mapped area is 3.5ha of otherwise compliant land that does not meet minimum size requirements and a further 48.4 ha of land that does not comply with WCZ Zonal Criteria 1-8. In total, non-compliant land covers 51.9ha or 44% of the mapped area, and is either associated with localised dissection (slopes >3%) in the south-western corner or with soils 5, 7a and 7d that fail Criteria 6, 7 or 8 in northern parts. Table 5 below summarises the conclusion of the BNCOP SCL Assessment.

Table 5 SCL Assessment Findings

Property Description	SCL Trigger Map Area	Non-compliant SCL Area	Compliant SCL Area
Lot 7 KM44 (MLA80201)	118ha	51.9ha	66.1ha

Assessment against the relevant assessment criteria for the Strategic Cropping Area can be found below in section 3.2.2.3



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Legend

Populated Place	○
Road	╱
Rail	╱
Watercourse	╱
BNCOP Operational Land	🟩
Priority Agricultural Area	🟩

TITLE

Figure 3-1
Priority
Agricultural Areas

REV	DESCRIPTION	DATE		
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STATUS **FINAL**

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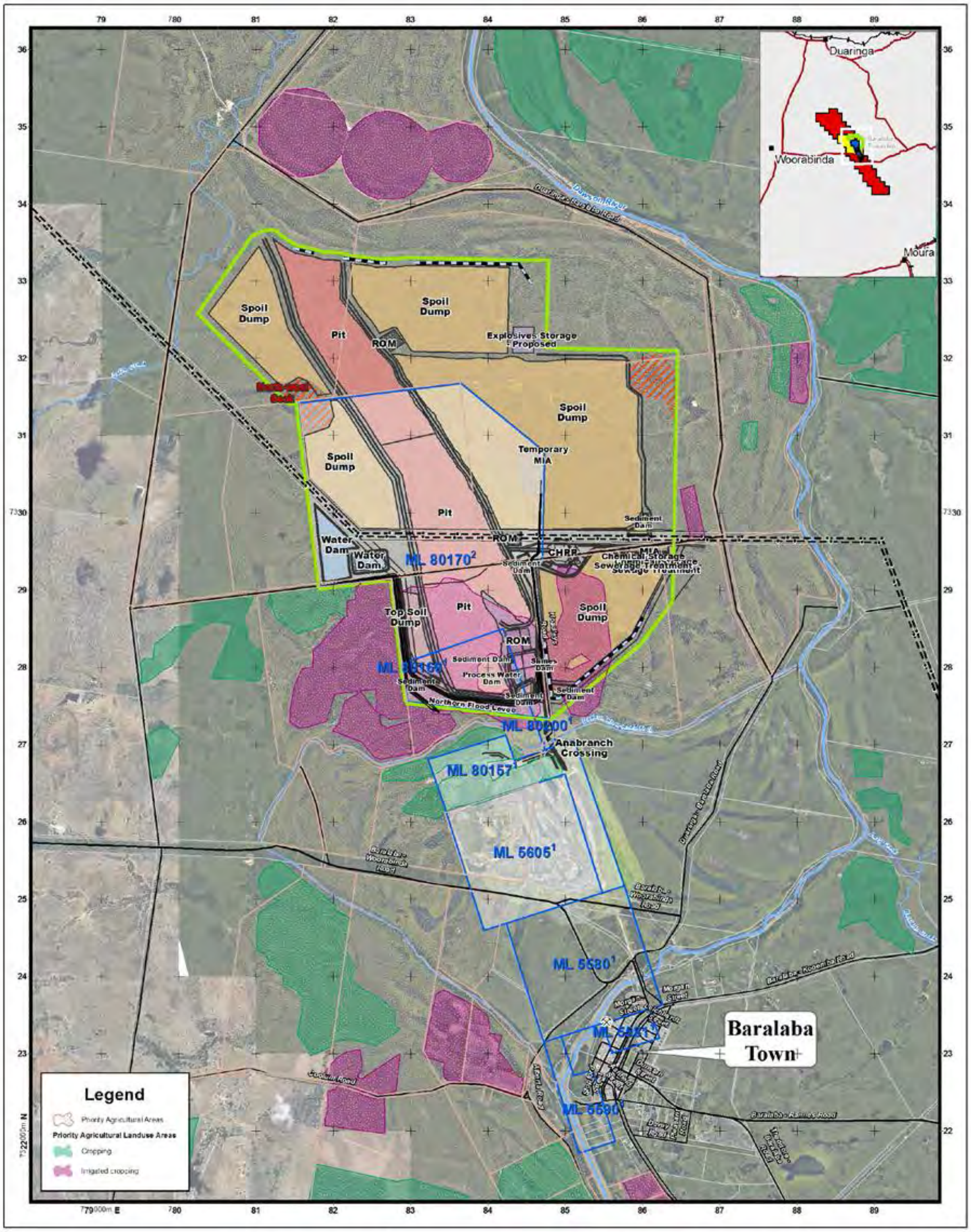

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Legend
Road
Watercourse
Cadastre
Cockatoo Coal ML
Area of Exclusion of Mining Activities
Pipeline & Power Pole
BNCOP Operational Land
PROPOSED Flood Levee

TITLE

**Figure 3-2
BNCOP Project Layout
&
Priority Agricultural Areas**

REV	DESCRIPTION	DATE
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1		
2		

SCALE 1:45,000	CURRENT ISSUE SIGNATURES		
SIZE A3	DRAWN	MJS	
DATUM GDA 94	CHECKED	BJD	
PROJECTION MGA Zone 55	APPROVED	BJD	

STATUS
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PROJECT NO	DRAWING NO
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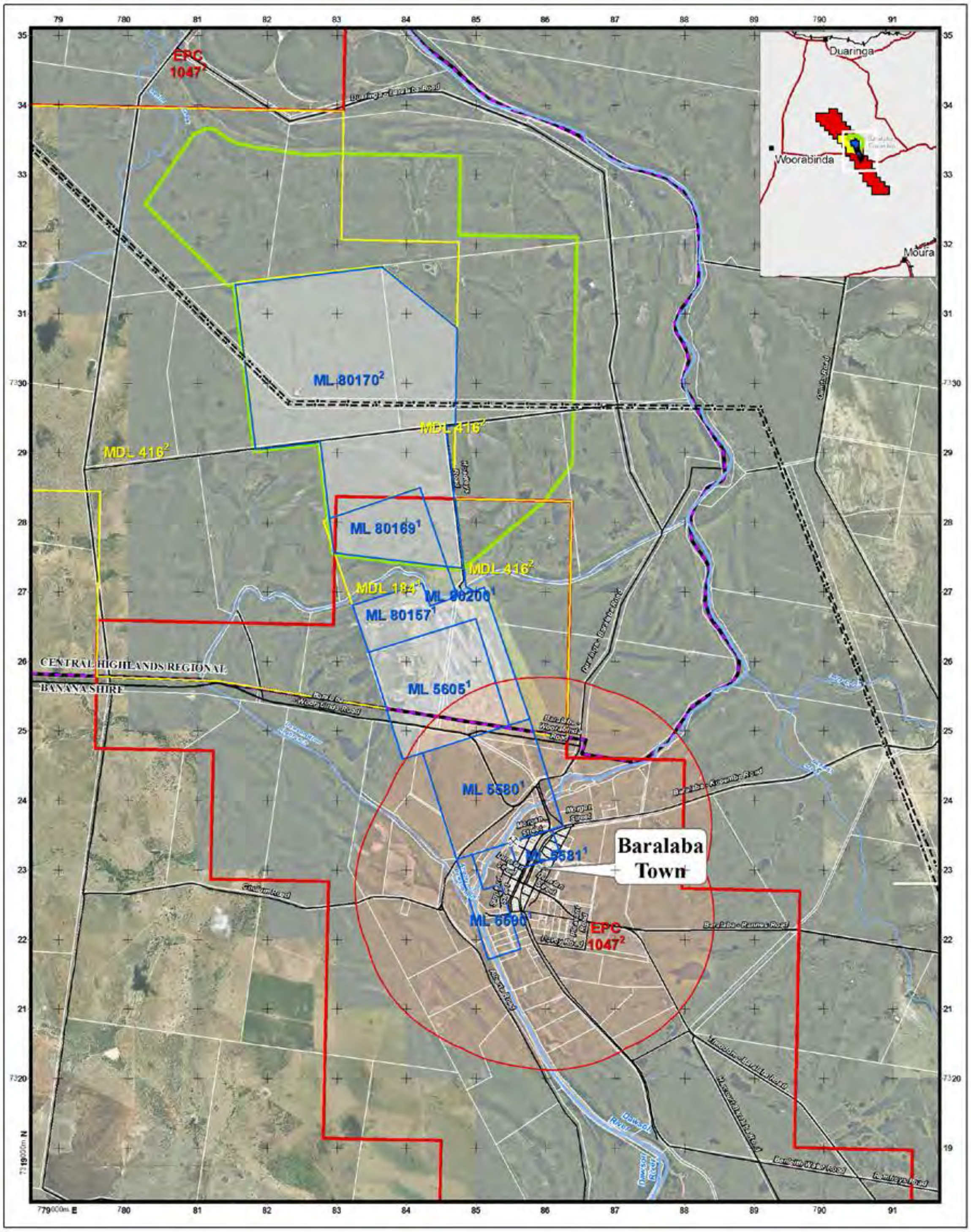

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TITLE

Figure 3-3
Baralaba
Priority Living Area

REV	DESCRIPTION	DATE
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2		

SCALE 1:50,000	CURRENT ISSUE SIGNATURES	
SIZE A3	DRAWN	MJS
DATUM GDA 94	CHECKED	BJD
PROJECTION MGA Zone 55	APPROVED	BJD

Legend

Road	Powerline & Power Pole
Watercourse	Local Government Area
Cadastre	Existing Operational Land
Cockatoo Coal ML	BNCOP Operational Land
Cockatoo Coal MDL	Priority Living Area
Cockatoo Coal EPC	

STATUS
FINAL

PROJECT NO	DRAWING NO
Baralaba Nth	BBN-117-14-00-140613

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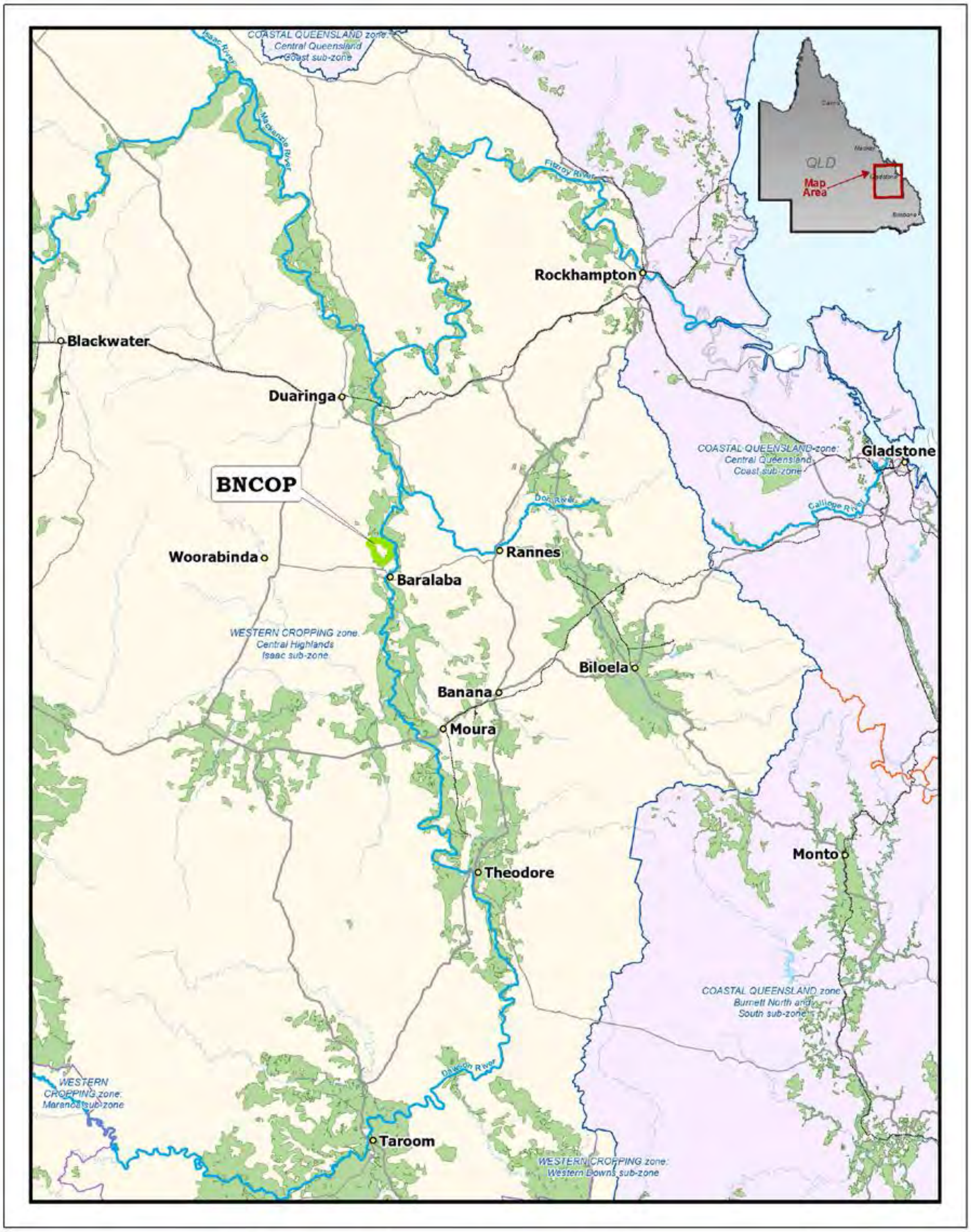

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DEVELOPMENT APPLICATION

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N
0 10 20 30 40 50
Kilometres

DATA SOURCES:
VECTOR DATA
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Legend

Populated Place ○
Road
Rail
Watercourse
BNCOP Operational Land
SCL - Trigger
Zone Boundaries
Sub-Zone Boundaries
COASTAL QUEENSLAND
WESTERN CROPPING
Strategic Cropping Land Zones
COASTAL QUEENSLAND
WESTERN CROPPING

TITLE

Figure 3-4
Potential Strategic Cropping Land
Regional

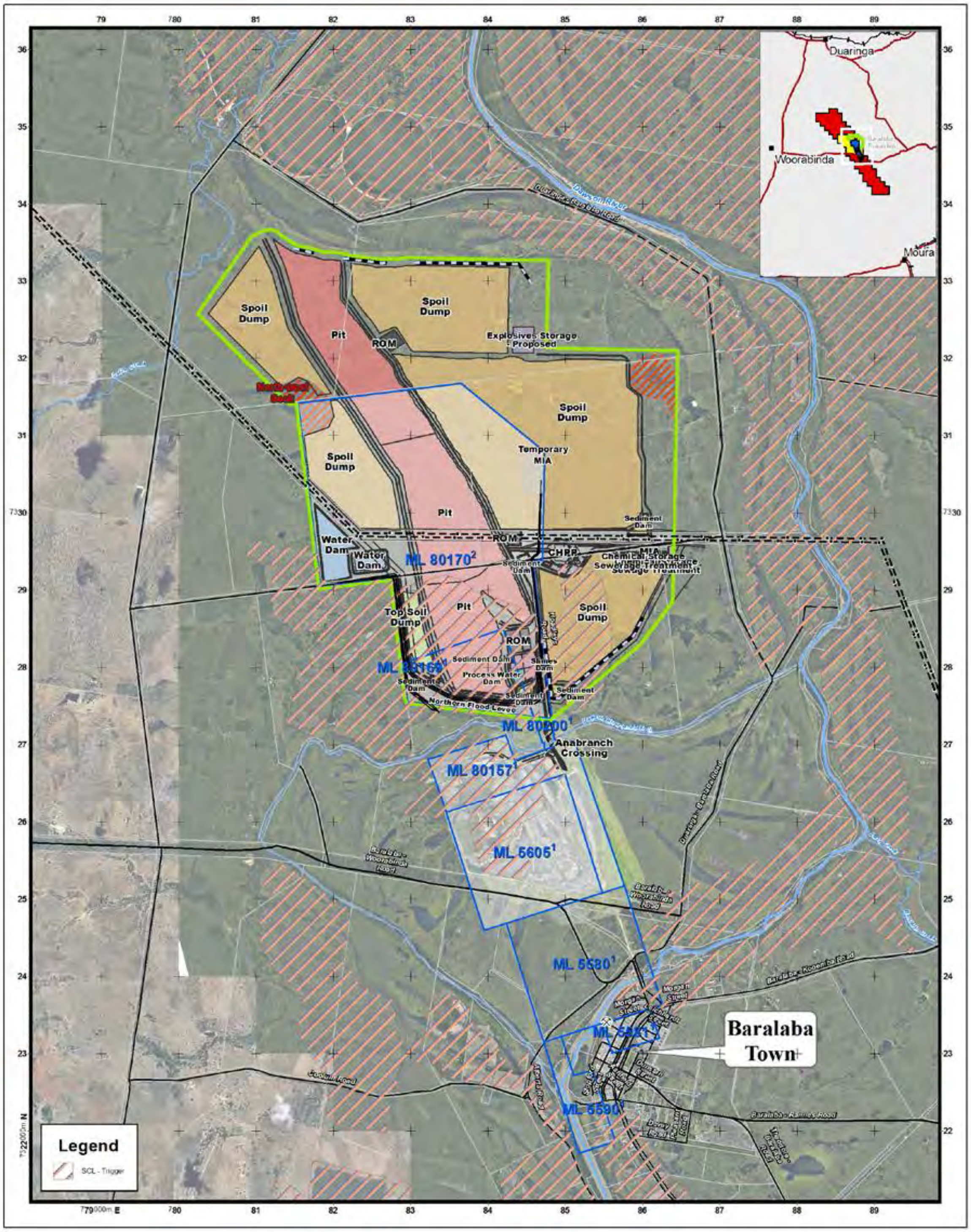
REV	DESCRIPTION	DATE
0	Original map output	13/06/14
1		
2		

SCALE 1:1,000,000	CURRENT ISSUE SIGNATURES	
SIZE A3	DRAWN	MJS
DATUM GDA 94	CHECKED	BJD
PROJECTION MGA Zone 55	APPROVED	BJD

STATUS **FINAL**

PROJECT NO	DRAWING NO
Baralaba Nth	BBN-117-15-00-140613

Path: N:\Baralaba\Baralaba_North\PROJECTS\140\BBN_117_140012_RIDA_Figures\BBN_117_15_00_140613_RIDA_SCL_Trigger_A3P.mxd



PROJECT

BCNOP
REGIONAL INTERESTS
DEVELOPMENT APPLICATION

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N
0 500 1,000 1,500 2,000
Metres

DATA SOURCES:
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NOTE:
¹ HELD BY BARALABA COAL PTY LTD
² HELD BY WONBINDI COAL PTY LTD

TITLE

Figure 3-5
BNCOP Project Layout
&
Potential Strategic Cropping Land

REV	DESCRIPTION	DATE
0	Original map output	13/06/14
1		
2		

SCALE 1:45,000	CURRENT ISSUE SIGNATURES	
SIZE A3	DRAWN	MJS
DATUM GDA 94	CHECKED	BJD
PROJECTION MGA Zone 55	APPROVED	BJD

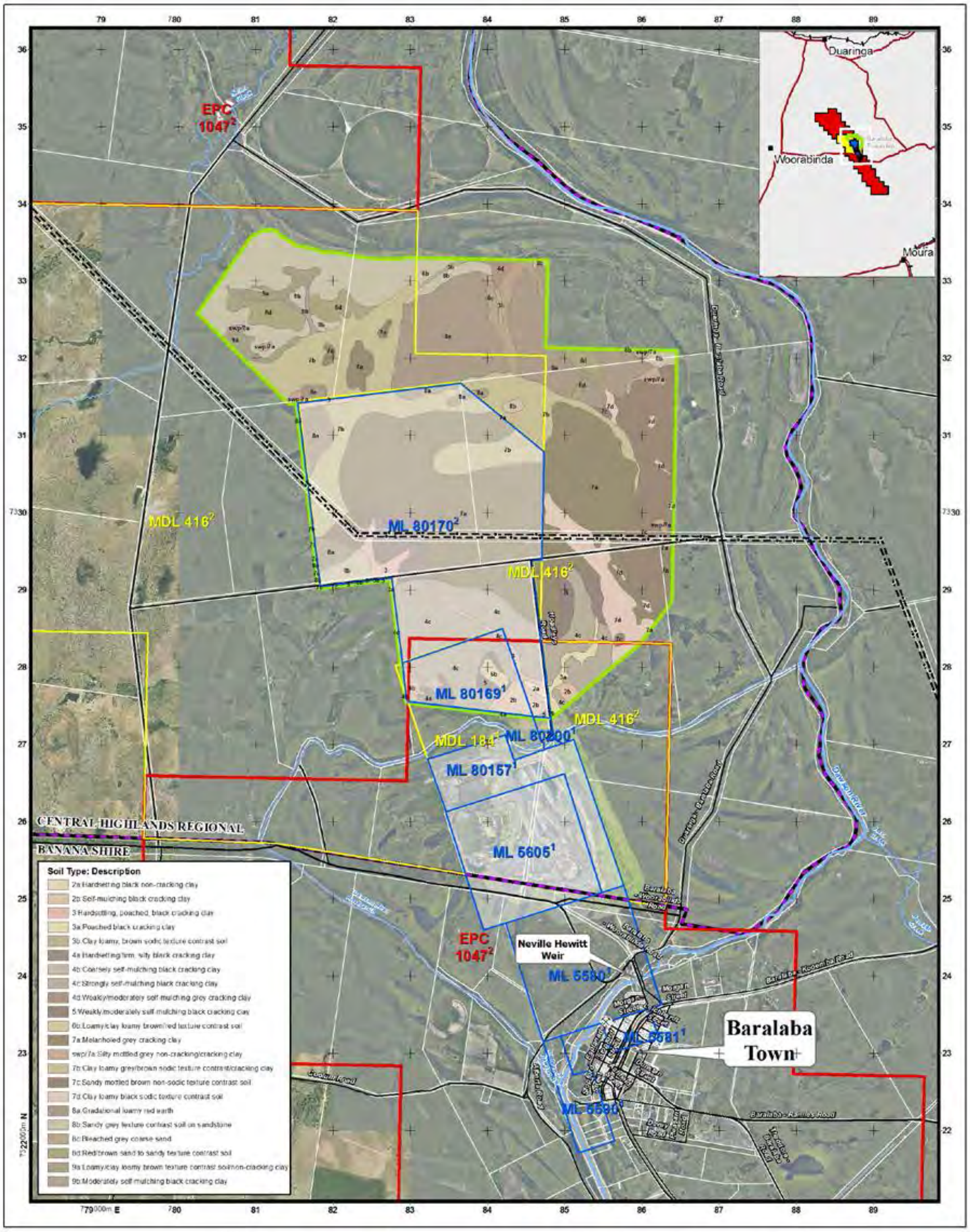
Legend

Road	Pipeline & Power Pole
Watercourse	BNCOP Operational Land
Cadastre	PROPOSED Flood Levee
Cockatoo Coal M.L.	
Area of Exclusion of Mining Activities	

STATUS **FINAL**

PROJECT NO	DRAWING NO
Baralaba Nth	BBN-117-16-00-140613

Path: N:\Baralaba\Baralaba_North\PROJECTS\140\BBN_117_140612_RIDA_Figures\BBN_117_16_00_140613_RIDA_Project_Layout_SCL_A3P.mxd



PROJECT

**BCNOP
REGIONAL INTERESTS
DEVELOPMENT APPLICATION**

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0 500 1,000 1,500 2,000
Metres

TITLE

**Figure 3-6
Soil Types
within the
BNCOP Operational Land**

REV	DESCRIPTION	DATE			
			SCALE 1:45,000	CURRENT ISSUE SIGNATURES	
0	Original map output	13/06/2014	SIZE A3	DRAWN	MJS
1			DATUM GDA 94	CHECKED	BJD
2			PROJECTION MGA Zone 55	APPROVED	BJD

DATA SOURCES:
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NOTE:
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² HELD BY WONBINDI COAL PTY LTD

Legend

Road	╱	Pipeline & Power Pole	╱
Watercourse	╱	Local Government Area	╱
Cadastre	╱	Existing Operational Land	▭
Cockatoo Coal ML	▭	BNCOP Operational Land	▭
Cockatoo Coal MDL	▭		
Cockatoo Coal EPC	🟥		

STATUS
FINAL

PROJECT NO	DRAWING NO
Baralaba Nth	BBN-117-17-00-140613

Path: N:\Baralaba\Baralaba_North\PROJECTS\140\BBN_117_140012_RIDA_Figures\BBN_117_17_00_140613_RIDA_Soil_Types_A3P.mxd

3.2.1.4 Strategic Environmental Areas

A strategic environmental area is defined under section 11 (1) of the RPI Act as an area that

a) Contains 1 or more environmental attributes for the area; and
b) Is either –
    i. Shown on a map in a regional plan as a strategic environmental area; or
    ii. Prescribed under a regulation.

For the purposes of section 11(1) an environmental attribute, for an area, means an attribute of the environment identified as an environmental attribute for the area under a regional plan or regulation.

The BNCOP is not located within or near a strategic environmental area as shown under the CQ Regional Plan. As such, this area of regional interest is not relevant to the BNCOP.

For completeness, assessment against the relevant assessment criteria for Strategic Environmental Areas can be found below in section 3.2.2.

3.2.2 Regional Planning Interests Regulation 2014

3.2.2.1 Priority Agricultural Areas

An assessment of the BNCOP against the required outcomes and prescribed solutions for Priority Agricultural Areas as prescribed under the RPI Reg can be found below in Table 6.

As the BNCOP is proposed to be carried out over more than one property, it is necessary to assess it against Required Outcome 2 for the PAA (rather than Required Outcome 1).

Table 6 Priority Agricultural Areas Assessment Criteria

Required Outcome	Prescribed Solution/s
Outcome 2 - The activity will not result in a material impact on the region because of the activity's impact on the use of land in the priority agricultural area for 1 or more priority agricultural land uses.	**Prescribed Solution 1** The application demonstrates all of the following— (a) if the activity is to be carried out in a priority agricultural area identified in a regional plan—the activity will contribute to the regional outcomes, and be consistent with the regional policies, stated in the regional plan; (b) the activity cannot be carried out on other land in the region that is not used for a priority agricultural land use, including, for example, land elsewhere on a property, on an adjacent property or at another nearby location; (c) the construction and operation footprint of the activity on the area in the region used for a priority agricultural land use is minimised to the greatest extent possible; (d) the activity will not result in widespread or irreversible impacts on the future use of an area in the region for 1 or more priority agricultural land uses; (e) the activity will not constrain, restrict or prevent the ongoing use of an area in the region for 1 or more priority agricultural land uses,

Required Outcome	Prescribed Solution/s
	including, for example, infrastructure essential to the operation of a priority agricultural land use. (2) Subsection (3) applies if the activity is to be carried out in a priority agricultural area that includes a regionally significant water source and— (a) if the activity is to be carried out under an authority to prospect or a petroleum lease under the Petroleum and Gas (Production and Safety) Act 2004—the activity is likely to produce CSG water; or (b) if the activity is to be carried out under a mineral development licence or a mining lease under the Mineral Resources Act 1989—the activity is likely to produce associated water. (3) Also, the application must demonstrate the applicant has in place a strategy or plan for managing the CSG water or associated water that provides for the net replenishment of the regionally significant water source. (4) For subsection (3), net replenishment of a regionally significant water source is the replacement to the water source, whether directly or indirectly, of all water that is no longer available for a priority agricultural land use in a priority agricultural area because carrying out a resource activity in the area produces CSG water or associated water. (5) Subsection (6) applies for each property on which the activity is to be carried out if the applicant is not the owner of the land and has not entered into a voluntary agreement with the owner. (6) The application must demonstrate the matters listed in this schedule, section 3 for a prescribed solution for required outcome 1 for the property. (7) In this section— associated water means underground water taken or interfered with, if the taking or interference happens during the course of, or results from, the carrying out of an activity authorised under a mineral development licence or mining lease. CSG water see the Petroleum and Gas (Production and Safety) Act 2004, schedule 2. overland flow water see the Water Act 2000, schedule 4. underground water see the Water Act 2000, schedule 4.

Response to Prescribed Solution
a) if the activity is to be carried out in a priority agricultural area identified in a regional plan—the activity will contribute to the regional outcomes, and be consistent with the regional policies, stated in the regional plan; Some of the activities associated with the BNCOP will be carried out in a Priority Agricultural Area as identified in the CQ Regional Plan. The regional policies in the CQ Regional Plan aim to protect PALUs while supporting co-existence opportunities for the resources sector, and provide certainty for the future of towns. As stated earlier, CCL believe the BNCOP is consistent with these policies.

Required Outcome	Prescribed Solution/s

The BNCOP will contribute to the regional outcome that ‘(a)griculture and resource industries within the Central Queensland region continue to grow with certainty and investor confidence’. The discussion above has highlighted the reasons for which the BNCOP needs to proceed – namely to allow the development of resources in the area economically and with investor confidence. Failure to undertake the BNCOP would ultimately lead to sterilization of an identified resource in the area, contrary to the best interests of the State, region and local area. In addition, if the BNCOP does not proceed, ongoing operations at Baralaba will be limited. This will be damaging to the local and regional economy, including agricultural producers, who supply goods and services for the current mining operations and staff such as sale of water for dust suppression along the Coal Haul Route.

The BNCOP also contributes to the regional outcome that ‘(t)he growth potential of towns within the Central Queensland region is enabled through the establishment of Priority Living Areas. Compatible resource activities within these areas which are in the communities’ interest can be supported by local governments’. As outlined above, no new activities are proposed for the BNCOP within the priority living area.

CCL’s ongoing operations at its existing and approved mines are fundamental to the growth and vitality of the Baralaba township. CCL, in its various undertakings, has already made substantial contributions to the township including in terms of infrastructure investment (e.g. for roads and water supply). The BNCOP will continue this pattern of investment for the benefit of all residents.

CCL will also ensure continual and ongoing agricultural production on properties surrounding the BNCOP through the following measures:

- A table drain along the western boundary of the flood levee was constructed as part of the Baralaba North/Wonbindi 1Mtpa Project. This drain was constructed to ensure that water drained adequately away from Lot 9 KM45 (the property adjoining the south-western ML boundary) and in doing so not affect crop productivity on this property.
- Leasing excess agricultural land, which is outside of CCL’s Mining Lease areas, back to local farmers for the purposes of grazing; and
- CCL is also currently exploring various options of supplying excess mine water to the surrounding properties for the purposes of irrigating cropping land (note: this would be done in compliance with existing EA conditions).

b) the activity cannot be carried out on other land in the region that is not used for a priority agricultural land use, including, for example, land elsewhere on a property, on an adjacent property or at another nearby location;

The following constraints surround the BNCOP (as shown in Figure 2-2):

- West – Large SCL Area and also Priority Agriculture Land Use Area;
- South – Dawson River Anabranch (associated flood risks and impacts on flood flows);
- East – Flood levee and also associated flood risks due to going outside flood Levee; and
- North – BNCOP Coal Handling Preparation Plant & Mining Infrastructure Area (which are required to be located on the high point of MLA80201).

The above constraints coupled with the complex geological structure of the coal measures which are mined as part the BNCOP results in the proposed location layout of the BNCOP being most efficient and economical method of mining the available coal reserves.

Required Outcome	Prescribed Solution/s

Numerous rounds of mine planning have been involved in the layout for the BNCOP as presently put forward. These have included attempts to revise the layout in light of the matters protected by the RPI Act. However, it is simply not feasible or economic for the BNCOP to proceed with a different layout, further the flood plain dictates the need for a levee and for all mining activities to be located within this flood levee.

The spoil dump which is located to the east of the BNCOP Pit is on land mapped as priority agricultural land use has been located there due to its proximity to the BNCOP. This is necessary for the viability of the operations proposed under the BNCOP. Unfortunately, it is simply not feasible to relocate the spoil dump further away so as to avoid PALU, the short haul distances to this spoil dump are critical to the overall feasibility of the BNCOP as the significantly reduce the ongoing operational expenditure for the BCOP . Moreover, doing so would increase the chance of adverse impacts arising from the spoil dump to other (e.g. increased dust deposition for surrounding landholders).

c) the construction and operation footprint of the activity on the area in the region used for a priority agricultural land use is minimised to the greatest extent possible;

The disturbance footprint for the BNCOP has been minimized to the greatest extent possible for safe and feasible mining of the identified coal seams. A proposed spoil dump is located on a PALU – which amounts to around 4% of the new land required for the project. However, this is the only new activity proposed by the BNCOP which will impact on a PALU, notwithstanding the prevalence of PALU in the local area (as highlighted in Figure 3-2). The BNCOP has been designed to allow the extraction of further coal reserves based largely around use of existing infrastructure, thereby minimizing the overall requirements for land disturbance when compared with an undertaking proposing to construct new infrastructure.

The location for the BNCOP is determined by the presence of coal seams that are amenable to be economically mined in the vicinity of the existing Baralaba Coal Mine and Baralaba North/Wonbindi North Mine. The BNCOP involves an extension to an existing open cut in the Permian Baralaba Coal Measures. Due to the proximity of the coal to the surface, the presence of faulting and the dipping nature of the coal seams in the BNCOP area (i.e. the seams are not flat or gently sloping and have dip angles of up to approximately 55^{o}), CCL has not identified any economically viable underground mining method for extraction of coal in the BNCOP area to date.

Due to the nature of the coal seams the BNCOP pit is elongated in nature and therefore spoil dumps must be located on either side of pit. CCL through its mine planning processes made the decision to locate the spoil dump to the east of BNCOP Pit on Lot 7 KM44 and not locate the spoil dump to the west of the BNCOP Pit on Lot 9 KM45 as this property a significantly larger area of SCL and is also being utilised on a yearly basis for cropping.

The above constraints coupled with the complex geological structure of the coal measures which are mined as part the BNCOP results in the proposed layout of the BNCOP being the most efficient and economical method of mining the available coal reserves.

d) the activity will not result in widespread or irreversible impacts on the future use of an area in the region for 1 or more priority agricultural land uses;

CCL believes that the BNCOP will not result in widespread or irreversible impacts on the future use of an area within the region for one or more PALUs. As discussed above, the BNCOP will impact an area of PALU (namely irrigated cropping) for the purposes of a spoil dump. However, other areas of irrigated cropping exist in the immediate vicinity which will not be impacted. The area proposed to be impacted is used for cropping for fodder, which supplements the cattle grazing use of the property. Spoil dumps associated with the BNCOP are

Required Outcome	Prescribed Solution/s

proposed to be rehabilitated as soon as possible, and subsequently used for nature conservation purposes. However, other areas of the BNCOP operational land will be rehabilitated to be suitable for cattle grazing, and may potentially be able to be used for irrigated cropping after mining ceases.

e) the activity will not constrain, restrict or prevent the ongoing use of an area in the region for 1 or more priority agricultural land uses, including, for example, infrastructure essential to the operation of a priority agricultural land use.

As noted above, the only area of PALU to be impacted within the new MLA is used for irrigated cropping. This proposed disturbance amounts to around 4% of the total land use requirements for the BNCOP area. As the owner of the land (via its subsidiary) CCL is aware that there is no essential infrastructure for ongoing operation of PALUs on this land. At the regional scale, CCL's operations may in fact enhance operations associated with PALUs by way of investment in infrastructure upgrades. The BNCOP also does not preclude future use of the area in the region for a PALU.

Two areas mapped as PALU within ML 80169 and ML 80170. However, the disturbance of these areas is already authorized and does not require assessment as part of this RIDA application.

2) Subsection (3) applies if the activity is to be carried out in a priority agricultural area that includes a regionally significant water source and—

a) if the activity is to be carried out under an authority to prospect or a petroleum lease under the Petroleum and Gas (Production and Safety) Act 2004—the activity is likely to produce CSG water; or

b) if the activity is to be carried out under a mineral development licence or a mining lease under the Mineral Resources Act 1989—the activity is likely to produce associated water.

The BNCOP is not proposed to be carried out in a priority agricultural area that includes a regionally significant water source, nor is the activity likely to produce associated water. Accordingly, assessment against the criteria in subsection (3) is not required.

3) Also, the application must demonstrate the applicant has in place a strategy or plan for managing the CSG water or associated water that provides for the net replenishment of the regionally significant water source.

As above. Assessment against this criteria is not required.

4) For subsection (3), net replenishment of a regionally significant water source is the replacement to the water source, whether directly or indirectly, of all water that is no longer available for a priority agricultural land use in a priority agricultural area because carrying out a resource activity in the area produces CSG water or associated water.

As above. Assessment against this criteria is not required.

(5) Subsection (6) applies for each property on which the activity is to be carried out if the applicant is not the owner of the land and has not entered into a voluntary agreement with the owner.

Activities associated with the BNCOP are proposed to be carried out on two properties which are not currently owned by CCL or its subsidiaries, namely Lot 13 on KM 182 and Lot 14 on KM 183. It is intended that agreement with the owner of these properties will be reached voluntarily prior to grant of the MLA however no agreement is presently in place.

(6) The application must demonstrate the matters listed in this schedule, section 3 for a prescribed solution

Required Outcome	Prescribed Solution/s
for required outcome 1 for the property. The two most northern properties on which BNCOP activities are proposed are not owned by CCL and are not currently the subject of a voluntary agreement. However, as indicated in Figure 3-2, neither of these two properties contain land used for PALU. Accordingly, the prescribed solution stated in subsection 3(2) of Schedule 2, Part 2 of the RPI Reg is satisfied in respect of each property. **(7) In this section— associated water means underground water taken or interfered with, if the taking or interference happens during the course of, or results from, the carrying out of an activity authorised under a mineral development licence or mining lease. CSG water see the Petroleum and Gas (Production and Safety) Act 2004, schedule 2. overland flow water see the Water Act 2000, schedule 4. underground water see the Water Act 2000, schedule 4.** Not applicable.	

3.2.2.2 Priority Living Areas

An assessment of the BNCOP against the required outcomes and prescribed solutions for Priority Living Areas as prescribed under the Regional Planning Interests Regulation 2014 can be found below in Table 7. All proposed activities which occur within the priority living area may currently be carried out lawfully on that land and are accordingly exempt resource activities for the Priority Living Area. The criteria has been addressed for the BNCOP in the interests of completeness.

Table 7 Priority Living Areas Assessment Criteria

Required Outcome	Prescribed Solution/s
Outcome 1: The location, nature and conduct of the activity is compatible with the planned future for the priority living area stated in a planning instrument under the *Sustainable Planning Act 2009*.	**Prescribed Solution 1:** The application demonstrates each of the following— a) the activity is unlikely to adversely impact on development certainty— i. for land in the immediate vicinity of the activity; and ii. in the priority living area generally; b) carrying out the activity in the priority living area, and in the location stated in the application, is likely to result in community benefits and opportunities, including, for example, financial and social benefits and opportunities.
Response to Prescribed Solution	
The BNCOP is located outside priority living area surrounding Baralaba and as such is deemed to be compatible with the planned future for the priority living area. Futher to this the BNCOP will contribute substantially to the future economic welfare of the township of Baralaba through the creation of up to 430 jobs during peak construction and up to 380 jobs during operation. CCL's operations in the area have already benefited the township by way of investment in infrastructure (e.g. water supply and roads) which will continue with the BNCOP.	

3.2.2.3 Strategic Cropping Areas

An assessment of the BNCOP against the required outcomes and prescribed solutions for Strategic Cropping Areas as prescribed under the Regional Planning Interests Regulation 2014 can be found below in Table 3.

Table 8 Strategic Cropping Areas Assessment Criteria

Required Outcome	Prescribed Solution/s
Outcome 1 - The activity will not result in any impact on strategic cropping land in the strategic cropping area.	**Prescribed Solution 1:** The application demonstrates the activity will not be carried out on strategic cropping land that meets the criteria stated in schedule 3, part 2.

Response to Prescribed Solution

The BNCOP will be carried out on SCL located within the SCA.

The following constraints surround the BCNOP (as shown in Figure 2-2):

- West – Large SCL Area and also Priority Agriculture Land Use Area;
- South – Dawson River Anabranch (associated flood risks and impacts on flood flows);
- East – Flood levee and also associated flood risks due to going outside flood levee; and
- North – BNCOP Coal Handling Preparation Plant & Mining Infrastructure Area (which are required to be located on the high point of MLA80201).

The location for the BNCOP is determined by the presence of coal seams that are amenable to be economically mined in the vicinity of the existing Baralaba Coal Mine and Baralaba North/Wonbindi North Mine. The BNCOP involves an extension to an existing open cut in the Permian Baralaba Coal Measures. Due to the proximity of the coal to the surface, the presence of faulting and the dipping nature of the coal seams in the BNCOP area (i.e. the seams are not flat or gently sloping and have dip angles of up to approximately 55o), CCL has not identified any economically viable underground mining method for extraction of coal in the BNCOP area to date.

Due to the nature of the coal seams the BNCOP pit is elongated in nature and therefore spoil dumps must be located on either side of pit. CCL through its mine planning processes made the decision to locate the spoil dump to the east of BNCOP Pit on Lot 7 KM44 and not locate the spoil dump to the west of the BNCOP Pit on Lot 9 KM45 as this property a significantly larger area of SCL and is also being utilised on a yearly basis for cropping.

The above constraints coupled with the complex geological structure of the coal measures which are mined as part the BNCOP results in the proposed location layout of the BNCOP being the most efficient and economical method of mining the available coal reserves.

Required Outcome	Prescribed Solution/s
Outcome 2 - The activity will not result in a material impact on strategic cropping land on the property (SCL).	**Prescribed Solution 1:** The application demonstrates all of the following— a) if the applicant is not the owner of the land and has not entered into a voluntary agreement with the owner—the applicant has taken all reasonable steps to consult and negotiate with the owner of the land

Required Outcome	Prescribed Solution/s
	about the expected impact of carrying out the activity on strategic cropping land; b) the activity cannot be carried out on land that is not strategic cropping land, including, for example, land elsewhere on the property (SCL), on adjacent land or at another nearby location; c) the construction and operation footprint of the activity on strategic cropping land on the property (SCL) is minimised to the greatest extent possible; d) if the activity will have a permanent impact on strategic cropping land on a property (SCL)—no more than 2% of the strategic cropping land on the property (SCL) will be impacted.

Response to Prescribed Solution

a) if the applicant is not the owner of the land and has not entered into a voluntary agreement with the owner—the applicant has taken all reasonable steps to consult and negotiate with the owner of the land about the expected impact of carrying out the activity on strategic cropping land;

CCL through its subsidiary company Wonbindi Coal Pty Ltd is the owner of Lot 7 KM44 on which the SCL is located.

b) the activity cannot be carried out on land that is not strategic cropping land, including, for example, land elsewhere on the property (SCL), on adjacent land or at another nearby location;

The following constraints surround the BNCOP (as shown in Figure 2-2):

- West – Large Area of SCL owned and currently cropped by private landowner, which is also mapped as a Priority Agriculture Land Use Area;
- South – Dawson River Anabranch (associated flood risks and impacts on flood flows);
- East – Flood levee and also associated flood risks due to going outside flood levee; and
- North – BNCOP Coal Handling Preparation Plant & Mining Infrastructure Area (which are required to be located on the high point of MLA80201).

The above constraints coupled with the complex geological structure of the coal measures which are mined as part the BNCOP results in the proposed layout of the BNCOP being most efficient and economical method of mining the available coal reserves.

c) the construction and operation footprint of the activity on strategic cropping land on the property (SCL) is minimised to the greatest extent possible;

The location for the BNCOP is determined by the presence of coal seams that are amenable to be economically mined in the vicinity of the existing Baralaba Coal Mine and Baralaba North/Wonbindi North Mine. The BNCOP involves an extension to an existing open cut in the Permian Baralaba Coal Measures. Due to the proximity of the coal to the surface, the presence of faulting and the dipping nature of the coal seams in the BNCOP area (i.e. the seams are not flat or gently sloping and have dip angles of up to approximately 55^{o}), CCL has not identified any economically viable underground mining method for extraction of coal in the BNCOP area to date.

CCL through its mine planning processes made the decision to locate the spoil dump to the east of BNCOP Pit on Lot 7 KM44 and not locate the spoil dump to the west of the BNCOP Pit on Lot 9 KM45 as this property a significantly larger area of SCL and is also being utilised on a yearly basis for cropping.

Unfortunately due to the numerous constraints surrounding the BNCOP as listed above, CCL has been unable to further minimise the footprint of the activity on strategic cropping land. The Soil and Land Suitability Assessment completed for the BNCOP EIS concluded that of the 118ha of mapped SCL within MLA 80201 only 66.1ha satisfied

<table>
<tr><th>Required Outcome</th><th>Prescribed Solution/s</th></tr>
<tr><td colspan="2">
<p>the requisite SCL western cropping zone criterion. In any event, the area of the SCA proposed to be impacted by the BNCOP overlaps the PALU for which the assessment criteria have been addressed in the table above. Assessment of impacts to land that is in both a Priority Agricultural Area and identified as being part of the SCA is only required against the criteria for the former of these areas of regional interest (section 14(4) of the RPI Reg).</p>
<p>d) if the activity will have a permanent impact on strategic cropping land on a property (SCL)—no more than 2% of the strategic cropping land on the property (SCL) will be impacted.</p>
<p>As noted above, the only area of impact to the SCA occurs in an area which is also mapped as being a PALU within a Priority Agricultural Area. The criteria for the Priority Agricultural Area have been addressed above. Accordingly, assessment against the criteria for the SCA is not required (section 14(4) of the RPI Reg)</p>
</td></tr>
<tr><th>Required Outcome</th><th>Prescribed Solution/s</th></tr>
<tr><td>Outcome 3 - The activity will not result in a material impact on strategic cropping land in an area in the strategic cropping area.</td><td>
<p>Prescribed Solution 1:</p>
<p>(1) The application demonstrates all of the following—</p>
<p>a. the activity cannot be carried out on other land in the area that is not strategic cropping land, including, for example, land elsewhere on the property (SCL), on adjacent land or at another nearby location;
b. if there is a regional plan for the area in which the activity is to be carried out—the activity will contribute to the regional outcomes, and be consistent with the regional policies, stated in the regional plan;
c. the construction and operation footprint of the activity on strategic cropping land is minimised to the greatest extent possible;
d. either—
1. the activity will not have a permanent impact on the strategic cropping land in the area; or
2. the mitigation measures proposed to be carried out if the chief executive decides to grant the approval and impose an SCL mitigation condition.</p>
<p>(2) Subsection (3) applies for each property (SCL) on which the activity is to be carried out if the applicant is not the owner of the land and has not entered into a voluntary agreement with the owner.</p>
<p>(3) The application must demonstrate the matters listed in this schedule, section 11 for a prescribed solution for required outcome 2 for the property (SCL).</p>
</td></tr>
<tr><th colspan="2">Response to Prescribed Solution</th></tr>
<tr><td colspan="2">Activities associated with the BNCOP which are not already authorized for the SCA are only being carried out on one property. Accordingly, CCL is of the view that required outcome 2 and not required outcome 3 applies.</td></tr>
</table>

3.2.2.4 Strategic Environmental Areas

An assessment of the BNCOP against the required outcomes and prescribed solutions for Strategic Environmental Areas as prescribed under the Regional Planning Interests Regulation 2014 can be found below in Table 4.

Table 9 Strategic Environmental Areas Assessment Criteria

Required Outcome	**Prescribed Solution/s**
Outcome 1 - The activity will not result in a widespread or irreversible impact on an environmental attribute of a strategic environmental area.	**Prescribed Solution:** The application demonstrates either— a) the activity will not, and is not likely to, have a direct or indirect impact on an environmental attribute of the strategic environmental area; or b) all of the following— i. if the activity is being carried out in a designated precinct in the strategic environmental area—the activity is not an unacceptable use for the precinct; ii. the construction and operation footprint of the activity on the environmental attribute is minimised to the greatest extent possible; iii. the activity does not compromise the preservation of the environmental attribute within the strategic environmental area; c) if the activity is to be carried out in a strategic environmental area identified in a regional plan—the activity will contribute to the regional outcomes, and be consistent with the regional policies, stated in the regional plan.
Response to Prescribed Solution	
The BNCOP is not located within or near a strategic environmental area as shown under the Central Qld Regional Plan and as such the BCNOP will not have a direct or indirect impact on an environmental attribute of a strategic environmental area. Accordingly, the prescribed solution is satisfied.	

3.3 BNCOP - SOIL AND ECONOMIC IMPACTS

The section below provides an overview of the key conclusion/findings of the Soil and Land Suitability, Surface Water and Economic Assessments which were completed for the BNCOP EIS.

3.3.1 Soils & Land use

A Soil and Land Suitability Assessment was undertaken as part of the BNCOP EIS and is presented in Appendix B.

Land in the Baralaba area is predominately used for rural activities including dairy farming, beef cattle grazing and fattening, and limited crop cultivation. Crops are generally restricted to providing forage for cattle, with Leucaena well established within the area. Exotic improved pastures dominated by Buffel

Grass (Cenchrus ciliaris) are also common, while crops of cotton and wheat are produced on an opportunistic basis.

The properties on which the BNCOP is proposed are consistent with the above land uses, and are used primarily for cattle grazing, with occasional cropping to provide fodder.

With the exception of one private landholder, all land within the BNCOP Operational Land is owned by CCL. Surrounding land in the vicinity of the BNCOP is predominantly privately-owned. The soil types with the BNCOP Operational Land are presented on Figure 3-6.

A Soil and Land Suitability Assessment has been prepared by Soil Mapping & Monitoring (2014) and is included as Appendix B. The Soil and Land Suitability Assessment show the majority of the soils in the BNCOP Disturbance Footprint comprise Vertosols (41%), Sodosols (31%) and Chromosols (12%), while lesser areas of Kandosols, Dermosols and Tenosols were also observed (Appendix B).

Assessment of dryland cropping suitability within the BNCOP Disturbance Footprint indicates pre-mining land suitability is predominantly unsuited to dryland cropping with only (Appendix B):

- 96 ha suitable (Classes 2-3), 68 ha marginal (Class 4) and 1,322 ha unsuitable (Class 5) for dryland summer cropping; and
- 5 ha suitable (Classes 1-3), 91 ha marginal (Class 4) and 1,390 ha unsuitable (Class 5) for dryland winter cropping.

Assessment of grazing suitability within the BNCOP Disturbance Footprint indicates a mix of pre-mining grazing suitability (Appendix B).

3.3.2 Economic

An Economic Assessment was undertaken for the BNCOP and is presented in Appendix A.

The economic assessment was conducted at three different scales to assess the potential impact of the BNCOP on the local, regional and Qld economies.

The local economy adopted for the BNCOP is the Banana LGA. The combined Banana and Central Highlands LGAs was adopted as the regional economy for the BNCOP.

Value-added for the local economy in 2011 (i.e. Banana LGA) is estimated at $1,431M, comprising $489M to households as wages and salaries (including payments to self-employed persons and employers) and $942M in other value-added contributions.

Value-added for the regional economy in 2011 (i.e. Central Highlands and Banana LGAs) is estimated at $5,045M, comprising $1,657M to households as wages and salaries (including payments to self-employed persons and employers) and $3,389M in other value-added contributions.

The economic assessment (Appendix A) included consideration of the impacts of the BNCOP (including construction) on the local (i.e. Banana LGA), regional (i.e. Banana and Central Highlands LGAs) and Qld economies, and also other potential economic impacts associated with the BNCOP. These impacts are listed below

Construction

Short-term construction/development activities would require additional construction workforce for short periods, resulting in a total workforce of up to approximately 430 people (peak).

An additional 76 personnel would be required on average during the construction phase.

The construction phase of the BNCOP is predicted to have the following flow-on effects for the local economy (Appendix A):

- $65M in annual direct and indirect regional output or business turnover;
- $23M in annual direct and indirect regional value-added;
- $8M in annual direct and indirect household income; and
- 157 direct and indirect jobs.

For the regional economy, the construction phase of the BNCOP is predicted to have the following flow-on effects (Appendix A):

- $72M in annual direct and indirect output;
- $26M in annual direct and indirect value added;
- $9M in annual direct and indirect household income; and
- 184 direct and indirect jobs.

The construction phase of the BNCOP is predicted to have the following flow-on effects on the Qld economy (Appendix A):

- $134M in annual direct and indirect output;
- $56M in annual direct and indirect value added;
- $31M in annual direct and indirect household income; and
- 422 direct and indirect jobs.

Operations

At full development, the BNCOP operational workforce would be in the order of 380 on-site personnel, including a mixture of direct CCL employees and contractors.

The operation of the BNCOP is predicted to have the following annual average incremental impacts on the local economy (Appendix A):

- $341M in annual direct and indirect regional output or business turnover;
- $39M in annual direct and indirect regional value added;
- $12M in annual direct and indirect household income; and
- 355 direct and indirect jobs.

For the regional economy, the operation of the BNCOP is predicted to have the following impacts (Appendix A):

- $364M in annual direct and indirect regional output or business turnover;
- $49M in annual direct and indirect regional value added;
- $19M in annual direct and indirect household income; and
- 472 direct and indirect jobs.

The operation of the BNCOP is predicted to have the following annual average incremental impacts on the Qld economy (Appendix A):

- $921M in annual direct and indirect regional output or business turnover;
- $320M in annual direct and indirect regional value added;
- $165M in annual direct and indirect household income; and
- 2,460 direct and indirect jobs.

4. Conclusion

The BNCOP is an exempt resource activity for the Priority Living Area and would not impact on any Strategic Environmental Areas.

The BNCOP is the subject of an EIS which is currently undergoing public notification, with the submission period closing on 7 July 2014. Construction for the BNCOP is scheduled to start in early 2015. Accordingly, CCL makes this RIDA assessment application in the interests of obtaining all relevant project approvals before this time.

The BNCOP has been designed to minimize land disturbance, including by allowing for the development of the State's coal resources utilizing existing infrastructure (rather than having to build all new infrastructure). Several iterations of the mine planning process have been carried out to date.

Notwithstanding the steps taken towards impact minimisation, the BNCOP will have some limited impacts on areas of regional interest. In particular, a spoil dump is proposed to be developed on the relatively small patch of land currently used for irrigated cropping to provide fodder in association with the broader cattle grazing land use. This patch of land is both a PALU within a Priority Agricultural Area under the CQ Regional Plan and within the SCA. Nonetheless, the assessment carried out above demonstrates that the BNCOP can meet the prescribed solutions in relation to this activity.

Accordingly and most importantly, the BNCOP was deemed not to have a regional impact on either Central Queensland's Priority Agricultural Areas or Strategic Cropping Areas as mapped in the CQ Regional Plan.

Appendix A –Economic Assessment

Baralaba North Continued Operations Project

Economic Assessment

Prepared for

Cockatoo Coal

By

Gillespie Economics
Email: gillecon@bigpond.net.au

April 2014

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EXECUTIVE SUMMARY

Cockatoo Coal Limited (CCL) operates the Baralaba Coal Mine which is located approximately 115 kilometres west of Rockhampton, in the lower Bowen Basin region of central Queensland (Qld). The Baralaba North Continued Operations Project (BNCOP) provides for the continuation and expansion of the open cut coal mine and the introduction of processing activities at the existing Baralaba Coal Mine.

From an economic perspective there are two important aspects of the BNCOP that can be considered:

- the economic efficiency of the BNCOP i.e. consideration of economic costs and benefits of the BNCOP; and
- the economic impacts of the BNCOP i.e. the economic activity that the Project would provide to the local (Banana Shire Local Government Area [LGA]), regional (Banana Shire and Central Highlands Regional LGAs) and Qld economy.

A benefit cost analysis (BCA) of the BNCOP indicated that it would have net production benefits to Australia of $831 million (M). Provided the residual environmental, social and cultural impacts of the BNCOP that accrue to Australia (after mitigation, offset and compensation) are considered to be valued at less than $831M, the BNCOP can be considered to provide an improvement in economic efficiency and hence is justified on economic grounds.

Instead of leaving the environmental, cultural and social impacts unquantified, an attempt was made to quantify them. This included incorporating into the estimate of net production benefits the mitigation, compensation and offset costs associated with the BNCOP. The main quantifiable environmental impacts of the BNCOP that have not already been incorporated into the estimate of net production benefits, relate to greenhouse gas emissions. These impacts are estimated at $54M globally or $1M to Australia, considerably less than the estimated net production benefits of the BNCOP. Overall, the BNCOP is estimated to have net social benefits to Australia of $831M and hence is desirable and justified from an economic efficiency perspective.

While the BCA is primarily concerned with the aggregate costs and benefits of the BNCOP to Australia, the costs and benefits may be distributed among a number of different stakeholder groups at the local, state, National and global level. The total net production benefit would be distributed amongst a range of stakeholders including:

- CCL shareholders in the form of after tax (and after voluntary contributions) profits;
- the Commonwealth Government in the form of any Company tax payable ($244M present value) from the BNCOP, which is subsequently used to fund provision of government infrastructure and services across Australia and Qld, including the local and regional area; and
- the Qld Government via royalties ($272M present value) which are subsequently used to fund provision of government infrastructure and services across the State, including the local and regional area.

The environmental, cultural and social impacts of the BNCOP may potentially accrue to a number of different stakeholder groups at the local, State, National and global level, however, are largely internalised into the production costs of CCL.

The non-market costs that accrue to Qld, that are not already included in the estimation of the net production benefits, are estimated at less than $1M. These are considerably less than the net production benefits that directly accrue to Qld. Consequently, as well as resulting in net benefits to Australia the BNCOP would result in net benefits to Qld.

An economic impact analysis, using input-output analysis found that the operation of the BNCOP would provide additional economic activity to the Banana Shire LGA, Banana Shire/Central Highlands Regional LGAs and Qld from expenditure during both construction and operation. Construction economic activity would last for approximately one year while incremental operation impacts would occur for up to 15 years. The incremental economic impact of the BNCOP operation on the Banana Shire LGA is estimates at up to:

- $341M in annual direct and indirect regional output or business turnover;
- $39M in annual direct and indirect regional value added;
- $12M in annual direct and indirect household income; and
- 355 direct and indirect jobs.

The incremental impact of the BNCOP operation on the Banana Shire and Central Highlands LGAs is estimated at up to:

- $364M in annual direct and indirect regional output or business turnover;
- $49M in annual direct and indirect regional value added;
- $19M in annual direct and indirect household income; and
- 472 direct and indirect jobs.

For the Qld economy, the operation of the BNCOP is estimated to make up to the following incremental contribution:

- $921M in annual direct and indirect regional output or business turnover;
- $320M in annual direct and indirect regional value added;
- $165M in annual direct and indirect household income; and
- 2,460 direct and indirect jobs.

‘Crowding out’ of economic activity in other sectors of the economy and regional house price and wage impacts are estimated to be minimal because of the potential availability of recently displaced labour in the region and the proposed BNCOP accommodation strategy.

Cessation of the BNCOP operation may lead to a reduction in economic activity. The significance of these BNCOP cessation impacts would depend on:

- The degree to which any displaced workers and their families remain within the region, even if they remain unemployed. This is because continued expenditure by these people in the regional economy (even at reduced levels) contributes to final demand.
- The economic structure and trends in the regional economy at the time. For example, if BNCOP cessation takes place in a declining economy the impacts might be felt more greatly than if it takes place in a growing diversified economy.
- Whether other mining developments or other opportunities in the region arise that allow employment of displaced workers.

1 INTRODUCTION

1.1 THE BARALABA COAL MINE

Cockatoo Coal Limited (CCL) operates the Baralaba Coal Mine which is located approximately 115 kilometres (km) west of Rockhampton, in the lower Bowen Basin region of central Queensland (Qld). Since CCL's acquisition of the mine in 2008, operations have progressed on an open cut basis and have produced approximately 500,000 tonnes of product coal per annum. The approved Baralaba Coal Mine Extension Project (including existing/approved operations within mining tenements at Baralaba Central and Baralaba North/Wonbindi North Mine) provides for an increase in production up to 1 million tonnes per annum (Mtpa) product coal for at least 15 years and up to 30 years.

The run-of-mine (ROM) coal is crushed and screened to produce a pulverized coal injection (PCI) product and several grades of thermal coal, which is then transported by road to product coal stockpiles and a train load-out (TLO) facility, located approximately 10 km east of Moura, for transport by rail and export via Gladstone. Currently, product coal specification is based on ash content, and the coal is sold unwashed.

1.2 PROJECT DESCRIPTION

The Baralaba North Continued Operations Project (BNCOP) provides for the continuation and expansion of the open cut coal mining and the introduction of processing activities at the existing Baralaba Coal Mine.

The BNCOP generally comprises:

- ROM coal production up to 4.1 Mtpa for 15 years (commencing approximately 1 April 2015 or upon grant of all required approvals), including mining operations associated with:
  - continued development of the Baralaba North pit;
  - extension of the Baralaba North pit to the north within MDL 416/EPC 1047 (both tenements held by Wonbindi Coal Pty Ltd); and
  - spoil dump to the east of the Baralaba North pit within EPC 1237 (tenement held by Queensland Coking Coal Pty Ltd).
- exploration activities;
- progressive backfilling of mine voids with waste rock behind the advancing open cut mining operations at the Baralaba North/Wonbindi North Mine and/or within the Baralaba Central void;
- continued and expanded placement of waste rock in spoil dumps adjacent to the pit extents;
- progressive development of new haul roads and internal roads;
- construction and operation of a CHPP at the Baralaba North/Wonbindi North Mine;
- disposal of CHPP rejects on-site within mine voids behind the advancing open cut mining operations and/or within the Baralaba Central void;
- progressive development of sediment basins and storage dams, pumps, pipelines and other water management equipment and structures (including levees);
- continued development of soil stockpiles, laydown areas and borrow areas;
- use of upgraded administration and maintenance facilities at the Baralaba Coal Mine and establishment of new mine infrastructure areas at the Baralaba North/Wonbindi North Mine;

- other associated minor infrastructure, plant, equipment and activities, including minor modifications and alterations to existing infrastructure as required to accommodate the increased throughput;
- continued road transport of product coal (using AB triple and AAB quad road-trains) along the “Middle Road” (a network of public roads including Theodore-Baralaba Road) to new product coal stockpiles and TLO facility (subject to separate approvals being in place); and
- use of new product coal stockpiles and TLO facility for loading of product coal to trains for transport by rail and export via Gladstone.

Based on the planned maximum production rate, approximately 52 million tonnes (Mt) of product coal would be produced during the 15 years of the BNCOP.

1.3 ECONOMIC ASSESSMENT

Gillespie Economics was commissioned by CCL to complete an economic assessment for the BNCOP. The purpose of the assessment is to form part of an Environmental Impact Statement (EIS) being prepared to support an application for approval under Chapter 3 of the *Environmental Protection Act 1994* (EP Act). Under Section 40 of the EP Act, the purpose of an EIS is “to assess the potential adverse and beneficial environmental, economic and social impacts of the project”. Economics provides a methodology for evaluating the positive and negative economic, environmental, social and cultural impacts of a project and identifying whether in aggregate the economic benefits of a project to the community exceed the economic costs. The method for making this assessment is benefit cost analysis (BCA). BCA is therefore the primary analysis undertaken in this report.

In addition, the Terms of Reference for the BNCOP require consideration of the likely impacts (positive and negative) of the project on the economies materially impacted by the BNCOP and the measures for avoiding or mitigating impacts or enhancing economic benefits (Refer to Attachment A1 of the EIS). This component of the analysis is undertaken using input-output analysis of the BNCOP and a range of data for the region.

2 REGIONAL DESCRIPTION

The BNCOP is located in the Central Highlands Regional Local Government Area (LGA) 7 km to the north west of Baralaba which is located in the Banana Shire LGA. For the purposes of this assessment, the Region consists of the Central Highlands Regional and Banana Shire LGAs. A description of the regional economic profile is provided below.

A key indicator of economic prosperity in the regional economy is population growth. Places that are able to attract population in-migration create increased demand for goods and services and thus more jobs. This growth leads to increasing local multiplier effects, scale economies and an increase in the rate of innovation and capital availability (Sorensen, 1990). The converse occurs if population declines.

Population growth in the Central Highlands Regional LGA has been 2.2% per annum from 2007 to 2012, similar to the population growth in Qld (Table 2.1). Over the same period the population growth in the Banana Shire LGA has been static (Table 2.1).

Table 2.1 – Population Growth

Local Government Area	**2007**	**2008**	**2009**	**2010**	**2011**	**2012r[1]**	**Change 2007-2012r**		
	no.	**no.**	**no.**	**no.**	**no.**	**no.**	**%**	**% pa**	**no.**
Banana Shire	14,883	14,880	14,941	14,855	14,812	14,947	0.4	0.1	64
Central Highlands Regional	27,596	28,090	28,714	29,082	29,541	30,573	10.8	2.2	2,977
Total Region	42,479	42,970	43,655	43,937	44,353	45,520	7.16	1.4	3,041
Queensland	**4,111,018**	**4,219,505**	**4,328,771**	**4,404,744**	**4,476,778**	**4,565,529**	**11.1**	2.2	**454,511**

Source: ABS (2013)

[1] Estimated Residential Population at 30 June

Projected population growth for the region is 1.9% per year over 20 years, with Central Highlands Regional LGA projected to have growth of 2.4% per year and Banana Shire LGA growth of 0.7%, compared to project growth across Qld of 1.8% (Table 2.2).

Table 2.2 – Projected Population by LGA

Region	**As at 30 June**					**Average Annual Growth Rate**
	2011	**2016**	**2021**	**2026**	**2031**	**2011-2031**
	Number -					**%**
Banana Central Highlands Region	**47,603**	**53,204**	**58,190**	**63,444**	**69,019**	**1.9**
Banana Shire LGA	15,742	16,948	17,310	17,759	18,277	0.7
Central Highlands Regional LGA	31,861	36,256	40,880	45,685	50,742	2.4
Queensland	**4,611,491**	**5,092,858**	**5,588,617**	**6,090,548**	**6,592,857**	**1.8**

Source: Queensland Government (2011)

Employment in the region has grown at a faster rate than population growth and is similar for Banana Shire LGA and Central Highlands Regional LGA (Table 2.3).

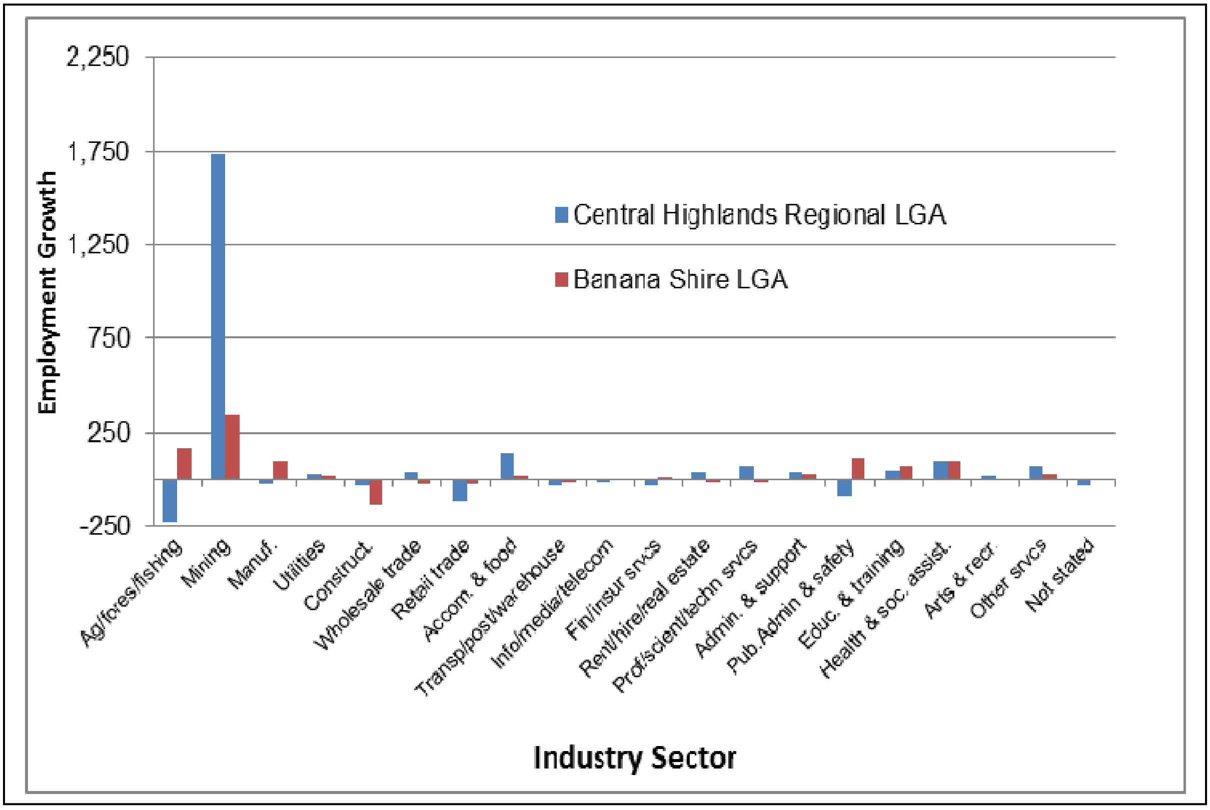
Table 2.3 – Employment by LGA

Local Government Areas	2006	2011	Change 2006-2011	
			%	% pa
Banana Shire	7,198	7,973	10.8	2.2
Central Highlands Regional	15,136	16,855	11.4	2.3
Total Region	**22,334**	**24,828**	**11.2**	**2.2**
Queensland	**1,737,619**	**1,991,753**	**14.6**	**2.9**

Source: ABS (2011)

Most of the employment growth in the region has been in the mining industry and specifically the coal mining industry (Figure 2.1).

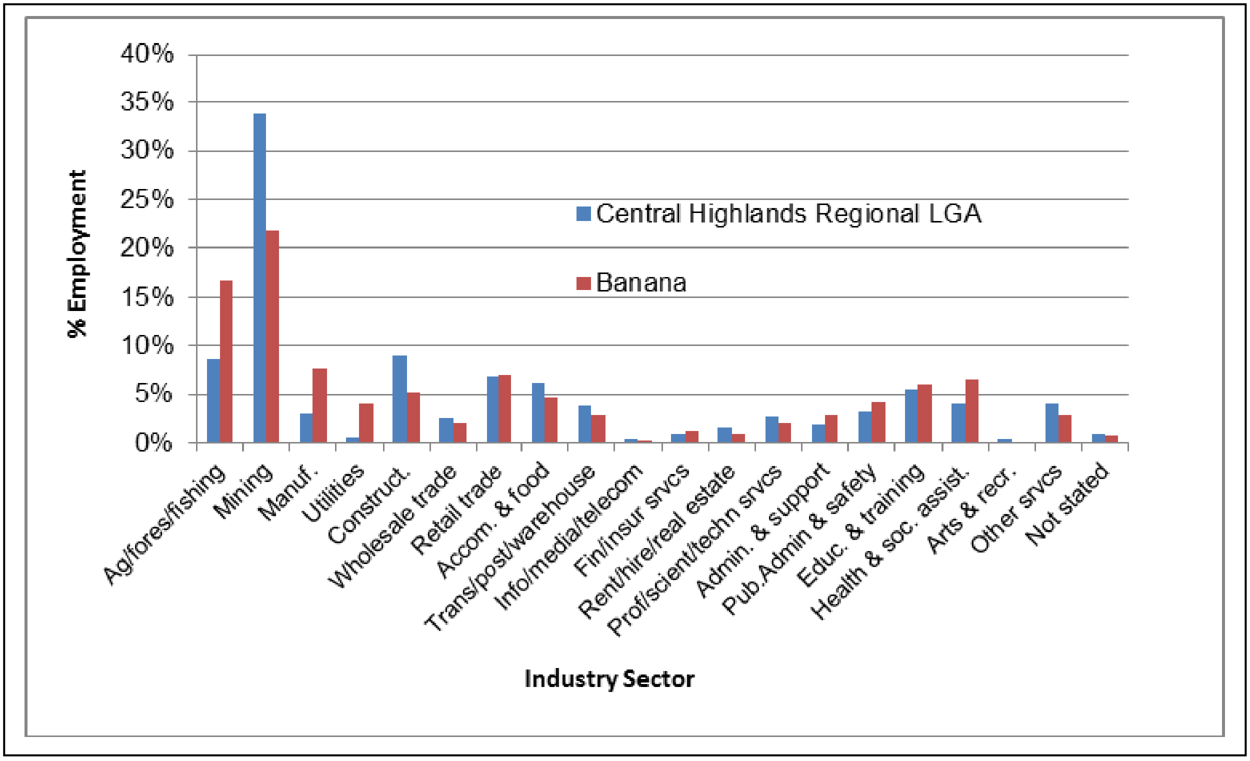
Figure 2.1 – Employment Growth by Industry 2006-2011



Source: ABS (2011)

The largest employer in both LGAs is the mining sector followed by the agricultural sector, although the mining sector is of greater relative significance in the Central Highlands Regional LGA and agriculture is of greater relative significance in the Banana Shire LGA (Figure 2.2).

Figure 2.2 – Percentage Employment by Industry 2011



Source: ABS (2011)

The unemployment rate in both LGAs is considerably lower than for Qld (6.0%), with the Central Highlands Regional LGA having an unemployment rate of 2.8% in June quarter 2013 and Banana Shire LGA having an unemployment rate of 3.5% (Table 2.4).

Table 2.4 Unemployed and Labour Force $^{(a)}$ by LGA, June Quarter 2013

Region	Unemployed	Labour Force	Unemployment Rate
	Number		%
Banana Central Highlands Region	**934**	**30,397**	**3.1**
Banana Shire	373	10,585	3.5
Central Highlands Regional	561	19,812	2.8
Queensland	**148,630**	**2,494,587**	**6.0**

Source: Department of Education, Employment and Workplace Relations (2013)

(a) Based on 4-quarter smoothed series

Reflecting the percentage of employment in the high wage sector of mining, the median total personal income in both the Banana Shire LGA and Central Highlands Regional LGA is higher than for Qld (Table 2.5).

Table 2.5 – Total Personal Income by LGA, 2011

Region	Less than $20,800 per year		$20,800 to $51,999 per year		$52,000 to $103,999 per year		$104,000 or more per year		Total (a)	Median ($/year)
	number	%	number	%	number	%	number	%	Number	$
Banana Central Highlands Region	**9,344**	**28.6**	**8,329**	**25.5**	**6,982**	**21.3**	**4,567**	**14.0**	**32,706**	**36,027**
Banana Shire	3,699	33.5	3,185	28.8	2,090	18.9	1,162	10.5	11,057	32,794
Central Highlands Regional	5,645	26.1	5,144	23.8	4,892	22.6	3,405	15.7	21,649	43,218
Queensland	**1,195,059**	**34.6**	**1,095,509**	**31.7**	**689,495**	**19.9**	**191,236**	**5.5**	**3,456,877**	**30,556**

Source: ABS (2011b)

(a) Includes personal income not stated

Additional descriptive information on the Banana Shire LGA and Central Highlands Regional LGA is provided in Section 4 using information from input-output tables developed for these regions.

3 BENEFIT COST ANALYSIS

3.1 INTRODUCTION

Introduction

BCA has its theoretical underpinnings in neoclassical welfare economics. Applications are guided by these theoretical foundations as well various jurisdictional guidelines. Qld Department of Infrastructure and Planning and Queensland Treasury (undated) provide guidelines for application of BCA for preparation of business cases for government projects however numerous other guidelines exist and BCA can be undertaken of private sector as well as public sector projects.

BCA is concerned with the single objective of economic efficiency. It provides a comparison of the present value of aggregate benefits to society, as a result of a project, policy or program, with the present value of the aggregate costs. These costs and benefits are defined and valued based on the microeconomic underpinnings of BCA. In particular, it is the values held by individuals in the society that are relevant, including both financial and non-financial values. Provided the present value of aggregate benefits to society exceed the present value of aggregate costs (i.e. a net present value of greater than zero), a project is considered to improve the well-being of society and hence is desirable from an economic efficiency perspective.

While BCA can provide qualitative and quantitative information on how economic efficiency costs and benefits are distributed, welfare economics and BCA are explicitly neutral on intra and intergenerational distribution of costs and benefits. There is no welfare criterion in economics for determining what constitutes a fair and equitable distribution of costs and benefits. Judgements about equity are considered subjective and are therefore left to decision-makers.

Similarly, BCA does not address other objectives of government. Decision-makers therefore need to consider the economic efficiency implications of a project, as indicated by BCA, alongside the performance of a project in meeting other, often conflicting, government goals and objectives.

Definition of Society

BCA includes the consideration of costs and benefits to all members of society i.e. consumers, producers and the broader society as represented by the government.

As a tool of investment appraisal for the public sector, BCA can potentially be applied across different definitions of society such as a local area, state, nation or the world. However, most applications of BCA are performed at the national level. This national focus extends the analysis beyond that which is strictly relevant to a Qld government planning authority. However, the interconnected nature of the Australian economy and society creates significant spillovers between States. These include transfers between States associated with the tax system and the movement of resources over state boundaries.

Nevertheless, “where major impacts spill over national borders, then BCA should be undertaken from the global as well as the national perspective” (Boardman et al 2001). For mining projects, impacts that spill over national borders include greenhouse gas costs and benefits to foreign owners.

BCA at a sub-national perspective is not recommended as it results in a range of costs and benefits from a project being excluded, making BCA a less valuable tool for decision-makers (Boardman et al 2001).

BCAs of mining projects are therefore often undertaken from a global perspective i.e. including all the costs and benefits of a project, no matter who they accrue to, and then truncated to assess whether there are net benefits to Australia. A consideration of the distribution of costs and benefits can then be undertaken to identify the benefits and costs that accrue to Qld and other regions. However, a project is considered to improve the well-being of society if it results in net benefits to the nation, even if it results in net costs to the local area.

Definition of the Project Scope

The definition of the project for which approval is being sought has important implications for the identification of the costs and benefits of a project. Even when a BCA is undertaken from a global perspective, and includes costs and benefits of a project that accrue outside the national border, only the costs and benefits associated with the defined project are relevant. For mining projects, typically only the costs and benefits from mining the coal and delivering it to Port or domestic users, are relevant.

Coal is an intermediate good i.e. it is an input to other production processes such as production of electricity and steel making. However, these other production processes themselves require approval and, in BCA, would be assessed as separate projects.

Net Production Benefits

BCA of mining proposals invariably involves a trade-off between:

- the net production benefits of a project; and
- the environmental, social and cultural impacts (most of which are costs of mining but some of which may be benefits).

Net production benefits can be estimated based on market data on the projected financial[1] value of coal less the capital and operating costs of projects, including opportunity costs of capital and land already in the ownership of mining companies. This is normally commercial-in-confidence data provided by the proponent. Production costs and benefits over time are discounted to a present value.

Environmental, Social and Cultural Impacts

The consideration of non-market impacts in BCA relies on the assessment of other experts contributing information on the biophysical impacts. The environmental impact assessment process results in detailed (non-monetary) consideration of the environmental, social and cultural impacts of a project and the proposed means of mitigating the impacts.

At its simplest level, BCA may summarise the consequences of the environmental, social and cultural impacts of a project (based on the assessments in the EIS), for people's well-being. These qualitatively described impacts can then be considered alongside the quantified net production benefits, providing important information to the decision-maker about the economic efficiency trade-offs involved with a project.

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[1] In limited cases the financial value may not reflect the economic value and therefore it is necessary to determine a shadow price for the coal.

At the next level of analysis, attempts may be made to value some of the environmental, social and cultural impacts. These environmental, social and cultural impacts generally fall into three categories, those which:

- can be readily identified, measured in physical terms and valued in monetary terms;
- can be identified and measured in physical terms but cannot easily be valued in money terms; and
- are known to exist but cannot be precisely identified, measured or valued.

Impacts in the first and second category can potentially be valued in monetary terms using benefit transfer or, subject to available resources, primary non-market valuation methods. Benefit transfer involves using information on the physical magnitude of impacts and applying per unit value estimates obtained from non-market valuation studies undertaken in other contexts.

Primary non-market valuation methods include choice modelling and the contingent valuation method where a sample of the community is surveyed to ascertain their willingness to pay to avoid a unit change in the level of a biophysical attribute. Other methods include the property valuation approach where changes in environmental quality may result in changes in property value.

In attempting to value the impacts of a project on the well-being of people there is also the practical principle of materiality. Only those impacts which are likely to have a material bearing on the decision need to be considered in BCA.

Where benefits and costs cannot be quantified these items should be included in the analysis in a qualitative manner.

Consideration of Net Social Benefits

The consideration of the net social benefits of a project combines the value estimate of net production benefits and the qualitative and quantitative estimates of the environmental, social and cultural impacts.

In combining these considerations it should be noted that the estimates of net production benefits of a project generally includes accounting for costs aimed at mitigating, offsetting or compensating for the main environmental, social and cultural impacts. This includes the costs of purchasing properties adversely affected by noise and dust, providing mitigation measures for properties moderately impacted by noise and dust, the costs of providing ecological offsets and the cost of purchasing water entitlements in the water market etc. Including these costs effectively internalises the non-monetary environmental, social and cultural costs. To avoid double counting of impacts, only residual impacts, after mitigation, offset and compensation, require additional consideration.

Even when no quantitative valuation is undertaken of the environmental, social and cultural impacts of a project, the threshold value approach can be utilised to inform the decision-maker of the economic efficiency trade-offs. The estimated net production benefits of a project provides the threshold value that the non-quantified environmental, social and cultural impacts of a project (based on the assessments in the EIS), after mitigation, offset and compensation by the proponent, would need to exceed for them to outweigh the net production benefits.

Where the main environmental, social and cultural impacts of a project are valued in monetary terms, stronger conclusions can be drawn about the economic efficiency of a project i.e. the well-being of society.

Any other residual environmental, cultural or social costs that remain unquantified in the analysis[2] can also be considered using the threshold value approach. The costs of these unquantified environmental, cultural and social impacts would need to be valued by society at greater than the quantified net social benefit of a project to make it questionable from an economic efficiency perspective.

Steps in BCA of the BNCOP

BCA of the BNCOP involves the following key steps:

- identification of the base case (the “without” BNCOP case);
- definition of the “with” BNCOP case;
- identification and valuation of the incremental benefits and costs associated with the BNCOP relative to the base case;
- consolidation of value estimates using discounting to account for temporal differences;
- application of decision criteria;
- sensitivity testing; and
- consideration of non-quantified benefits and costs..

What follows is a BCA of the BNCOP based on financial, technical and environmental advice provided by CCL and its’ specialist consultants.

3.2 IDENTIFICATION OF THE BASE CASE AND THE BNCOP

Identification of the “base case” or “without” BNCOP scenario is required in order to facilitate the identification and estimation of the incremental economic benefits and costs of the BNCOP.

Under the base case, the Baralaba Coal Mine would produce 1 Mtpa of ROM and product coal (unwashed) for 30 years. In contrast, the BNCOP (as described in Section 1.1) would undertake coal mining from the same land area plus an additional 1,486 ha at a rate of production of up to 4.1 Mtpa of ROM coal over a 15 year period. A proportion of the ROM coal from the BNCOP would be washed to produce in the order of 3.5 Mtpa of a higher quality product coal. Production under the base case and BNCOP case is illustrated in Figure 3.1.

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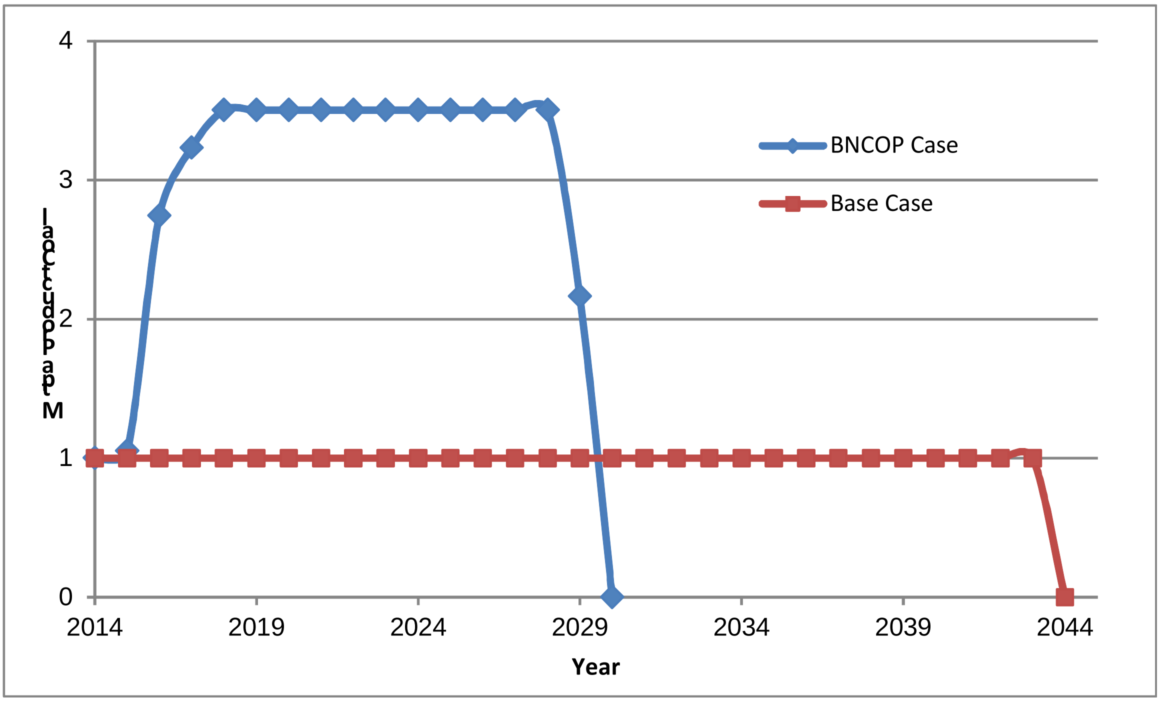
[2] Including potential impacts that were unknown at the time of the preparation of the EIS or arise during the EIS assessment process due to differences in technical opinions.

Figure 3.1 – Comparison of Mining Under the Base Case and BNCOP Case



BCA is primarily concerned with the evaluation of a project relative to the counterfactual of no project. Where there are a number of alternatives to a project then these can also be evaluated using BCA. However, alternatives need to be feasible to the proponent and to this end a number of alternatives to the BNCOP were considered by CCL in the development of the project description. Section 2.11.2 in the Main Volume of the EIS provides more detail on the consideration of Project alternatives.

The BNCOP assessed in the EIS and evaluated in the BCA is considered by CCL to be the most feasible alternative for minimising environmental and social impacts whilst maximising resource recovery and operational efficiency. It is therefore this alternative that is proposed by CCL and was subject to detailed economic analysis.

3.3 IDENTIFICATION OF BENEFITS AND COSTS

Relative to the base case or “without” BNCOP scenario, the BNCOP may have the potential incremental economic benefits and costs shown in Table 3.1. The main potential economic benefit is the producer surplus (net production benefits) generated by the BNCOP and any non-market employment benefits it provides. The additional net production benefits of the BNCOP partly come from bringing forward in time production that would otherwise occur over a longer time period under the base case, partly from an increase in overall production volume from an extension of the mine footprint and partly from washing of the ROM coal (i.e. increasing the quality and value of the product coal). The main potential economic costs relate to bringing forward in time environmental, social and cultural costs that would occur under the base case as well as additional impacts from extension of the BNCOP footprint.

Table 3.1 - Incremental Economic Benefits and Costs of the BNCOP

Category	Costs	Benefits
Net production benefits	Opportunity cost of additional land required for the BNCOP that is already in CCL ownership Incremental development costs including labour, capital equipment and acquisition costs for impacted properties and offsets[1] Incremental operating costs of mine including labour and mitigation measures Incremental rehabilitation and decommissioning costs	Incremental value of coal production Incremental residual value of capital equipment and land
Potential environmental, social and cultural impacts	Greenhouse gas impacts Noise impacts Blasting impacts Air quality impacts Surface water impacts Groundwater impacts Ecology impacts Road transport impacts Indigenous heritage impacts Non-Indigenous heritage impacts Visual impacts	Any non-market benefits of employment

[1] The value of foregone agricultural production is included in the value of land.

It should be noted that the potential environmental, social and cultural costs, listed in Table 3.1, are only economic costs to the extent that they affect individual and community well-being through direct use of resources by individuals or non-use. If the potential impacts do not occur or are mitigated to the extent where community wellbeing is insignificantly affected (e.g. those bearing the costs are fully compensated), then no environmental, social or cultural economic costs should be included in the BNCOP BCA.

3.4 QUANTIFICATION/VALUATION OF BENEFITS AND COSTS

The analysis has been undertaken in real values with discounting at 7 percent (%) and sensitivity testing at 4% and 10%. The analysis period is 31 years to capture the main costs and benefits of the BNCOP and the foregone production under the base case. However, any costs or benefits that occur after this time period have been included in the final year of the analysis as a terminal value. Where competitive market prices are available, they have generally been used as an indicator of economic values. Environmental, cultural and social impacts have been initially been left unquantified and interpreted using the threshold value method[3]. An attempt has also been made to estimate environmental, cultural and social impacts using market data and benefit transfer[4].

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[3] The threshold value method uses the value of quantified net production benefits as the amount that unquantified environmental, social and cultural costs would need to exceed to make a project questionable from an economic efficiency perspective.

[4] Benefit transfer refers to borrowing economic values that have been determined for other study sites.

3.4.1 *Production Costs and Benefits*[5]

Production Costs

Opportunity Cost of Land

The majority of the land required for the BNCOP is owned by CCL and is also required for the continuation of mining under the base case. However, an additional 1,486 ha is required for the BNCOP of which 720 ha is in CCL ownership. There is an opportunity cost associated with using this land for the BNCOP instead of its next best use (i.e. agricultural production). An indication of the opportunity cost of this land can be gained from its market value, estimated at $2.5M. The market value of land reflects among other things, the present value of the expected stream of profits from the next best alternative land use (agricultural production).

Development Cost of the BNCOP

Development costs of the BNCOP are associated with the purchase of additional mining equipment, development of the CHPP, progressive development of new haul roads and internal roads, development of the mine infrastructure area, provision of services, engineering costs, land acquisitions, purchase of water allocations etc. These costs include labour costs during the development of the BNCOP, which reflect the value of labour resources in their next best use.

These incremental development costs over the life of the mine are estimated at $371M. These incremental development costs include sustaining capital, an allowance for acquisition of land for the mine extension itself, implementation of noise and air quality mitigation measures and ecological offsets. Development costs are included in the economic analysis in the years that they are expected to occur.

Annual Operating Costs of the BNCOP

The operating costs of the BNCOP include those associated with mine operation (including top soil and overburden stripping, ROM coal mining and haulage and rehabilitation), plant and infrastructure operations (including CHPP operation), coal delivery (rail freight and Port handling and loading) and general costs (including overheads and administration, marketing and the Australian Coal Industry's Research Program levy). These costs include labour costs, which reflect the value of labour resources in their next best use. Average annual operating costs (excluding depreciation and royalties) are estimated at approximately $293M per annum for the 15 year period compared to $92M per annum for 30 years under the base case.

While royalties are a cost to CCL, they are part of the overall net production benefit of the mining activity that is redistributed by government. Royalties are therefore not included in the calculation of the resource costs of operating the BNCOP. Nevertheless, it should be noted that the BNCOP would generate total royalties in the order of $816M ($437M present value), compared to $444M ($165M present value) under the base case.

Depreciation has also been omitted from the estimation of operating costs since depreciation is an accounting means of allocating the cost of a capital asset over the years of its estimated useful life. The economic capital costs are included in the years in which they occur.

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[5] All values reported in this section are undiscounted Australian dollars unless otherwise specified.

Rehabilitation and Decommissioning Costs

Annual rehabilitation costs are included in the operating costs for the BNCOP reported above. A provision for final void rehabilitation works of $10M has also been included in the analysis of the BNCOP compared to $5M under the base case.

Production Benefits

Value of Coal

Total product coal is estimated at approximately 52 Mt of product coal (washed and unwashed) under the BNCOP case and 30 Mt of product coal (unwashed) under the base case. The BNCOP product coal would be of higher quality than the base case product coal as a proportion of the product coal would be washed.

Both demand for and supply of coal influences current and projected prices.

Projected real prices for the BNCOP product coal were provided by CCL and ranged from USD$123 in 2013 to USD$188 in 2030. An exchange rate of 0.91 was assumed. Under the base case product coal is assumed to sell at a 15% discount to the higher quality BNCOP product coal. There is uncertainty around future coal prices (valued in USD) as well as the AUD/USD exchange rate and hence assumed coal prices have been subjected to sensitivity testing (see Section 3.6).

Residual Value at End of the Evaluation Period

At the end of the BNCOP, capital equipment and land (excluding offsets) may have some residual value that could be realised by sale or alternative use. This residual value is incorporated into the development costs above.

3.4.2 *Environmental, Social and Cultural Costs and Benefits*

Greenhouse Gases

The BNCOP is predicted to generate in the order of:

- 3.6 Mt of direct greenhouse gas emissions associated with fugitive emissions, use of diesel fuel and vegetation clearance (Scope 1 emissions) over the lifetime of the BNCOP (Appendix D of the EIS) compared to 1.9 Mt of Scope 1 emissions under the base case;
- 1.4 Mt of indirect (Scope 2) emissions associated with on-site electricity consumption (Appendix D of the EIS) compared to 0.01 Mt under the base case; and
- 0.5 Mt of indirect (Scope 3) emissions associated with the transport of product coal to Gladstone and on-site diesel and electricity use (Appendix D of the EIS) compared to 0.3 Mt under the base case.

The economic analysis has included these incremental emissions as a potential environmental cost of the BNCOP.

To place an economic value on carbon dioxide equivalent (CO_2-e) emissions, a shadow price of CO_2-e is required that reflects its social costs. The social cost of CO_2-e is the present value of additional economic damages now and in the future caused by an additional tonne of CO_2-e emissions. There is great uncertainty around the social cost of CO_2-e with a wide range of estimated damage costs reported in the literature. An alternative method to trying to estimate the damage costs of CO_2-e is to examine the price of CO_2-e credits/taxes. Again, however, there is a wide range of prices. For this analysis, a shadow price of AUD$23/t CO_2-e in 2013 rising by 2.5% per annum for three years and then remaining constant was used, with sensitivity testing from AUD$8/t CO_2-e to AUD$40/t CO_2-e (refer to Attachment 1).

This represents the global social cost of carbon i.e. the cost of carbon emissions to the population of the whole world. In the absence of any studies that have focused on the social damage cost of carbon emissions to Australians, some means of apportioning global damage costs borne by Australians is required. For the purpose of the economic assessment this has been undertaken using Australia's share of global gross domestic product (around 1%). An alternative approach would be Australia's share of world population which is considerably less than 1%.

The greenhouse gas costs associated with the burning of the coal or downstream manufacturing that uses coal are not relevant to the BCA of a mining project. After coal leaves port it becomes an input into different production processes. In the case of PCI coal the production process is concerned with steel production. This production process requires approval of the states/countries purchasing the coal and has its own set of costs and benefits. Costs of steel production in other states/countries include the costs of iron ore, coal, labour, land and capital inputs and environmental costs, such as greenhouse gas generation. Benefits include the financial value of steel as well as any associated consumer surplus. All of these costs and benefits are relevant to a consideration of this next stage of the production process.

Agricultural Production

The present value of foregone agricultural production is reflected in land prices. The value of foregone agricultural production, as a result of the BNCOP, has therefore been incorporated in the BCA through inclusion of the full land value (opportunity cost) of affected properties.

Operational Noise

As described in the Noise and Vibration Assessment (Appendix H of the EIS), the Baralaba Coal Mine contributes to the existing noise environment at nearby private rural residences.

In order to comply with the *Environmental Protection (Noise) Policy 2008* Noise Quality Objectives, CCL has committed to a number of noise mitigation measures for the BNCOP (Appendix H of the EIS). These mitigation measures have been included in the incremental development cost and annual operating cost of the BNCOP.

Blasting

The Noise and Vibration Assessment (Appendix H of the EIS) concluded that the BNCOP would comply with the criteria in DERM's *Ecoaccess Guideline Noise and Vibration from Blasting.*

Based on the above, no material economic effects have been identified for inclusion in the BCA with respect to blasting impacts on private receivers.

Air Quality

Potential air quality impacts may occur at nearby residences as a result of dust generation at the BNCOP from activities such as coal and waste rock handling, emissions from stockpiles and haul roads, and blasting.

The Air Quality and Greenhouse Gas Assessment for the BNCOP (Appendix G of the EIS) indicates that there is only limited potential for air quality levels to exceed the air quality objective for 24-hour PM_{10} concentrations at a number of isolated rural receptors, and only on a few days each year.

CCL has committed to the implementation of a range of potential dust mitigation and management measures in the day-to-day operation to minimise potential dust impacts at sensitive receptors during these periods. The potential mitigation measures have been included in the incremental development cost and annual operating cost of the BNCOP.

Surface Water

The BNCOP would result in changes to flows in local creeks due to the progressive extension of the open cut mining operations and associated subsequent capture and re-use of drainage from operational catchment areas.

Changes to groundwater baseflow contributions to local creeks were also identified as a potential impact of the BNCOP. The Groundwater Modelling and Assessment (Appendix D of the EIS) concluded that potential impacts on baseflow would be limited primarily due to the pronounced unsaturated depth and therefore relatively little connection between watercourses and aquifers (i.e. baseflow). Potential impacts on baseflow to rivers and creeks adjacent to the BNCOP would therefore be negligible (Appendix D of the EIS).

Compared to the existing/approved total catchment area excised by the Baralaba Coal Mine and Baralaba North/Wonbindi North Mine, the BNCOP is expected to have the following impacts on catchments at the end of mining (Appendix C of the EIS):

- no measurable change to the Dawson River catchment (to Beckers stream gauge);
- an increase of less than 0.1% of the Saline Creek catchment; and
- a reduction of approximately 23% of the Northern Wetland catchment.

The Northern Wetland is periodically inundated by flood backflow from the Dawson River and Saline Creek, and therefore the predicted maximum changes in catchment would not result in a directly proportional change in the flow regime (Appendix C of the EIS).

The BNCOP water management system is to be operated with the objective to achieve no contained water storage overflow. The Site Water Balance and Surface Water Assessment modelling results show no uncontrolled spills of mine-affected water from the Mine Water Dam or Process Water Dam, consistent with the proposed operating strategy for the mine water system (Appendix C of the EIS).

Controlled releases from the BNCOP when considered cumulatively with controlled releases from the Baralaba South Project would have no measurable impact on Dawson River flows (Appendix C of the EIS).

Based on the above, no material economic effects have been identified in the BCA with respect to water quality and quantity impacts.

Groundwater

Numerical modelling of the BNCOP impacts on groundwater has been undertaken as part of the EIS (Appendix D of the EIS). This assessment also included cumulative consideration of the Baralaba South Project.

Numerical modelling conducted as part of the Groundwater Modelling and Assessment (Appendix D of the EIS) predicts that the maximum effect (BNCOP-specific) at or after the end of mining would be a drawdown in the regional water table of approximately 10-20 m around the perimeter of the mining footprint. The 1 m drawdown contour is likely to extend approximately 1-2 km west, 2-3 km north and less than 1 km east of the Baralaba North pit (Appendix D of the EIS).

However, the numerical modelling predicts that impacts on groundwater levels or groundwater yield for groundwater users with privately owned bores registered on the Queensland government's Groundwater Bore database would be negligible (Appendix D of the EIS).

The BNCOP is not predicted to cause a change in flow direction in the hydrogeological units that constitute the Great Artesian Basin (GAB), and capture of groundwater from the GAB units and the decline in GAB water levels are predicted to be negligible (Appendix D of the EIS).

Drawdowns are predicted in the regional water table to the north of the BNCOP, including under the North-west Soak and Northern Wetland (Figure 2). The most significant drawdown occurs late in the life of the BNCOP, with maximum drawdowns occurring post-mining. However, the predicted drawdown impact on these two wetlands is expected to be negligible, given that these wetland features exist in an area where the water table lies 10-12 m below ground level (Appendix D of the EIS).

No net drawdown in the regional water table is predicted to the east of the BNCOP around the HESN and HESS wetlands. Any small drawdown impact at these sites (if not perched) would be offset by an increase in recharge and elevated water table conditions in the spoil emplacement areas proposed for the area between the wetlands and final void (Appendix D of the EIS).

Based on the above, no material economic effects have been identified for inclusion in the BCA with respect to impacts on groundwater users or groundwater quality impacts.

Ecology

An assessment of the impacts of the BNCOP on terrestrial and aquatic ecology has been undertaken as part of the EIS (Appendices A and B of the EIS). The surface disturbance associated with the BNCOP would involve the clearance of approximately 277 ha of remnant native vegetation, (Appendix A of the EIS). Although this remnant native vegetation does not represent a threatened ecological community, it is known to provide habitat for some threatened fauna species (Appendix A of the EIS). The aquatic ecology assessment identifies potential impacts on aquatic habitat (Appendix B of the EIS).

A range of measures to avoid, mitigate and offset impacts on biodiversity are proposed (Appendices A and B of the EIS). Of particular note, the BNCOP incorporates progressive rehabilitation of disturbance areas and the development and implementation of a Biodiversity Offset Strategy. As no biodiversity offset area has been identified at this stage it has been costed in accordance with the Department of Environment and Heritage Protection's offset payments calculator (DEHP 2012) and included in the capital and operating costs of the BNCOP. Provided the offsets developed for the BNCOP compensate for the lost biodiversity values from the BNCOP no additional costs are relevant for inclusion in the BCA.

Road Transport

A Road Transport Assessment was prepared for the BNCOP by Cardno (2014) and is presented in Appendix I of the EIS. The Road Transport Assessment concluded that, with implementation of the haul route upgrade package proposed by CCL for the existing operations at the Baralaba Coal Mine and Baralaba North/Wonbindi North Mine, the BNCOP would not have a significant impact on the safety and efficiency of the road network.

No further mitigation measures outside of those committed to by CCL for the existing operations are required and therefore road transport does not warrant further consideration in the BCA.

Indigenous Heritage

CCL has entered into a Cultural Heritage Investigation and Management Agreement (CHIMA) with the Gaangalu Nation People. The CHIMA was approved as a Cultural Heritage Management Plan (CHMP) pursuant to section 107 of the *Aboriginal Cultural Heritage Act, 2003* (Qld) by the Department of Aboriginal and Torres Strait Islander and Multicultural Affairs on 12 August 2013.

The CHMP provides for the engagement of the Gaangalu Nation People prior to the commencement of any ground disturbance works, which allows for an assessment of the cultural heritage values within the proposed area of disturbance, and for the development of appropriate management strategies.

The CHMP applies to all land within the BNCOP operational land and includes the following provisions:

- Establishment of a Coordinating Committee comprised of representatives from CCL and the Gaangalu Nation People Endorsed Parties for the purposes of coordination, implementation, management and future conduct of matters arising in relation to the CHMP.
- Reporting of discovery of any Aboriginal Cultural Heritage within the BNCOP operational land.
- Process for obtaining approval for BNCOP works and cultural heritage management, including the implementation of agreed management arrangements relevant to previously identified significant areas and objects (through initial cultural heritage assessments in accordance with an initial cultural heritage assessment agreement).
- Procedures in relation to the discovery of any human remains.
- Access to the BNCOP operational land and surrounding areas covered by the CHIMA.

The BNCOP would be constructed and operated in accordance with the above provisions.

Provided these measures minimise the impacts on Indigenous cultural heritage there would be no material economic effects that would arise with respect to Indigenous Cultural Heritage for inclusion in the BCA.

Non-Indigenous Heritage

Five non-Indigenous cultural heritage items were identified during the Non-Indigenous Cultural Heritage Assessment (NICH Assessment). Only one site (a telephone line), was assessed as having low cultural heritage significance, would be impacted by the BNCOP. The remaining four items (earthern banked dams) were assessed as having no cultural heritage significance.

The recording of the telephone line undertaken as part of the NICH assessment was determined by Converge Heritage + Community (2013) to be a sufficient mitigation measure (Appendix L of the EIS).

Therefore no material residual economic effects would arise with respect to non-Indigenous cultural heritage for inclusion in the BCA.

Visual Impacts

Potential views of the BNCOP landforms would be available from the following locations (Section 4.2 of the EIS):

- rural residences to the north-east, south-east, west and south-west of the BNCOP;
- local roads; and
- other areas such as private roads and paddocks.

Visual impacts of the BNCOP would include new and/or increased views of the spoil dumps and open cut from local viewpoints. Modification of topographic features, construction of flood levees and additional clearance or disturbance of vegetation within the BNCOP area would also result in visual impacts. Visual impacts associated with mine landforms would decrease over time due to progressive rehabilitation (Section 4.2 of the EIS).

Continuation and extension of night-lighting would also be associated with the BNCOP. The use of night-lighting would cease at mine closure.

When assessing the impacts outlined above, the existing/approved alterations to the visual landscape associated with the approved Baralaba North/Wonbindi North Mine must be taken into account (Section 4.2 of the EIS).

Visual intrusion can potentially impact the property value (and potentially consumer surplus) of affected households and the consumer surplus of visitors. Visual impacts would be most appreciable at the nearest privately owned dwellings with views of the BNCOP landforms. The potential impacts at the nearest private dwellings have been assessed as being very low to high and following rehabilitation, residual impacts would be very low to moderate (Section 4.2 of the EIS).

Progressive rehabilitation would be implemented at the BNCOP, gradually reducing the contrast between the landforms of the BNCOP and the surrounding landscape. Rehabilitation activities would include planting of native tree and shrub species consistent with those found in other elevated landforms in the region (Section 5 of the EIS). Rehabilitation costs have been included in the annual operating costs for the BNCOP.

There are considered to be no additional material visual impacts for inclusion in the BCA.

Non-market Value of Employment

Historically employment benefits of projects that are enjoyed by people other than those who are employed, have tended to be omitted from BCA on the implicit assumption that labour resources used in a proposal would otherwise be employed elsewhere and that there are no costs associated with transferring from one job to another. Where this is not the case and labour resources would otherwise be unemployed for some period of time, Boardman *et al.* (2001) identifies that these labour resources should be valued in a BCA at their opportunity cost (e.g. wages less social security payments and income tax) rather than the wage rate. Adopting this approach would have the effect of increasing the net production benefits of the proposal. In addition, there may be social costs of unemployment that require the estimation of employees' willingness to pay to avoid the trauma created by unemployment (Streeting and Hamilton, 1991). These values have not been included in the BNCOP BCA.

Although employees' willingness to pay to avoid the trauma created by unemployment are omitted from the BNCOP BCA, it has also been recognised that the broader community may hold non-market values (Portney, 1994) for social outcomes such as employment (Johnson and Desvouges, 1997).

In a study of the Metropolitan Colliery in the NSW Southern Coalfields, Gillespie Economics (2008) estimated the value the community would hold for the 320 jobs provided over 23 years at $756M (present value). In a similar study of the Bulli Seam Operations, Gillespie Economics (2009a) estimated the value the community would hold for the 1,170 jobs provided over 30 years at $870M (present value). In a study for the Warkworth Mine extension, Gillespie Economics (2009b) estimated the value the community would hold for 951 jobs from 2022 to 2031 at $286M (present value).

The BNCOP would directly employ on average approximately 380 people for 15 years i.e. directly provide 5,700 job years. However, under the base case employment would be provided for 190 people for 30 years i.e. the same number of job years. Non-market valuation studies have not examined community willingness to pay for a change in the timing of the provision of the same number of job years and hence no economic value for employment provided by the BNCOP has been included in the analysis.

3.5 CONSOLIDATION OF VALUE ESTIMATES

3.5.1 Aggregate Costs and Benefits

The present value of costs and benefits, using a 7% discount rate, is provided in Table 3.2. The main decision criterion for assessing the economic desirability of a project to society is its net present value (NPV). NPV is the present value of benefits less the present value of costs. A positive NPV indicates that it would be desirable from an economic perspective for society to allocate resources to the BNCOP, because the community as a whole would obtain net benefits from the BNCOP.

The BNCOP is estimated to have total net production benefits of $910M. Based on the current ownership structure of CCL, $831M of these net production benefits would accrue to Australia[6]. The estimated net production benefits that accrue to Australia can be used as a threshold value or reference value against which the relative value of the residual environmental impacts of the BNCOP, after mitigation, may be assessed. This threshold value is the opportunity cost to society of not proceeding with the BNCOP. The threshold value indicates the price that the community must value any residual environmental impacts of the BNCOP (be willing to pay) to justify in economic efficiency terms the no development option.

For the BNCOP to be questionable from an economic efficiency perspective, all incremental residual environmental impacts from the BNCOP, that impact Australia[7], would need to be valued by the community at greater than the estimate of the Australian net production benefits i.e. greater than $831M. This is equivalent to each household in the Banana Shire/Central Highlands Regional area valuing residual environmental impacts at $52,000. The equivalent figure for Qld and Australian households is $500 and $100, respectively.

Instead of leaving the analysis as a threshold value exercise, an attempt has been made to quantify the residual environmental impacts of the BNCOP that have not already been incorporated into the estimation of net production benefits. From Table 3.2 these impacts to Australia are estimated at $1M, considerably less than the estimated net production benefits of the BNCOP to Australia.

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[6] This is the net production benefits of the BNCOP minus net profit accruing to overseas.

[7] Consistent with the approach to considering net production benefits, environmental impacts that occur outside Australia would be excluded from the analysis. This is mainly relevant to the consideration of greenhouse gas impacts.

Table 3.2 - Benefit Cost Analysis Results of the BNCOP (Present Values at 7% discount rate)

	Costs		Benefits	
	Description	**Value ($M)**	**Description**	**Value ($M)**
Production	Opportunity cost of land	$2	Value of coal	$2,739
	Opportunity cost of capital	$0	Residual value of land and capital	$0
	Develpoment costs including land acquisitions and mitigation works	$325		
	Operating costs	$1,498		
	Decommissioning and rehabilitation costs	$3		
	Sub-total	**$1,829**	***Sub-total***	**$2,739**
	Net Production Benefits			**$910 ($831)**
Non-market Impacts	Greenhouse gas impacts	$54($1)	Non-market values of employment	Unquantified
	Agricultural impacts	Included in opportunity cost of land and development costs (land acquisitions)		
	Noise impacts	Cost of mitigation is included in development and operational costs		
	Blasting impacts	Negligible		
	Air quality impacts	Cost of mitigation is included in development and operational costs		
	Surface water impacts	Negligible		
	Groundwater impacts	Negligible		
	Ecology impacts	Some loss of values but offset. Cost of biodiversity offset included in development costs and operating costs		
	Road transport impacts	Negligible		
	Indigenous heritage impacts	Mitigation and management via the CHMP		
	Non-Indigenous heritage impacts	Negligible		
	Visual impacts	Cost of visual screening is included in development costs		
	Non-market impacts sub-total	***$54 ($1)***		***Unquantified***
NET SOCIAL BENEFITS – including employment benefits				**$856 ($831)**

Note: totals may have minor discrepancies due to rounding. When impacts accrue globally, the numbers in brackets relates to the level of impact estimated to accrue to Australia.

Overall, the BNCOP is estimated to have net social benefits to Australia of $831M and hence is desirable and justified from an economic efficiency perspective.

While the major environmental, cultural and social impacts have been quantified and included in the BNCOP BCA, any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than $831M for the BNCOP to be questionable from an Australian economic perspective.

3.5.2 Distribution of Costs and Benefits

While BCA is primarily concerned with the aggregate benefits and costs of the BNCOP to Australia, the distribution of costs and benefits may also be of interest to decision-makers.

The net production benefit is potentially distributed amongst a range of stakeholders including (Table 3.3):

- CCL shareholders in the form of after tax (and after voluntary contributions) profits;
- the Commonwealth Government in the form of any Company tax payable ($244M present value) from the BNCOP, which is subsequently used to fund provision of government infrastructure and services across Australia and Qld, including the local and regional area; and
- the Qld Government via royalties ($272M present value) which are subsequently used to fund provision of government infrastructure and services across the State, including the local and regional area.

The environmental, cultural and social impacts of the BNCOP may potentially accrue to a number of different stakeholder groups at the local, State, National and global level, however, are largely internalised into the production costs of CCL.

Any noise costs, air quality costs and agricultural production costs would occur at a local level. These have been incorporated into the estimation of net production benefits via acquisition costs for affected properties and mitigation costs, where relevant. As such, the bearers of these costs are compensated. Any road transport impacts would also occur at the local level however have been assessed as being insignificant (with the implementation of the product coal haul route upgrade package proposed for the existing operations at the Baralaba Coal Mine and Baralaba North/Wonbindi North Mine). Similarly, any surface water and groundwater effects would occur at the local level but have been assessed as negligible. Greenhouse gas costs would occur at the national and global level and would be addressed at a strategic level by the Commonwealth Government's greenhouse gas strategies.

The economic costs associated with the clearing of native vegetation would occur at the local and State level and would be counterbalanced by progressive rehabilitation and the provision of an offset. Similarly Indigenous heritage impacts would potentially occur to Indigenous people and Qld households[8], however, these economic costs would be mitigated and managed via the CHMP. Visual impacts would occur at the local level and would be at least be partially internalised by CCL through the funding of rehabilitation of the BNCOP. All of these measures mean that those who experience costs have them either mitigated or compensated. Other potential environmental impacts would largely occur at the local level and were found to be (economically) insignificant. Any non-market benefits associated with employment provided by the BNCOP would largely accrue at the local or State level[9].

The non-market costs that accrue to Qld that are not already included in the estimation of net production benefits are estimated at less than $1M. These are considerably less than the net production benefits that directly accrue to Qld through royalties ($272M). Qld would also benefit from the company tax paid to the Commonwealth Government. Consequently, the BNCOP would result in net benefits to Qld.

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[8] Non-market valuation studies have found that the broader community may hold values for the conservation of highly significant Indigenous heritage (Gillespie Economics 2008, 2009a, 2009b).

[9] Nonmarket valuation studies that examine the willingness to pay for the employment of others have mainly been undertaken at the State level.

Table 3.3 - Distribution of Benefits and Costs (Present Values at 7% Discount Rate)

Value ($M)		Distribution			
		Local	**State**	**National**	**Global**
Net Production Benefits					
Net production benefits to CCL	$395	✓	✓	✓	✓
Net production benefits to Commonwealth Government – Company tax	$244	✓	✓	✓	-
Net production benefits to Qld Government – Royalties	$272	✓	✓	-	-
Total	**$910**				
Non-market Costs and Benefits					
Benefits					
Non-market benefit of employment	Unquantified	✓	✓	-	-
Total					
Costs					
Greenhouse gas emissions rest of the world[1]	$53	-	-	-	✓
Greenhouse gas emissions Australia[2]	$1	✓	✓	✓	
Agricultural impacts	Included in opportunity cost of land and development costs (land acquisitions)	✓	-	-	-
Noise impacts	Cost of mitigation is included in development and operational costs	✓	-	-	-
Blasting	Negligible	✓	-	-	-
Air quality impacts	Cost of mitigation is included in development and operational costs	✓	-	-	-
Surface water	Negligible	✓	-	-	-
Groundwater	Negligible	✓	-	-	-
Ecology	Some loss of values but offset. Cost of biodiversity offset included in development costs and operating costs	✓	✓	-	-
Road transport impacts	Negligible	✓	-	-	-
Indigenous heritage	Mitigation and management via the CHMP	✓	-	-	-
Non-Indigenous heritage impacts	Negligible	✓	-	-	-
Visual impacts	Cost of visual screening is included in development costs	✓	-	-	-
Total	***$54***				
Net Social Benefits	**$856**				

Note: Totals may have minor discrepancies due to rounding.

[1] Assuming the global social damage cost of carbon is distributed in accordance with relative share of global gross domestic product.

3.6 SENSITIVITY ANALYSIS

The NPV presented in Table 3.2 is based on a range of assumptions around which there is some level of uncertainty. Uncertainty in a BCA can be dealt with through changing the values of critical variables in the analysis (James, 1994) to determine the effect on the NPV.

In this analysis, the BCA result was tested for 20% (+ and -) changes to the following variables at a 4%, 7% and 10% discount rate:

- Opportunity costs of land;
- Development costs;
- Operating costs;
- Value of coal;
- Rehabilitation and decommissioning costs; and
- Greenhouse costs.

What this analysis indicates (refer to Attachment 2) is that the results of the BCA are not sensitive to the changes made in assumptions regarding any of these variables. In particular, significant increases in the values used for external impacts such as greenhouse gas costs or capital and operating costs within which mitigation costs are included did not change the positive sign of the net present value of the BNCOP. Hence the BNCOP's desirability from an economic efficiency perspective is not changed.

The results were most sensitive to any potential decreases in the sale value of coal. A sustained reduction in coal price (over 44%) would be required to make the BNCOP welfare reducing.

4 ECONOMIC IMPACT ASSESSMENT

4.1 INTRODUCTION

The BCA in Section 3 is concerned with whether the incremental benefits of the BNCOP exceed the incremental costs and therefore whether the community would, in aggregate, be better off ‘with’ the BNCOP compared to ‘without’ it. In contrast, the focus of the regional economic impact assessment is the effect (impact) of the BNCOP on the economy in terms of a number of specific indicators of economic activity, such as gross regional output, value-added, income and employment.

These indicators can be defined as follows:

- ***Gross regional output*** – the gross value of business turnover;
- ***Value-added*** – the difference between the gross regional output and the costs of the inputs of raw materials, components and services bought in to produce the gross regional output;
- ***Income*** – the wages paid to employees including imputed wages for self-employed and business owners; and
- ***Employment*** – the number of people employed (including full-time and part-time).

An impacting agent may be an existing activity within an economy or may be a change to an economy (Powell *et al.,* 1985; Jensen and West, 1986). This assessment is concerned with the economic impact of average annual production of the BNCOP i.e. 3.5 Mtpa product coal compared to 1 Mtpa under the base case.

4.2 ECONOMIES

The economy on which the impact is measured can range from a township to the entire nation (Powell *et al.,* 1985). In selecting the appropriate economy, regard needs to be had to capturing the local expenditure and employment associated with the production scenarios, but not making the economy so large that the impact of the proposal becomes trivial (Powell and Chalmers, 1995). For this study, the economic impacts have been estimated for three regions:

- the local economy comprising the LGA of Banana Shire;
- the regional economy comprising the LGAs of Banana Shire and Central Highlands Regional; and
- the Qld economy.

Although the BNCOP is located in the Central Highlands Regional LGA, the Banana Shire LGA was selected as the local economy because the BNCOP is expected to have greater interaction with the Banana Shire as it is located near Baralaba which is located in the Banana Shire LGA.

4.3 METHOD OF ASSESSMENT

A range of methods can be used to examine the economic impacts of an activity on an economy including economic base theory, Keynesian multipliers, econometric models, mathematical programming models and input-output models (Powell *et al.,* 1985). This study uses input-output analysis.

Input-output analysis essentially involves two steps:

- Construction of an appropriate input-output table (regional transaction table) that can be used to identify the economic structure of the region and multipliers for each sector of the economy; and
- Identification of the initial impact or stimulus of the BNCOP (construction and/or operation) in a form that is compatible with the input-output equations so that the input-output multipliers and flow-on effects can then be estimated (West, 1993).

The input-output method is based on a number of assumptions that are outlined in Attachment 3. These result in estimated impacts being an upper bound impact estimate. Input-output analysis reports multipliers which are summary measures used for identifying the total impact on all industries in an economy from changes in the demand for the output of any one industry (ABS, 1995). There are many types of multipliers that can be generated from input-output analysis (refer to Attachment 3). Type 11A ratio multipliers (the kind reported in this assessment) summarise the total impact on all industries in an economy in relation to the initial own sector effect e.g. total income effect from an initial income effect and total employment effect from an initial employment effect, etc.

4.4 INPUT-OUTPUT TABLES AND ECONOMIC STRUCTURE OF THE REGIONS

A 2011 input-output table[10] of the local and regional economy was developed using the Generation of Input-Output Tables (GRIT) procedure (Attachment 4) using a 2010 input-output table of the Australian economy as the parent table (ABS, 2014). The 111 sector input-output tables of the local and regional economy were aggregated to 50 sectors and 8 sectors for the purpose of describing the economies.

Highly aggregated 2011 input-output tables for the local and regional economy are provided in Tables 4.1 and 4.2. The rows of these tables indicate how the gross regional output of an industry is allocated as sales to other industries, to households, to exports and other final demands (OFD - which includes stock changes, capital expenditure and government expenditure). The corresponding column shows the sources of inputs to produce that gross regional output. These include purchases of intermediate inputs from other industries, the use of labour (household income), the returns to capital or other value-added (OVA - which includes gross operating surplus and depreciation and net indirect taxes and subsidies) and goods and services imported from outside the region. The number of people employed in each industry is also indicated in the final row.

Value-added for the local economy is estimated at $1,431M, comprising $489M to households as wages and salaries (including payments to self-employed persons and employers) and $942M in OVA.

Value-added for the regional economy is estimated at $5,045M, comprising $1,657M to households as wages and salaries (including payments to self-employed persons and employers) and $3,389M in OVA.

The employment total working in the local and regional economy was 7,971 and 24,832, respectively.

The economic structure of the local and regional economy can be compared with that for Qld through a comparison of results from the respective input-output models (Figures 4.1, 4.2 and 4.3). This clearly shows the greater relative significance of the mining and agriculture sectors to the local and regional economy compared to Qld. All other aggregations of sectors are of less relative significance in the local and regional economies than they are for Qld, apart from the utilities sectors in the local economy. The local and regional economies are of similar economic structure.

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[10] A key driver in the development of regional input-output tables is detailed employment by industry data from the 2011 Census.

Table 4.1 - Aggregated Transactions Table: Local Economy 2011 ($’000)

	Ag Forestry Fishing	**Mining**	**Manuf.**	**Utilities**	**Building**	**Trade/ Accomm.**	**Business Services**	**Public Personal Services**	**TOTAL**	**Household Expenditure**	**OFD**	**Exports**	**Total**
Ag/Forest/Fish	35,289	1,271	30,273	47	202	1,408	305	285	**69,080**	3,251	36,324	96,789	**205,444**
Mining	110	118,325	9,267	17,068	415	384	210	73	**145,852**	742	54,605	1,316,248	**1,517,447**
Manufacturing	7,496	34,469	24,067	799	4,077	2,704	808	1,283	**75,702**	7,152	16,610	185,427	**284,891**
Utilities	2,880	14,442	2,455	15,455	976	1,069	1,464	835	**39,575**	7,179	112,040	3,472	**162,266**
Building	1,968	37,120	744	3,012	19,172	1,174	2,972	1,626	**67,789**	237	87,682	122	**155,829**
Trade/Accomm.	7,665	22,561	9,943	1,228	2,910	3,169	4,214	3,771	**55,460**	53,653	2,724	20,539	**132,376**
Business Srvs	11,323	62,082	15,685	5,648	10,672	10,320	22,339	8,961	**147,032**	65,719	16,473	8,297	**237,521**
Public/Personal Srvs	1,659	17,456	2,219	626	1,419	1,282	5,191	3,254	**33,105**	31,670	103,111	1,937	**169,823**
TOTAL	**68,390**	**307,724**	**94,655**	**43,881**	**39,842**	**21,510**	**37,503**	**20,089**	**633,594**	**169,602**	**429,569**	**1,632,831**	**2,865,597**
Household Income	34,839	168,362	42,225	19,103	31,890	45,297	58,229	88,769	**488,712**	-	-	-	**488,712**
OVA	48,575	608,092	40,081	49,474	19,122	25,975	78,004	18,777	**888,098**	34,735	18,581	638	**942,053**
Imports	53,640	433,269	107,930	49,808	64,975	39,595	63,786	42,189	**855,192**	210,795	40,476	50,108	**1,156,571**
TOTAL	**205,444**	**1,517,447**	**284,891**	**162,266**	**155,829**	**132,376**	**237,521**	**169,823**	**2,865,597**	**415,132**	**488,627**	**1,683,577**	**5,452,932**
Employment	**1,357**	**1,764**	**616**	**323**	**418**	**1,106**	**796**	**1,592**	**7,971**				

Table 4.2- Aggregated Transactions Table: Regional Economy 2011 ($’000)

	Ag Forestry Fishing	**Mining**	**Manuf.**	**Utilities**	**Building**	**Trade/ Accomm.**	**Business Services**	**Public Personal Services**	**TOTAL**	**Household Expenditure**	**OFD**	**Exports**	**Total**
Ag/Forest/Fish	73,828	5,109	32,087	78	1,007	4,723	1,345	828	**119,006**	11,385	81,645	216,697	**428,732**
Mining	278	831,750	21,062	22,178	3,254	1,376	850	258	**881,005**	2,622	-3,5461	5,518,248	**6,366,414**
Manufacturing	16,234	178,285	48,850	1,709	37,877	10,531	4,641	5,250	**303,376**	28,567	-8525	196,399	**519,818**
Utilities	5,972	60,679	4,645	22,815	5,777	3,696	5,586	2,477	**111,646**	25,300	76,921	2516	**216,383**
Building	6,096	228,657	2,424	7,768	135,770	5,838	18,930	6,876	**412,360**	1,100	412,693	113	**826,267**
Trade/Accomm.	17,280	105,837	20,741	1,930	16,800	11,610	16,356	12,320	**202,875**	204,189	-10594	49597	**446,066**
Business Srvs	27,535	409,419	33,389	9,012	70,580	41,683	93,044	30,911	**715,574**	201,379	-27153	-67445	**822,355**
Public/Personal Srvs	4,595	117,755	4,966	1,307	8,352	4,870	19,278	10,027	**171,150**	114,111	215,315	-18617	**481,960**
TOTAL	**151,819**	**1,937,489**	**168,166**	**66,798**	**279,418**	**84,326**	**160,030**	**68,946**	**2,916,991**	**588,652**	**704,841**	**5,897,509**	**10,107,994**
Household Income	73,216	713,931	82,642	28,457	159,436	151,687	200,495	246,702	**1,656,568**	-	-	-	**1,656,568**
OVA	100,870	2,499,595	74,209	64,995	106,625	87,082	248,252	52,761	**3,234,389**	121,648	30,488	2,304	**3,388,829**
Imports	102,826	1,215,399	194,801	56,133	280,787	122,971	213,578	113,550	**2,300,046**	698,830	66,414	180,981	**3,246,270**
TOTAL	428,732	6,366,414	519,818	216,383	826,267	446,066	822,355	481,960	**10,107,994**	1,409,130	801,742	6,080,794	**18,399,660**
Employment	**2,802**	**7,523**	**1,109**	**422**	**1,985**	**3,723**	**2,751**	**4,518**	**24,832**				

Figure 4.1 - Summary of Aggregated Sectors: Local Economy (2011)

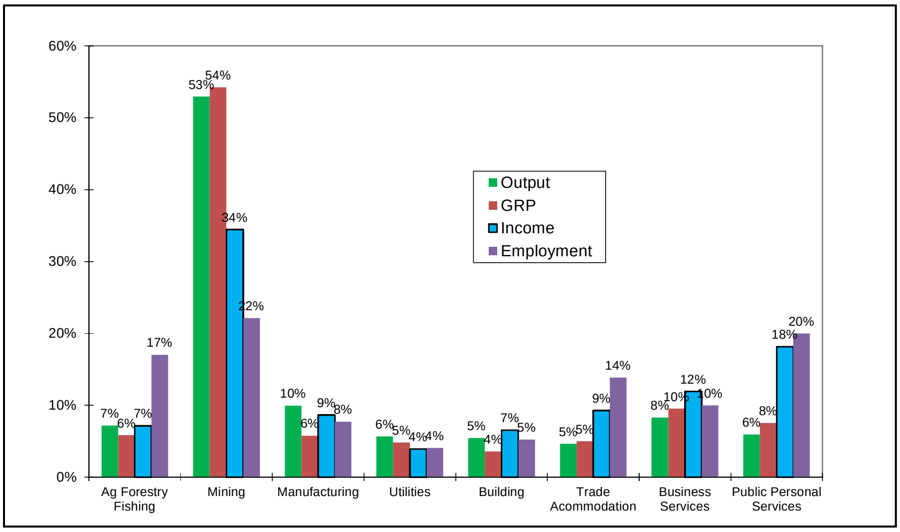


Figure 4.2 - Summary of Aggregated Sectors: Regional Economy (2011)

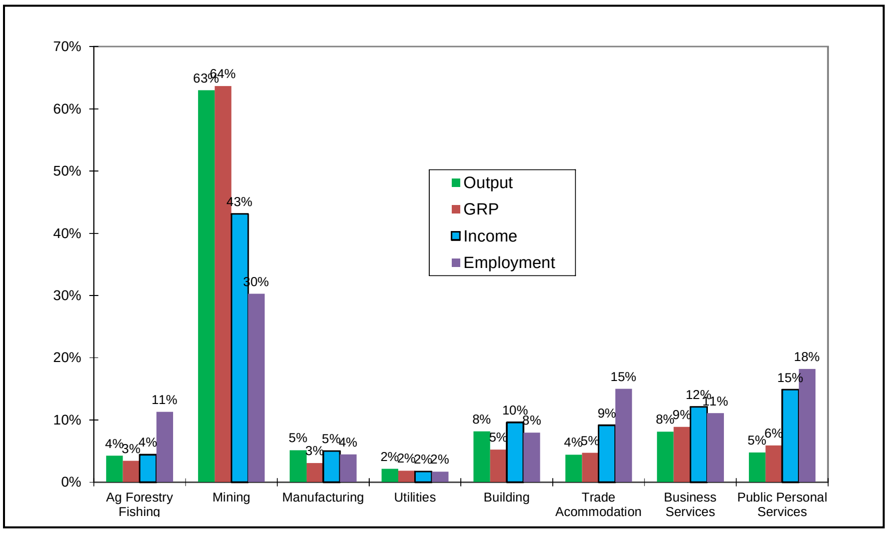
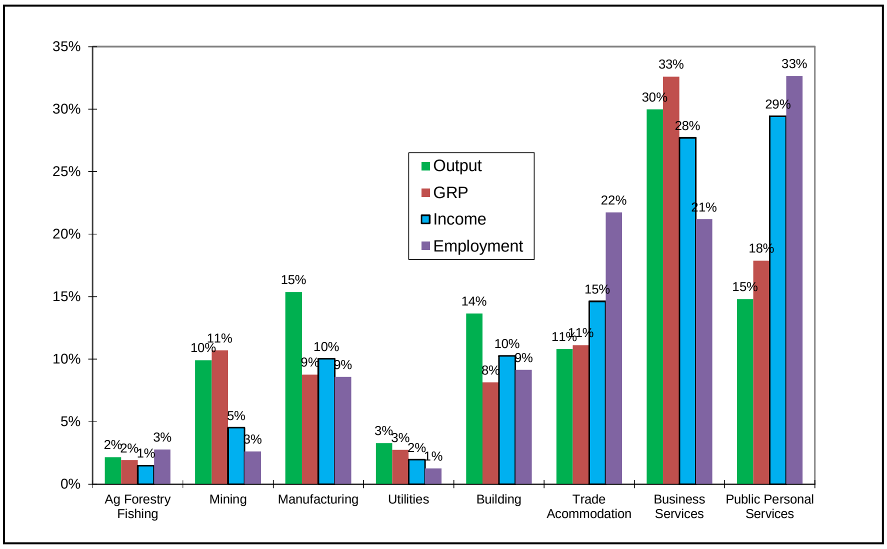


Figure 4.3 - Summary of Aggregated Sectors: Qld Economy (2011)



Figures 4.4 to 4.7 provide a more expansive sectoral distribution of gross regional output, value-added, household income, employment, exports and imports, and can be used to provide some more detail in the description of the economic structure of the local and regional economy.

In terms of output and value-added, the coal mining sector and other mining sectors are the most significant to both the local and regional economy. In terms of employment the coal mining sector, sheep, grains and beef sectors, retail trade sectors and education sectors are the most significant to the local and regional economy. For household income, the coal mining sector, other mining sectors, and education sectors are the most significant.

4.5 ECONOMIC IMPACT OF THE BNCOP

The revenue, expenditure and employment associated with the construction and operation of the BNCOP would stimulate economic activity for the Banana Shire, Banana Shire/Central Highlands Regional and Qld economies. The following sections document the predicted economic activity stimulated by the BNCOP.

4.5.1 *Construction*

Introduction

Economic activity associated with the construction phase of the BNCOP is estimated to directly occur within the following six sectors of the economy, the:

- *Other construction sector* which includes businesses involved in the construction of non-residential buildings and sites;
- *Heavy and Civil Engineering Construction* which includes businesses involved in the construction of CHPPs;
- *Construction trade services sector* which includes businesses involved in site preparation services, plumbing, electrical, and other trades;
- *Other property services sector* which includes businesses involved in the leasing of industrial machinery, plant or equipment;
- *Agriculture, mining and construction machinery, lifting and material handling equipment manufacturing sector*; and
- *Other machinery and equipment manufacturing sector*.

Figure 4.4 Sectoral Distribution of Gross Regional Output ($’000)

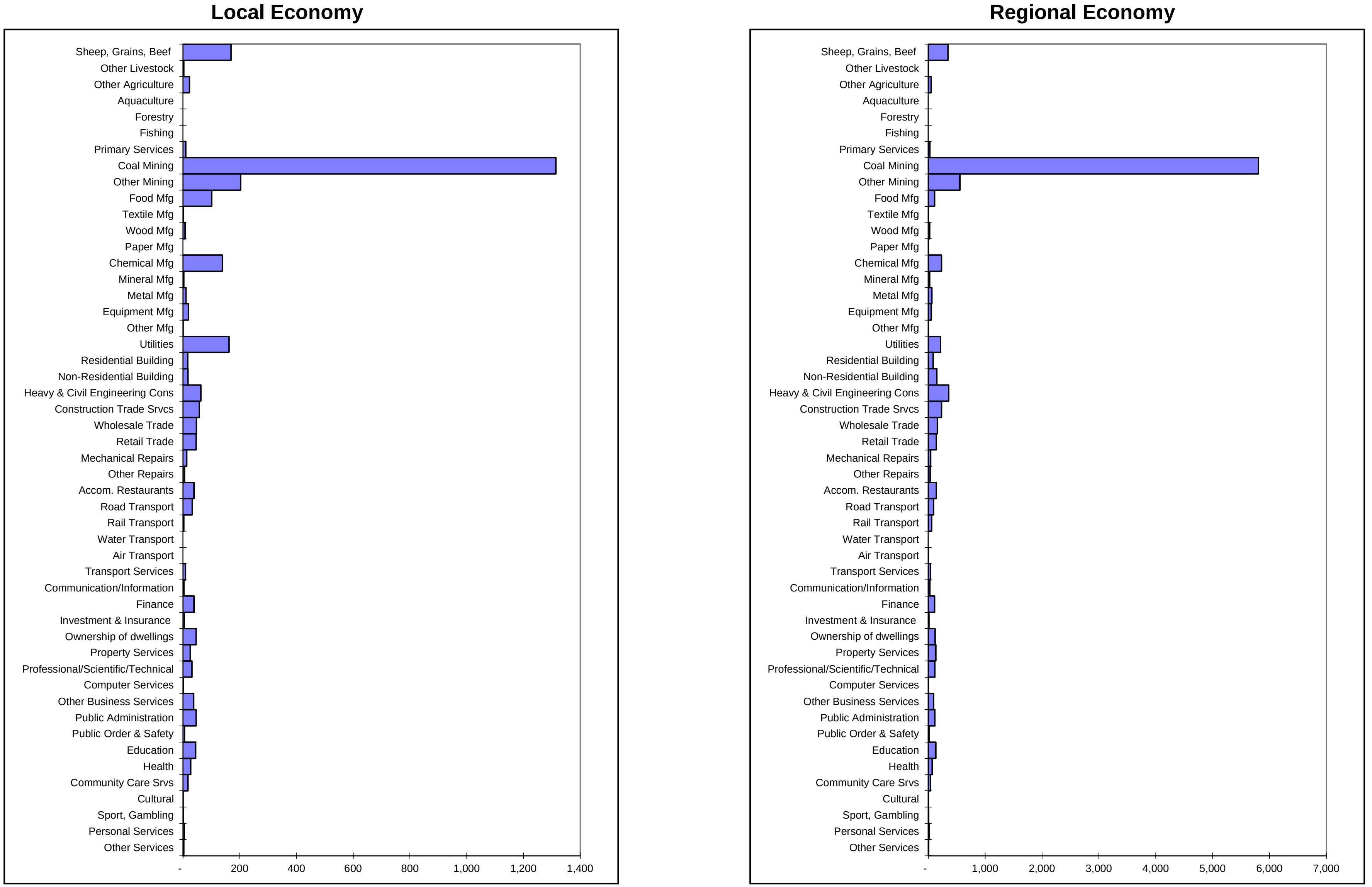
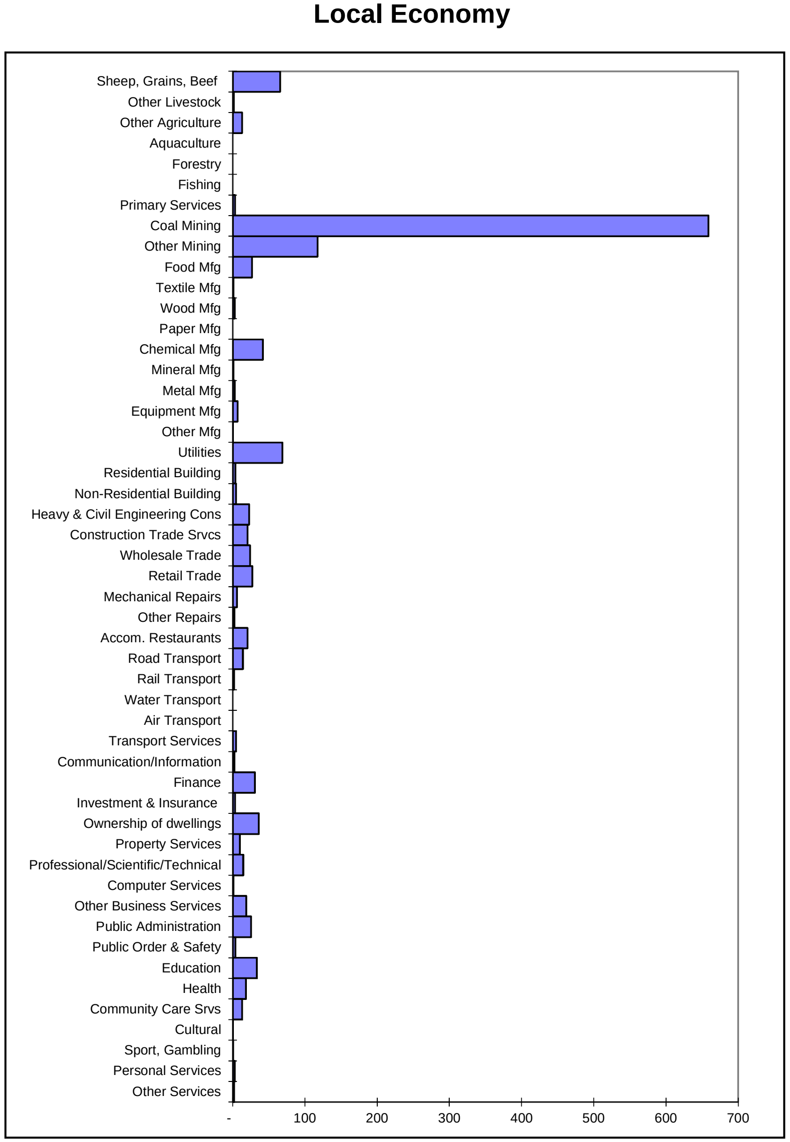


Figure 4.5 Sectoral Distribution of Value Added ($'000)



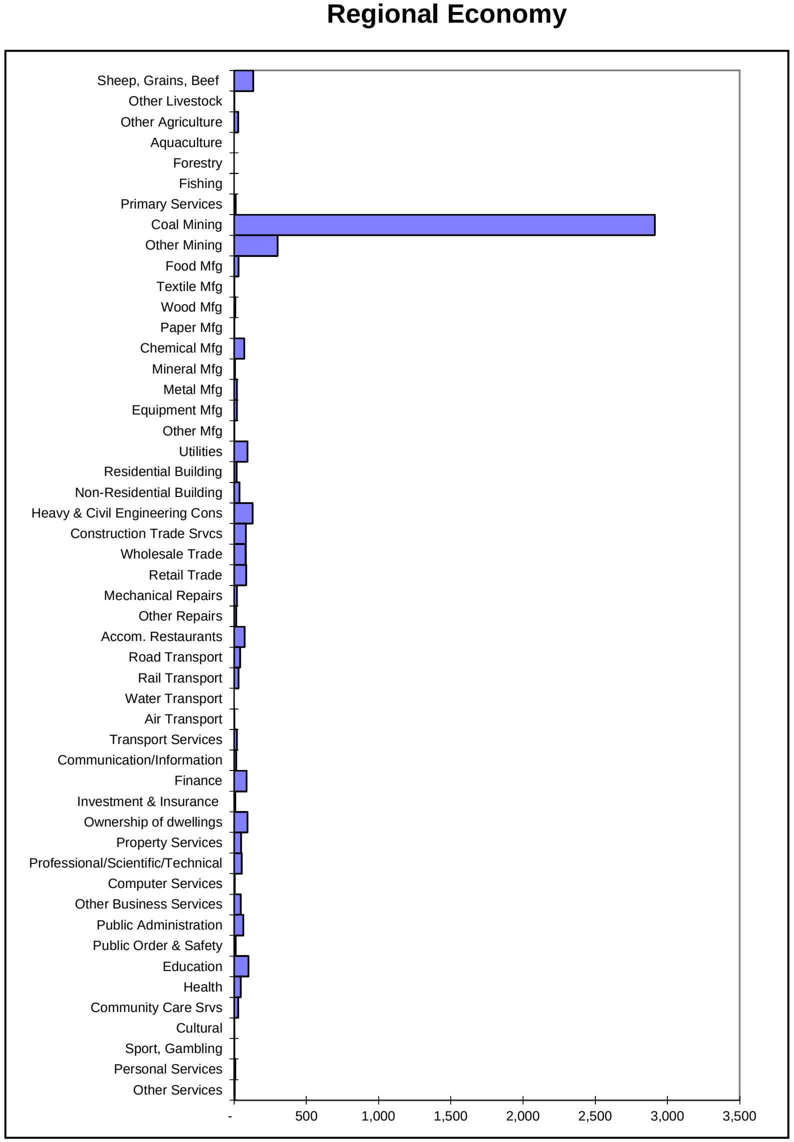
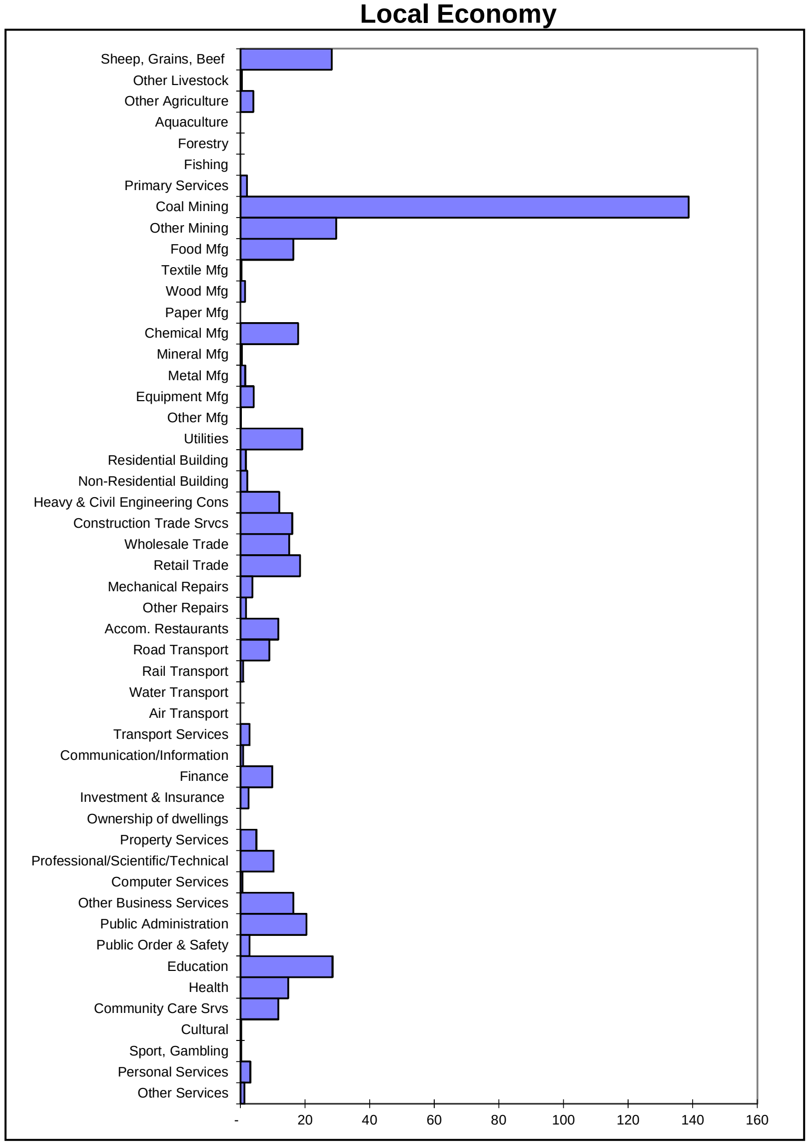


Figure 4.6 Sectoral Distribution of Household Income ($'000)



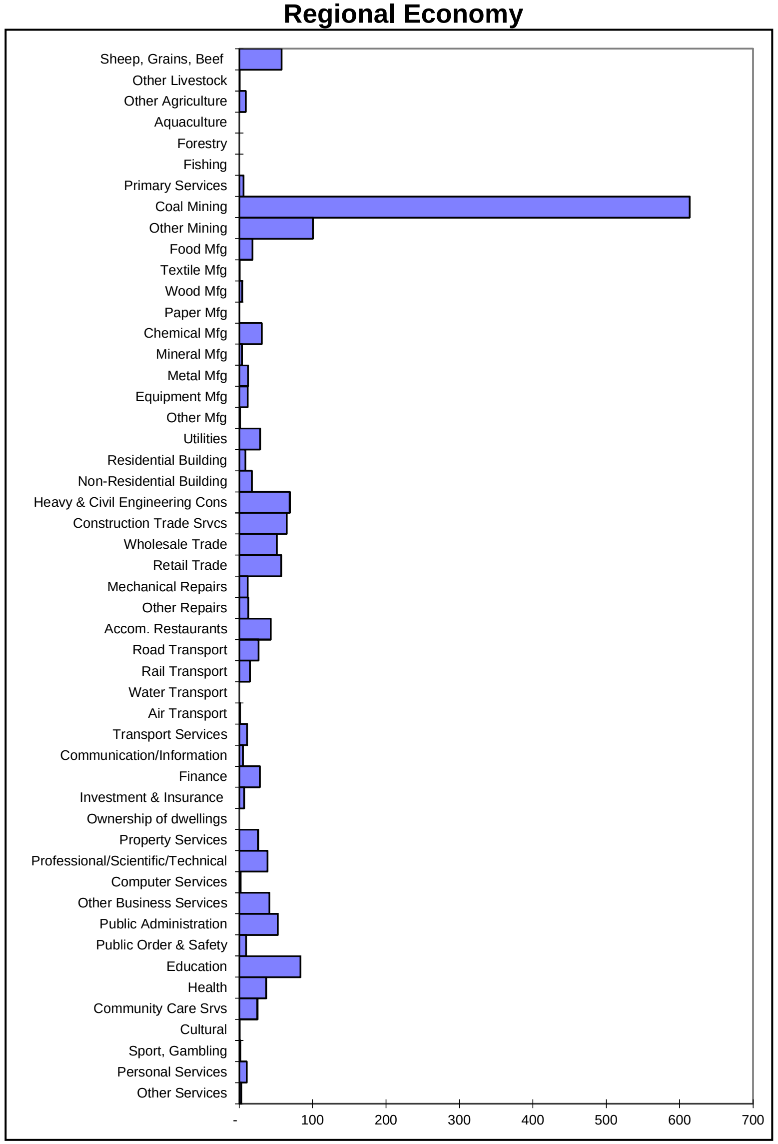
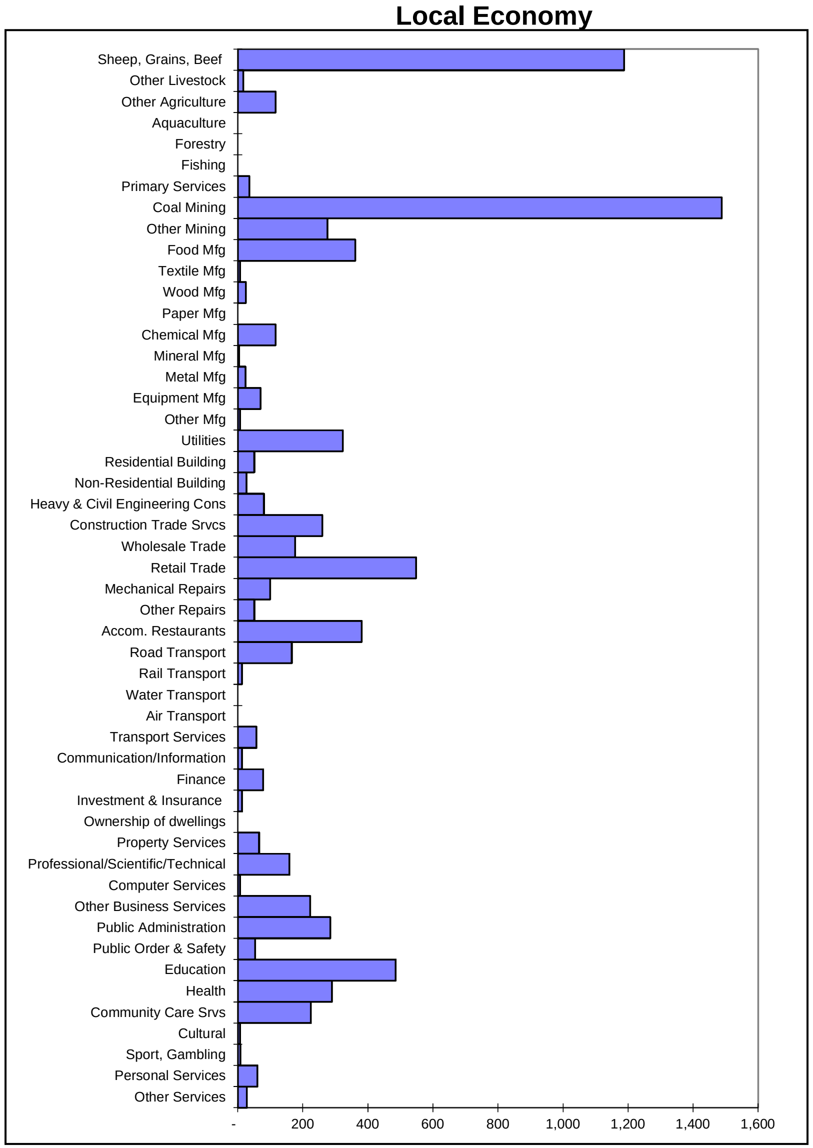
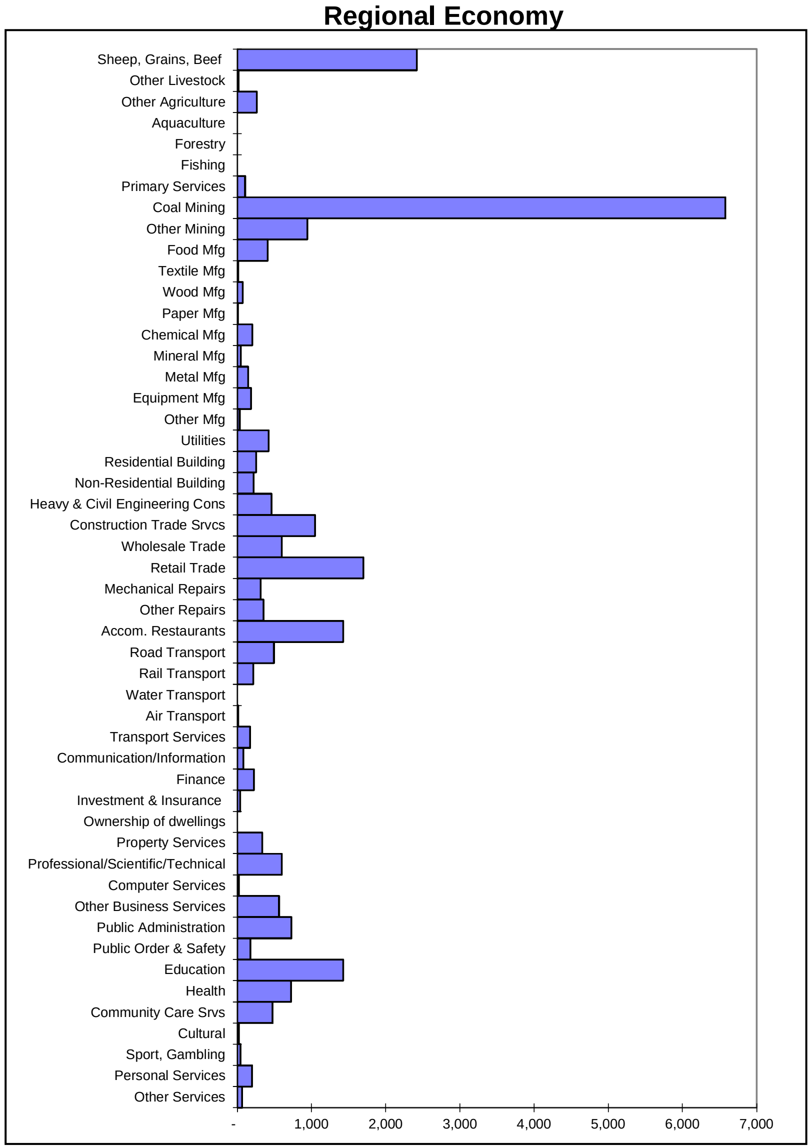


Figure 4.7 Sectoral Distribution of Employment (No.)





Impact on Economy

Given the largely specialist nature of the capital equipment required for the project and the relatively small size of the Banana Shire and Banana Shire/Central Highlands Region economy, for the purpose of this analysis a conservative assumption is made that all such purchases and the leasing of machinery are made outside the local and regional economy. Thus economic activity from the project construction phase primarily relates to the *other construction sector, heavy and civil engineering construction sector* and *construction trade services sector*.

CHPP and other construction activities are estimated to occur over a 13-month period, with average annual employment of 76. This employment is assumed to be evenly distributed between the *other construction sector*, *heavy and civil engineering construction sector* and *construction trade services sector.* Based on the input-output coefficients of these sectors in the local, regional and Qld input-output tables, in the order of $18M, $22M and $6M, of development costs would need to be spent in the *other construction sector, heavy and civil engineering construction sector* and *construction trade services sector,* respectively, to result in a direct construction workforce of 76 people spread evenly across the three sectors. The computer program IO7 (Input-Output Analysis Version 7.1) was used to estimate the average annual direct and indirect output, value-added, income and employment impacts (and multipliers) of this level of expenditure in the Banana Shire LGA, Central Highlands Regional LGA and Qld economies. The results are reported in Tables 4.3, 4.4 and 4.5.

Table 4.3 - Economic Impacts of the BNCOP Construction on the Local Economy ($2013)

	Direct Effect	**Production Induced**	**Consumption Induced**	**Total Flow-on**	**TOTAL EFFECT**
OUTPUT ($'000)	46,071	15,047	4,104	19,151	65,223
Type 11A Ratio	1.00	0.33	0.09	0.42	1.42
VALUE-ADDED ($'000)	14,472	6,319	2,473	8,792	23,264
Type 11A Ratio	1.00	0.44	0.17	0.61	1.61
INCOME ($'000)	3,984	3,483	1,017	4,501	8,484
Type 11A Ratio	1.00	0.87	0.26	1.13	2.13
EMPLOYMENT (No.)	76	61	21	82	157
Type 11A Ratio	1.00	0.80	0.28	1.08	2.08

Note: Totals may have minor discrepancies due to rounding.

Table 4.4 - Economic Impacts of the BNCOP Construction on the Regional Economy ($2013)

	Direct Effect	**Production Induced**	**Consumption Induced**	**Total Flow-on**	**TOTAL EFFECT**
OUTPUT ($'000)	46,071	21,598	4,755	26,354	72,425
Type 11A Ratio	1.00	0.47	0.10	0.57	1.57
VALUE-ADDED ($'000)	14,472	8,810	2,747	11,558	26,030
Type 11A Ratio	1.00	0.61	0.19	0.80	1.80
INCOME ($'000)	3,630	4,447	1,198	5,645	9,275
Type 11A Ratio	1.00	1.23	0.33	1.56	2.56
EMPLOYMENT (No.)	76	82	26	108	184
Type 11A Ratio	1.00	1.09	0.35	1.43	2.43

Note: Totals may have minor discrepancies due to rounding.

Table 4.5 - Economic Impacts of the BNCOP Construction on the Queensland Economy ($2013)

	Direct Effect	Production Induced	Consumption Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	46,071	50,541	36,905	87,446	133,517
Type 11A Ratio	1.00	1.10	0.80	1.90	2.90
VALUE-ADDED ($'000)	14,472	21,315	20,340	41,655	56,128
Type 11A Ratio	1.00	1.47	1.41	2.88	3.88
INCOME ($'000)	7,976	13,537	9,511	23,048	31,025
Type 11A Ratio	1.00	1.70	1.19	2.89	3.89
EMPLOYMENT (No.)	76	182	165	347	422
Type 11A Ratio	1.00	2.41	2.18	4.59	5.59

Note: Totals may have minor discrepancies due to rounding.

In estimating the total regional impacts, it is important to separate the flow-on effects that are associated with firms buying goods and services from each other (production-induced effects) and the flow-on effects that are associated with employing people who subsequently buy goods and services as households (consumption-induced effects). This is because these two effects operate in different ways and have different spatial impacts.

Production-induced effects occur in a near-proportional way within a region, whereas the consumption-induced flow-on effects only occur in a proportional way if workers and their families are currently located in the region or migrate into the region. Where workers commute from outside the region some of the consumption-induced flow-on effects leak from the region.

In total, it is estimated the construction phase of the BNCOP would contribute to the Banana Shire economy (Table 4.3) up to:

- $65M in annual direct and indirect regional output or business turnover;
- $23M in annual direct and indirect regional value-added;
- $8M in annual direct and indirect household income; and
- 157 direct and indirect jobs.

For the Banana Shire/Central Highlands Regional economy (Table 4.4), the construction phase of the BNCOP would contribute up to:

- $72M in annual direct and indirect output;
- $26M in annual direct and indirect value added;
- $9M in annual direct and indirect household income; and
- 184 direct and indirect jobs.

For the Qld economy (Table 4.5), the construction phase of the BNCOP would contribute up to:

- $134M in annual direct and indirect output;
- $56M in annual direct and indirect value added;
- $31M in annual direct and indirect household income; and
- 422 direct and indirect jobs.

The above estimated impacts would be felt for approximately one year. The estimated impacts on the Banana Shire/Central Highlands Regional economy and Qld economy are likely to be conservative because expenditures in these economies may not be limited to expenditures in the *other construction sector, heavy and civil engineering construction sector* and *construction trade services sector*. These economies may be able to also supply some machinery and equipment manufacturing and machinery leasing.

To the extent that the proponent can maximise local procurement, the local, regional and state intersectoral linkages reported in this assessment could be increased, with corresponding increases in economic activity and employment.

Multipliers

The type 11A ratio multipliers for the construction of the BNCOP are provided in Tables 4.3, 4.4 and 4.5. For the Banana Shire economy, the Type 11A ratio multipliers range from 1.42 for output up to 2.13 for income. For the larger Banana Shire/Central Highlands Regional economy Type 11A ratio multipliers range from 1.57 for output up to 2.56 for income. For the Qld economy the Type 11A ratio multipliers range from 2.90 for output up to 5.59 for employment.

Main Sectors Affected

The input-output analysis results indicate that flow-on impacts from the construction phase of the project are likely to affect a number of different sectors of the local and regional economy. The sectors most impacted by output, value-added, income and employment flow-ons are likely to be:

- other construction sector;
- heavy and civil engineering construction sector;
- construction trade services sector;
- wholesale and retail trade sectors;
- professional, scientific and technical services sector;
- building cleaning, pest control, administrative and other support sector;
- road transport sector; and
- the automotive repair and maintenance sector.

4.5.2 *Operation*

Introduction

The revenue, expenditure and employment associated with the operation of the BNCOP would provide additional economic activity to the local and regional economy, as well as for the broader Qld economy for the life of the BNCOP. The economic impacts of operations under the base case and the BNCOP for the local, regional and Qld economy are estimated for the indicators of output, value-added, income and employment. The incremental impacts for the local, regional and Qld economies during the life of the BNCOP are also estimated.

To estimate impacts, a sector revenue and expenditure profile was developed and inserted into the local, regional and Qld input-output tables reflecting average annual production levels under the base case and BNCOP case. The revenue and expenditure data for the new sectors were obtained from financial information provided by CCL. For these new sectors:

- the estimated gross annual revenue was allocated to the *Output* row;
- the estimated wage bill of those residing in the region was allocated to the *household wages* row with any remainder allocated to *imports*;
- non-wage expenditure was initially allocated across the relevant *intermediate sectors* in the economy, *imports* and *other value-added*;
- allocation was then made between *intermediate sectors* in the economy and *imports* based on advice from CCL and regional location quotients;
- purchase prices for expenditure in the each sector in the region were adjusted to basic values and margins and taxes and allocated to appropriate sectors using relationships in the National Input-Output Tables;
- the difference between total revenue and total costs was allocated to the *other value-added* row*;* and
- direct employment in the region was allocated to the *employment* row.

The main difference between the sector for the local, regional and Qld economy was that for larger regions a greater number of employees reside in the economy (and hence more consumption expenditure is captured) and the larger economies are able to capture a greater level of direct expenditure.

Impacts on the Local Economy

The total and disaggregated annual impacts of the base case and BNCOP on the local economy (in 2013 dollars) are shown in Tables 4.6 and 4.7. The incremental impacts during the life of the BNCOP are shown in Table 4.8.

Table 4.6 - Economic Impacts of the Base Case on the Local Economy ($2013)

	Direct Effect	Production Induced	Consump. Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	187,546	10,653	7,507	18,160	205,706
Type 11A Ratio	1.00	0.06	0.04	0.10	1.10
VALUE ADDED ($'000)	75,251	5,035	4,523	9,558	84,809
Type 11A Ratio	1.00	0.07	0.06	0.13	1.13
INCOME ($'000)	11,220	2,440	1,861	4,301	15,521
Type 11A Ratio	1.00	0.22	0.17	0.38	1.38
EMPL. (No.)	190	65	39	104	294
Type 11A Ratio	1.00	0.34	0.21	0.55	1.55

* Contractors are located in production-induced flow-ons.

Table 4.7 - Economic Impacts of the BNCOP on the Local Economy ($2013)

	Direct Effect	Production Induced	Consump. Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	500,000	32,733	13,543	46,277	546,277
Type 11A Ratio	1.00	0.07	0.03	0.09	1.09
VALUE ADDED ($'000)	100,138	15,303	8,160	23,463	123,601
Type 11A Ratio	1.00	0.15	0.08	0.23	1.23
INCOME ($'000)	17,204	7,440	3,357	10,798	28,002
Type 11A Ratio	1.00	0.43	0.20	0.63	1.63
EMPL. (No.)	380	198	70	269	649
Type 11A Ratio	1.00	0.52	0.19	0.71	1.71

* Contractors are located in production-induced flow-ons.

Table 4.8 – Incremental Impacts on the Local Economy ($2013)

	Direct Effect	Production Induced	Consump. Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	312,454	22,080	6,036	28,116	340,570
Type 11A Ratio	1.00	0.07	0.02	0.09	1.09
VALUE ADDED ($'000)	24,887	10,268	3,637	13,905	38,792
Type 11A Ratio	1.00	0.41	0.15	0.56	1.56
INCOME ($'000)	5,984	5,000	1,496	6,496	12,480
Type 11A Ratio	1.00	0.84	0.25	1.09	2.09
EMPL. (No.)	190	134	31	165	355
Type 11A Ratio	1.00	0.70	0.17	0.87	1.87

* Contractors are located in production-induced flow-ons.

The BNCOP is estimated to make up to the following total annual contribution to the local economy for 15 years:

- $546M in annual direct and indirect regional output or business turnover;
- $124M in annual direct and indirect regional value added;
- $28M in annual direct and indirect household income; and
- 649 direct and indirect jobs.

The incremental impact of the higher level of production under the BNCOP is estimated to be up to:

- $341M in annual direct and indirect regional output or business turnover;
- $39M in annual direct and indirect regional value added;
- $12M in annual direct and indirect household income; and
- 355 direct and indirect jobs.

Flow-on impacts from the BNCOP are likely to affect a number of different sectors of the local economy. The sectors most impacted by output, value-added and income flow-ons are likely to be the:

- accommodation, cafes and restaurants sector;
- other repairs and maintenance sector;
- professional, scientific and technical services sector;
- retail trade sector;
- wholesale trade sector; and
- ownership of dwellings sector.

Examination of the estimated direct and flow-on employment impacts gives an indication of the sectors in which employment opportunities would be generated by the BNCOP (Table 4.9).

Table 4.9 – Incremental Sectoral Distribution of Employment Impacts on the Local Economy

Sector	**Local Economy**			
	Average Direct Effects	**Production -Induced**	**Consumption-Induced**	**Total**
Primary	0	1	1	**2**
Mining	190	0	0	**190**
Manufacturing	0	6	1	**8**
Utilities	0	1	0	**2**
Wholesale/Retail	0	47	12	**59**
Accommodation, cafes, restaurants	0	53	4	**57**
Building/Construction	0	9	0	**9**
Transport	0	2	1	**3**
Services	0	14	11	**25**
Total	**190**	**134**	**31**	**355**

Note: Totals may have minor discrepancies due to rounding.

Table 4.9 indicates that incremental direct, production-induced and consumption-induced employment impacts of the BNCOP on the local economy are likely to have different distributions across sectors. Incremental production-induced flow-on employment would occur mainly in the accommodation, cafes and restaurants sector and the wholesale and retail trade sectors while consumption induced flow-on employment would be mainly in wholesale/retail trade sectors and services sectors.

Impacts on the Regional Economy

The total and disaggregated annual impacts of the base case and BNCOP on the regional economy (in 2013 dollars) are shown in Tables 4.10 and 4.11. The incremental impacts during the life of the BNCOP are shown in Table 4.12.

Table 4.10 - Economic Impacts of the Base Case on the Regional Economy ($2013)

	Direct Effect	Production Induced	Consump. Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	187,546	20,613	10,090	30,703	218,249
Type 11A Ratio	1.00	0.11	0.05	0.16	1.16
VALUE ADDED ($'000)	75,297	9,043	5,829	14,872	90,169
Type 11A Ratio	1.00	0.12	0.08	0.20	1.20
INCOME ($'000)	12,716	4,422	2,542	6,964	19,680
Type 11A Ratio	1.00	0.35	0.20	0.55	1.55
EMPL. (No.)	190	109	56	164	354
Type 11A Ratio	1.00	0.57	0.29	0.87	1.87

* Contractors are located in production-induced flow-ons.

Table 4.11 - Economic Impacts of the BNCOP on the Regional Economy ($2013)

	Direct Effect	Production Induced	Consump. Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	500,000	62,675	19,857	82,532	582,532
Type 11A Ratio	1.00	0.13	0.04	0.17	1.17
VALUE ADDED ($'000)	100,296	27,394	11,472	38,866	139,162
Type 11A Ratio	1.00	0.27	0.11	0.39	1.39
INCOME ($'000)	20,196	13,530	5,003	18,533	38,729
Type 11A Ratio	1.00	0.67	0.25	0.92	1.92
EMPL. (No.)	380	337	109	446	826
Type 11A Ratio	1.00	0.89	0.29	1.17	2.17

* Contractors are located in production-induced flow-ons.

Table 4.12 – Incremental Impacts on the Regional Economy ($2013)

	Direct Effect	Production Induced	Consump. Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	312,454	42,062	9,767	51,829	364,283
Type 11A Ratio	1.00	0.13	0.03	0.17	1.17
VALUE ADDED ($'000)	24,999	18,351	5,643	23,994	48,992
Type 11A Ratio	1.00	0.73	0.23	0.96	1.96
INCOME ($'000)	7,480	9,109	2,461	11,570	19,050
Type 11A Ratio	1.00	1.22	0.33	1.55	2.55
EMPL. (No.)	190	228	54	282	472
Type 11A Ratio	1.00	1.20	0.28	1.48	2.48

* Contractors are located in production-induced flow-ons.

The BNCOP is estimated to make up to the following total annual contribution to the regional economy for 15 years:

- $583M in annual direct and indirect regional output or business turnover;
- $139M in annual direct and indirect regional value added;
- $39M in annual direct and indirect household income; and
- 826 direct and indirect jobs.

The incremental impact of the higher level of production under the BNCOP is estimated to be up to:

- $364M in annual direct and indirect regional output or business turnover;
- $49M in annual direct and indirect regional value added;
- $19M in annual direct and indirect household income; and
- 472 direct and indirect jobs.

Flow-on impacts from the BNCOP are likely to affect a number of different sectors of the regional economy. The sectors most impacted by output, value-added and income flow-ons are likely to be the:

- other repairs and maintenance sector;
- accommodation, cafes and restaurants sector;
- construction services sector;
- professional, scientific and technical services sector;
- wholesale trade sector;
- retail trade sector;
- specialised and other Machinery and Equipment Manufacturing sector;
- rental and Hiring Services; and
- ownership of dwellings sector.

Examination of the estimated direct and flow-on employment impacts gives an indication of the sectors in which regional employment opportunities would be generated by the BNCOP (Table 4.13).

Table 4.13 – Incremental Sectoral Distribution of Employment Impacts on the Regional Economy

Sector	**Local Economy**			
	Average Direct Effects	**Product.-induced**	**Consump.-induced**	**Total**
Primary	0	4	2	**6**
Mining	190	0	0	**190**
Manufacturing	0	20	2	**22**
Utilities	0	2	1	**3**
Wholesale/Retail	0	89	19	**109**
Accommodation, cafes, restaurants	0	57	9	**66**
Building/Construction	0	26	1	**27**
Transport	0	5	2	**7**
Services	0	25	18	**43**
Total	**190**	**228**	**54**	**472**

Note: Totals may have minor discrepancies due to rounding.

Table 4.13 indicates that direct, production-induced and consumption-induced employment impacts of the BNCOP on the regional economy are likely to have different distributions across sectors. Production-induced flow-on employment would occur mainly in the wholesale/retail trade sectors, accommodation, cafes and restaurants sectors, building and construction sectors, services sectors and manufacturing sectors while consumption induced flow-on employment would be mainly in services sectors and wholesale/retail trade sectors.

Impacts on the Qld Economy

The total and disaggregated annual impacts of the base case and BNCOP on the Qld economy (in 2013 dollars) are shown in Tables 4.14 and 4.15. The incremental impacts during the life of the BNCOP are shown in Table 4.16.

Table 4.14 - Economic Impacts of the Base Case on the Qld Economy ($2013)

	Direct Effect	Production Induced	Consump. Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	187,546	153,958	90,252	244,210	431,756
Type 11A Ratio	1.00	0.82	0.48	1.30	2.30
VALUE ADDED ($'000)	85,066	66,264	49,743	116,007	201,073
Type 11A Ratio	1.00	0.78	0.59	1.36	2.36
INCOME ($'000)	14,972	37,640	23,260	60,901	75,873
Type 11A Ratio	1.00	2.51	1.55	4.07	5.07
EMPL. (No.)	190	548	403	951	1,141
Type 11A Ratio	1.00	2.88	2.12	5.00	6.00

* Contractors are located in production-induced flow-ons.

Table 4.15 - Economic Impacts of the BNCOP on the Qld Economy ($2013)

	Direct Effect	Production Induced	Consump. Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	500,000	565,737	286,674	852,410	1,352,410
Type 11A Ratio	1.00	1.13	0.57	1.71	2.71
VALUE ADDED ($'000)	117,824	245,563	158,003	403,566	521,390
Type 11A Ratio	1.00	2.08	1.34	3.43	4.43
INCOME ($'000)	29,940	137,176	73,884	211,060	241,000
Type 11A Ratio	1.00	4.58	2.47	7.05	8.05
EMPL. (No.)	380	1,941	1,280	3,221	3,602
Type 11A Ratio	1.00	5.11	3.37	8.47	9.47

* Contractors are located in production-induced flow-ons.

Table 4.16 – Incremental Impacts on the Regional Economy ($2013)

	Direct Effect	Production Induced	Consump. Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	312,454	411,779	196,421	608,200	920,654
Type 11A Ratio	1.00	1.32	0.63	1.95	2.95
VALUE ADDED ($'000)	32,759	179,300	108,259	287,559	320,318
Type 11A Ratio	1.00	5.47	3.30	8.78	9.78
INCOME ($'000)	14,967	99,536	50,623	150,160	165,127
Type 11A Ratio	1.00	6.65	3.38	10.03	11.03
EMPL. (No.)	190	1,393	877	2,270	2,460
Type 11A Ratio	1.00	7.33	4.61	11.94	12.94

* Contractors are located in production-induced flow-ons.

The BNCOP is estimated to make up to the following total annual contribution to the Qld economy for 15 years:

- $1,352M in annual direct and indirect regional output or business turnover;
- $521M in annual direct and indirect regional value added;
- $241M in annual direct and indirect household income; and
- 3,602 direct and indirect jobs.

The incremental impact of the higher level of production under the BNCOP is estimated to be up to:

- $921M in annual direct and indirect regional output or business turnover;
- $320M in annual direct and indirect regional value added;
- $165M in annual direct and indirect household income; and
- 2,460 direct and indirect jobs.

The impacts on the Qld economy are substantially greater than for the local and regional economy, as the Qld economy is able to capture more mine and household expenditure, and there is a greater level of intersectoral linkages in the larger Qld economy. At the Qld level, there is greater scope for labour and resources required for the BNCOP to be diverted from other sectors of the economy, particularly in times of near full employment of the economy, and hence for there to be some partially offsetting contraction in economic activity.

Businesses in the local, regional and Qld economies that can provide the inputs to the production process required by the BNCOP and/or the products and services required by employees would directly benefit from the BNCOP by way of an increased economic activity. However, because of the inter-linkages between sectors, many indirect businesses also benefit.

4.6 OTHER ECONOMIC IMPACTS

4.6.1 Potential Contraction in Other Sectors

Economic impacts for local, regional and State economies modelled using input-output analysis represent only the positive economic activity associated with the BNCOP. Where employed and unemployed labour resources in the region are limited and the mobility of in-migrating or commuting labour from outside the region is restricted there may be competition for regional labour resources that drives up local and regional wages. In these situations, there may be some ‘crowding out’ of economic activity in other sectors of the local and regional economy. However, ‘crowding out’ of other economic activities does not indicate losses of jobs but the shifting of labour resources to higher valued economic activities. This reflects the operation of the market system where scarce resources are reallocated to where they are most highly valued and where society would benefit the most from them. This reallocation of resources is therefore considered a positive outcome for the economy not a negative.

‘Crowding out’ would be most prevalent if the local/regional/Qld economy was at full employment and it was a closed economy with no potential to use labour and other resources that currently reside outside the region. However, the local, regional and State economy are not at full employment and they each have access to external labour resources. The BNCOP may provide alternative employment opportunities for the estimated 200 people announced to lose their jobs from the nearby Dawson Mine[11]. To the extent that this occurs, little ‘crowding out’ of economic activity in other sectors would be expected as a result of the BNCOP.

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[11] Australian Newspaper, November 05, 2013.

4.6.2 Wage Impacts

In the short-run, increased regional demand for labour as a result of the BNCOP could potentially result in some increases pressure on wages in other sectors of the economy. The magnitude and duration of this upward wages pressure would depend on the level of demand for additional labour, the availability of labour resources in the region and the availability and mobility of labour from outside the region. Where upward pressure on regional wages occurs it represents at economic transfer between employers and owners of skills and would attract skilled labour to the region leading to wages returning to normal.

The announcement by Anglo-American in late 2013 to reduce its workforce by 200 jobs at the nearby Dawson Mine would suggests that there may be sufficient available and suitably skilled labour in the region to ensure minimal regional wage impacts as a result of the BNCOP.

4.6.3 Housing Impacts

The BNCOP would create increased demand for accommodation during both the construction and operation phases. It is expected however that all non-local members of the construction workforce would be accommodated at the mine accommodation village which is located at the expanded Baralaba Caravan Park (i.e. no increase in demand for accommodation would occur). In addition, the bulk (approximately 72%) of the operations workforce would also be accommodated in the expanded mine accommodation village located at the Baralaba Caravan Park (i.e. only a slight increase in the demand for accommodation would occur).

Notwithstanding the above, where local housing supply is insufficient to meet demand, even temporarily, this may manifest itself in increased property prices and higher rent prices in the region. While increased property prices and higher rent prices may be seen as beneficial for property owners, it can adversely affect existing tenants, particularly those on lower incomes who can be priced out of the market.

The timely response of Banana Shire rezoning policies and land releases to market signals would further ensure that pressures on housing prices and rents are managed.

4.6.4 Mine Cessation

As outlined in Section 4.5, the BNCOP would stimulate demand in the local, regional and Qld economy, for up to 15 years, leading to increased business turnover in a range of sectors and increased employment opportunities. Conversely, the cessation of the mining operations in the future would result in a contraction in local, regional and Qld economic activity.

The magnitude of the local and regional economic impacts of cessation of the BNCOP would depend on a number of interrelated factors at the time, including:

- the movements of workers and their families;
- alternative development opportunities; and
- economic structure and trends in the regional economy at the time.

Ignoring all other influences, the impact of BNCOP cessation on the local and regional area would depend on whether the workers and their families affected would leave the local and regional area. If it is assumed that some or all of the workers remain in the local and regional area, then the impacts of BNCOP cessation would not be as severe compared to a greater level leaving the local and regional area. This is because the consumption-induced flow-ons of the decline would be reduced through the continued consumption expenditure of those who stay (Economic and Planning Impact Consultants, 1989). Under this assumption, the local and regional economic impacts of BNCOP cessation would approximate the direct and production-induced effects in Table 4.7 and Table 4.11, respectively. However, if displaced workers and their families leave the region then impacts would be greater and begin to approximate the total effects in Table 4.7 and Table 4.11.

The decision by workers, on cessation of the BNCOP, to move or stay would be affected by a number of factors including the prospects of gaining employment in the local and regional economy compared to other regions, the likely loss or gain from homeowners selling, and the extent of "attachment" to the local and regional areas (Economic and Planning Impact Consultants, 1989).

To the extent that alternative development opportunities arise in the local and regional economy, the regional economic impacts associated with mining closure that arise through reduced production and employment expenditure can be substantially ameliorated and absorbed by the growth of the region. One key factor in the growth potential of a region is its capacity to expand its factors of production by attracting investment and labour from outside the region (BIE, 1994). This in turn can depend on a region’s natural endowments. In this respect, the local and regional area is highly prospective with considerable coal resources.

It is therefore likely that, over time, new mining developments would occur, offering potential to strengthen and broaden the economic base of the local and regional area and hence buffer against impacts of the cessation of individual activities.

Ultimately, the significance of the economic impacts of cessation of the BNCOP would depend on the economic structure and trends in the local and regional economy at the time. For example, if BNCOP cessation takes place in a declining economy, the impacts might be significant. Alternatively, if BNCOP cessation takes place in a growing diversified economy where there are other development opportunities, the ultimate cessation of the BNCOP may not be a cause for concern.

Nevertheless, given the uncertainty about the future complementary mining activity in the local and regional economy it is not possible to foresee the likely circumstances within which BNCOP cessation would occur.

4.7 MITIGATION MEASURES

CCL would work in partnership with the Banana Shire Council, the Central Highlands Regional Council and the local community so that the benefits of the projected economic growth in the region are maximised and impacts minimised, as far as possible. In this respect, a range of general and specific economic impact mitigation and management measures are proposed and would include:

- Early provision of information to the Banana Shire Council, the Central Highlands Regional Council and relevant State Government agencies regarding employment and population level changes, to facilitate appropriate management of land releases and housing development and minimise excess demand for housing and community infrastructure.
- Employ local and regional residents, including members of Indigenous communities and the disabled, preferentially where they have the required skills and experience and demonstrate a cultural fit with the organisation, to manage regional housing demands and support the local community.

- Purchase local non-labour inputs to production preferentially where local producers can be cost and quality competitive and adoption of the Queensland Resources and Energy Sector Code of Practice for Local Content, to support local industries.
- Development of an accommodation camp to reduce excess demand for short-term and long term accommodation.

Labour skills shortages are a national issue that is being addressed through a Federal Government National Skill Shortages Strategy. The BNCOP is expected to directly and indirectly bring additional skilled workers into the region and retain skilled workers who otherwise may have left the region.

5 CONCLUSION

A BCA of the BNCOP indicated that it would have net production benefits to Australia of $831M. Provided the residual environmental, social and cultural impacts of the BNCOP that accrue to Australia are considered to be valued at less than $831M, the BNCOP can be considered to provide an improvement in economic efficiency and hence is justified on economic grounds.

Instead of leaving the environmental, cultural and social impacts unquantified, an attempt was made to quantify them. The main quantifiable environmental impacts of the BNCOP that have not already been incorporated into the estimate of net production benefits, relate to greenhouse gas emissions. These impacts are estimated at $54M globally or $1M to Australia, considerably less than the estimated net production benefits of the BNCOP. Overall, the BNCOP is estimated to have net social benefits to Australia of $831M and hence is desirable and justified from an economic efficiency perspective.

While the BCA is primarily concerned with the aggregate costs and benefits of the BNCOP to Australia, the costs and benefits may be distributed among a number of different stakeholder groups at the local, state, National and global level. The total net production benefit would be distributed amongst a range of stakeholders including:

- CCL shareholders in the form of after tax (and after voluntary contributions) profits;
- the Commonwealth Government in the form of any Company tax payable ($244M present value) from the BNCOP, which is subsequently used to fund provision of government infrastructure and services across Australia and Qld, including the local and regional area; and
- the Qld Government via royalties ($272M present value) which are subsequently used to fund provision of government infrastructure and services across the State, including the local and regional area.

The environmental, cultural and social impacts of the BNCOP may potentially accrue to a number of different stakeholder groups at the local, State, National and global level, however, are largely internalised into the production costs of CCL.

The non-market costs that accrue to Qld are estimated at less than $1M. These are considerably less than the net production benefits that directly accrue to Qld. Consequently, as well as resulting in net benefits to Australia the BNCOP would result in net benefits to Qld.

An economic impact analysis, using input-output analysis found that the operation of the BNCOP would provide additional economic activity to the Banana Shire, Banana Shire/Central Highlands Regional economy and Qld from expenditure during both construction and operation. Construction economic activity would last for approximately one year while incremental operation impacts would occur for up to 15 years. The incremental economic impact of the BNCOP operation on the local economy is estimates at up to:

- $341M in annual direct and indirect regional output or business turnover;
- $39M in annual direct and indirect regional value added;
- $12M in annual direct and indirect household income; and
- 355 direct and indirect jobs.

The incremental impact of the BNCOP operation on the regional economy is estimated at up to:

- $364M in annual direct and indirect regional output or business turnover;
- $49M in annual direct and indirect regional value added;
- $19M in annual direct and indirect household income; and
- 472 direct and indirect jobs.

For the Qld economy, the operation of the BNCOP is estimated to make up to the following incremental contribution:

- $921M in annual direct and indirect regional output or business turnover;
- $320M in annual direct and indirect regional value added;
- $165M in annual direct and indirect household income; and
- 2,460 direct and indirect jobs.

Cessation of the BNCOP operation may lead to a reduction in economic activity. The significance of these BNCOP cessation impacts would depend on:

- The degree to which any displaced workers and their families remain within the region, even if they remain unemployed. This is because continued expenditure by these people in the regional economy (even at reduced levels) contributes to final demand.
- The economic structure and trends in the regional economy at the time. For example, if Project cessation takes place in a declining economy the impacts might be felt more greatly than if it takes place in a growing diversified economy.
- Whether other mining developments or other opportunities in the region arise that allow employment of displaced workers.

Crowding out of economic activity in other sectors of the economy and regional house price and wage impacts are estimated to be minimal because of the potential availability of recently displaced labour in the region and the proposed BNCOP accommodation strategy.

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ATTACHMENT 1

VALUING GREENHOUSE GAS EMISSIONS

To place an economic value on carbon dioxide equivalent (CO_2-e) emissions a shadow price of carbon is required that reflects its social costs. The social cost of carbon is the present value of additional economic damages now and in the future caused by an additional tonne of carbon emissions.

A prerequisite to valuing this environmental damage is scientific dose-response functions identifying how incremental emissions of CO_2-e would impact climate change and subsequently impact human activities, health and the environment on a spatial basis. Only once these physical linkages are identified is it possible to begin to place economic values on the physical changes using a range of market and non market valuation methods. Neither the identification of the physical impacts of additional greenhouse gas nor valuation of these impacts is an easy task, although various attempts have been made using different climate and economic modelling tools. The result is a great range in the estimated damage costs of greenhouse gas.

The *Stern Review: Economics of Climate Change* (Stern, 2006) acknowledged that the academic literature provides a wide range of estimates of the social cost of carbon. It adopted an estimate of United States (US) $85 per tonne (/t) of carbon dioxide (CO_2) for the "business as usual" case (i.e. an environment in which there is an annually increasing concentration of greenhouse gas in the atmosphere).

Tol (2006) highlights some significant concerns with Stern’s damage cost estimates including:

- that in estimating the damage of climate change Stern has consistently selected the most pessimistic study in the literature in relation to impacts;
- Stern’s estimate of the social cost of carbon is based on a single integrated assessment model, PAGE2002, which assumes all climate change impacts are necessarily negative and that vulnerability to climate change is independent of development; and
- Stern uses a near zero discount rate which contravenes economic theory and the approach recommended by Treasury’s around the world.

All these have the effect of magnifying the social cost of the carbon estimate, providing what Tol (2006) considers to be an outlier in the marginal damage cost literature.

Tol (2005) in a review of 103 estimates of the social cost of carbon from 28 published studies found that the range of estimates was right-skewed: the mode was US$0.55/t CO_2 (in 1995 US$), the median was US$3.82/t CO_2, the mean US$25.34/t CO_2 and the 95th percentile US$95.37/t CO_2. He also found that studies that used a lower discount rate and those that used equity weighting across regions with different average incomes per head, generated higher estimates and larger uncertainties. The studies did not use a standard reference scenario, but in general considered ‘business as usual’ trajectories.

Tol (2005) concluded that “it is unlikely that the marginal damage costs of CO_2 emissions exceed US$14/t CO_2 and are likely to be substantially smaller than that”. Nordhaus’s (2008) modelling using the DICE-2007 Model suggests a social cost of carbon with no emissions limitations of US$30 per tonne of carbon (US$8/t CO_2).

Tol (2011) surveyed the literature on the economic impact of climate change. Tol (2011) identifies the mean estimated from published studies is a marginal cost of carbon of $177/t C ($48/ tCO2-e) and a modal estimate of $49/t C ($13 tCo2-e) reflecting the fact that the mean estimate is driven by some very large estimates. For peer reviewed studies only, the mean estimate of the social cost of carbon is $80/tC ($22/tCo2-e).

An alternative method to trying to estimate the damage costs of CO_2 is to examine the price of carbon credits. This is relevant because emitters can essentially emit CO_2 resulting in climate change damage costs or may purchase credits that offset their CO_2 impacts, internalising the cost of the externality at the price of the carbon credit. The price of carbon credits therefore provides an alternative estimate of the economic cost of greenhouse gas. However, the price is ultimately a function of the characteristics of the scheme and the scarcity of permits, etc. and hence may or may not reflect the actual social cost of carbon.

In the first half of 2008 the carbon price under the European Union Emissions Trading Scheme was over €20/t CO_2 The average price was €22/t CO_2 in the second half of 2008, and €13/t CO_2 in the first half of 2009. In March 2012, the permit price reduced to under €10 /t CO_2.

In 2008, spot prices in the Chicago Climate Exchange were in the order of US$3.95/t CO_2. However, the Chicago Climate Exchange cap and trade system ended on December 31, 2010.

In 2011, the greenhouse penalty for benchmark participants in the New South Wales Government Greenhouse Gas Reduction Scheme that fail to reduce emissions rose to $15.50 t $CO_{2.}$

Under the Australian Commonwealth Government's Climate Change Plan (Department of Climate Change and Energy Efficiency 2011) around 500 of the biggest polluters in Australia would need to buy and surrender to the Government a permit for every tonne of carbon pollution they produce. For the first three years, the carbon price was to be fixed like a tax, before moving to an emissions trading scheme in 2015. In the fixed price stage, starting on 1 July 2012, the carbon price was to start at $23 a tonne, rising at 2.5 per cent a year in real terms. From 1 July 2015, the carbon price was to be set by the market. This proposed scheme is proposed to be repealed by the Liberal government.

Given the above information and the great uncertainty around damage cost estimates, the BCA uses the carbon price proposed by Australian Government's Climate Change Plan i.e. $23 a tonne, rising at 2.5 per cent a year in real terms for three years, as reflective of the global social damage cost of carbon. From 2015 it is assumed that the carbon price remains constant. A range for the social cost of greenhouse gas emissions from AUD$8/t CO_2-e to AUD$40/t CO_2-e was used in the sensitivity analysis described in Section 3.6 of this report.

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ATTACHMENT 2

BCA SENSITIVITY TESTING

Table 2-1
Benefit Cost Analysis Sensitivity Testing, Project Australian Net Present Value ($Millions)

	4% Discount Rate	7% Discount Rate	10% Discount Rate
CENTRAL ANALYSIS	$1,021	$831	$660
INCREASE 20%			
Opportunity cost of land	$1,020	$830	$659
Development costs	$982	$790	$619
Operating costs	$721	$573	$441
Coal value	$1,590	$1,314	$1,064
Rehabilitation and decommissioning costs	$1,020	$830	$659
GREENHOUSE COSTS @ $40/TONNE (T)	$1,020	$830	$659

	4% Discount Rate	7% Discount Rate	10% Discount Rate
DECREASE 20%			
Opportunity cost of land	$1,021	$831	$660
Development costs	$1,066	$876	$703
Operating costs	$1,321	$1,089	$878
Coal value	$451	$347	$255
Rehabilitation and decommissioning costs	$1,021	$831	$660
GREENHOUSE COSTS @ $8/T	$1,021	$831	$660

ATTACHMENT 3

UNDERLYING ASSUMPTIONS AND INTERPRETATIONS OF INPUT-OUTPUT ANALYSIS AND MULTIPLIERS

1. “The *basic assumptions* in input-output analysis include the following:

    - there is a fixed input structure in each industry, described by fixed technological coefficients (evidence from comparisons between input-output tables for the same country over time have indicated that material input requirements tend to be stable and change but slowly; however, requirements for primary factors of production, that is labour and capital, are probably less constant);
    - all products of an industry are identical or are made in fixed proportions to each other;
    - each industry exhibits constant returns to scale in production;
    - unlimited labour and capital are available at fixed prices; that is, any change in the demand for productive factors would not induce any change in their cost (in reality, constraints such as limited skilled labour or investment funds lead to competition for resources among industries, which in turn raises the prices of these scarce factors of production and of industry output generally in the face of strong demand); and
    - there are no other constraints, such as the balance of payments or the actions of government, on the response of each industry to a stimulus.

2. The multipliers therefore describe *average effects, not marginal effects*, and thus do not take account of economies of scale, unused capacity or technological change. Generally, average effects are expected to be higher than the marginal effects.

3. The input-output tables underlying multiplier analysis only take account of one form of *interdependence,* namely the sales and purchase links between industries. Other interdependence such as collective competition for factors of production, changes in commodity prices which induce producers and consumers to alter the mix of their purchases and other constraints which operate on the economy as a whole are not generally taken into account.

4. The combination of the assumptions used and the excluded interdependence means that input-output multipliers are higher than would realistically be the case. In other words, they tend to *overstate* the potential impact of final demand stimulus. The overstatement is potentially more serious when large changes in demand and production are considered.

5. The multipliers also do not account for some important pre-existing conditions. This is especially true of Type II multipliers, in which employment generated and income earned induce further increases in demand. The implicit assumption is that those taken into employment were previously unemployed and were previously consuming nothing. In reality, however, not all 'new' employment would be drawn from the ranks of the unemployed; and to the extent that it was, those previously unemployed would presumably have consumed out of income support measures and personal savings. Employment, output and income responses are therefore overstated by the multipliers for these additional reasons.

6. The most *appropriate interpretation* of multipliers is that they provide a relative measure (to be compared with other industries) of the interdependence between one industry and the rest of the economy which arises solely from purchases and sales of industry output based on estimates of transactions occurring over a (recent) historical period. Progressive departure from these conditions would progressively reduce the precision of multipliers as predictive device” (ABS 1995, p.24).

Multipliers therefore do not take account of economies of scale, unused capacity or technological change since they describe average effects rather than marginal effects (ABS, 1995).

Multipliers indicate the total impact of changes in demand for the output of any one industry on all industries in an economy (ABS, 1995). Conventional output, employment, value-added and income multipliers show the output, employment, value-added and income responses to an initial output stimulus (Jensen and West, 1986).

Components of the conventional output multiplier are as follows:

Initial effect - which is the initial output stimulus, usually a $1 change in output from a particular industry (Powell and Chalmers, 1995; ABS, 1995).

First round effects - the amount of output from all intermediate sectors of the economy required to produce the initial $1 change in output from the particular industry (Powell and Chalmers, 1995; ABS, 1995).

Industrial support effects - the subsequent or induced extra output from intermediate sectors arising from the first round effects (Powell and Chalmers, 1995; ABS, 1995).

Production induced effects - the sum of the first round effects and industrial support effects (i.e. the total amount of output from all industries in the economy required to produce the initial $1 change in output) (Powell and Chalmers, 1995; ABS, 1995).

Consumption induced effects - the spending by households of the extra income they derive from the production of the extra $1 of output and production induced effects. This spending in turn generates further production by industries (Powell and Chalmers, 1995; ABS, 1995).

The *simple multiplier* is the initial effect plus the production induced effects.

The *total multiplier* is the sum of the initial effect plus the production-induced effect and consumption-induced effect.

Conventional employment, value-added and income multipliers have similar components to the output multiplier, however, through conversion using the respective coefficients show the employment, value-added and income responses to an initial output stimulus (Jensen and West, 1986).

For employment, value-added and income, it is also possible to derive relationships between the initial or own sector effect and flow-on effects. For example, the flow-on income effects from an initial income effect or the flow-on employment effects from an initial employment effect, etc. These own sector relationships are referred to as ratio multipliers, although they are not technically multipliers because there is no direct line of causation between the elements of the multiplier. For instance, it is not the initial change in income that leads to income flow-on effects, both are the result of an output stimulus (Jensen and West, 1986).

A description of the different ratio multipliers is given below.

$$\text{Type 1A Ratio Multiplier} = \frac{\text{Initial + First Round Effects}}{\text{Initial Effects}}$$

$$\text{Type 1B Ratio Multiplier} = \frac{\text{Initial + Production Induced Effects}}{\text{Initial Effects}}$$

$$\text{Type 11A Ratio Multiplier} = \frac{\text{Initial + Production Induced + Consumption Induced Effects}}{\text{Initial Effects}}$$

$$\text{Type 11B Ratio Multiplier} = \frac{\text{Flow-on Effects}}{\text{Initial Effects}}$$

Source: Centre for Farm Planning and Land Management (1989).

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ATTACHMENT 4

THE GRIT SYSTEM FOR GENERATING INPUT-OUTPUT TABLES

The Generation of Regional Input-Output Tables (GRIT) system was designed to:

- combine the benefits of survey based tables (accuracy and understanding of the economic structure) with those of non-survey tables (speed and low cost);
- enable the tables to be compiled from other recently compiled tables;
- allow tables to be constructed for any region for which certain minimum amounts of data were available;
- develop regional tables from national tables using available region-specific data;
- produce tables consistent with the national tables in terms of sector classification and accounting conventions;
- proceed in a number of clearly defined stages; and
- provide for the possibility of ready updates of the tables.

The resultant GRIT procedure has a number of well-defined steps. Of particular significance are those that involve the analyst incorporating region-specific data and information specific to the objectives of the study. The analyst has to be satisfied about the accuracy of the information used for the important sectors; in this case the coal mining sector. The method allows the analyst to allocate available research resources to improving the data for those sectors of the economy that are most important for the study.

An important characteristic of GRIT-produced tables relates to their accuracy. In the past, survey-based tables involved gathering data for every cell in the table, thereby building up a table with considerable accuracy. A fundamental principle of the GRIT method is that not all cells in the table are equally important. Some are not important because they are of very small value and, therefore, have no possibility of having a significant effect on the estimates of multipliers and economic impacts. Others are not important because of the lack of linkages that relate to the particular sectors that are being studied. Therefore, the GRIT procedure involves determining those sectors and, in some cases, cells that are of particular significance for the analysis. These represent the main targets for the allocation of research resources in data gathering. For the remainder of the table, the aim is for it to be 'holistically' accurate (Jensen, 1980). This means a generally accurate representation of the economy is provided by the table, but does not guarantee the accuracy of any particular cell. A summary of the steps involved in the GRIT process is shown in Table A4-1 (Powell and Chalmers, 1995).

Table A4-1
The GRIT Method

Phase	Step	Action
PHASE I		ADJUSTMENTS TO NATIONAL TABLE
	1	Selection of national input-output table (106-sector table with direct allocation of all imports, in basic values).
	2	Adjustment of national table for updating.
	3	Adjustment for international trade.
PHASE II		ADJUSTMENTS FOR REGIONAL IMPORTS
		(*Steps 4-14 apply to each region for which input-output tables are required*)
	4	Calculation of 'non-existent' sectors.
	5	Calculation of remaining imports.
PHASE III		DEFINITION OF REGIONAL SECTORS
	6	Insertion of disaggregated superior data.
	7	Aggregation of sectors.
	8	Insertion of aggregated superior data.
PHASE IV		DERIVATION OF PROTOTYPE TRANSACTIONS TABLES
	9	Derivation of transactions values.
	10	Adjustments to complete the prototype tables.
	11	Derivation of inverses and multipliers for prototype tables.
PHASE V		DERIVATION OF FINAL TRANSACTIONS TABLES
	12	Final superior data insertions and other adjustments.
	13	Derivation of final transactions tables.
	14	Derivation of inverses and multipliers for final tables.

Source: Bayne and West (1988).

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Powell, R. and Chalmers, L. (1995) *The Regional Economic Impact of Gibraltar Range and Dorrigo National Park*. A Report for the NSW National Parks and Wildlife Service.

Appendix B – Soil and Land Suitability

Baralaba North Continued Operations Project

Cockatoo Coal Limited

Soil and Land Suitability Assessment

Soil mapping, characterization, topsoil stripping, pre-mining land suitability, Strategic Cropping Land and erosion potential

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Disclaimer:

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1. Introduction

This report presents findings from a baseline soil mapping and soil characterization investigation within the Baralaba North Continued Operations Project (BNCOP) area, situated north of the township of Baralaba. The purpose of the investigation was firstly to define and quantify soil landscapes within the defined BNCOP Soil Investigation survey area (see Figures 1 and 2); and secondly to determine topsoil resources for salvage and to assess pre-mining land suitability, Agricultural Land Class status, Strategic Cropping Land (SCL) status and inherent erosion potential more specifically within the BNCOP Disturbance Footprint. Soil Mapping and Monitoring Pty Ltd (in association with B.R. Emmerton Pty Ltd) were commissioned by Cockatoo Coal Pty Ltd to undertake the investigation.

The aims of the investigation were threefold. Initial field and laboratory studies aimed to map, describe and fully characterise the soil landscapes present within the defined BNCOP soil investigation survey area (see Figures 1 and 2). Subsequent analysis of the data from this process has enabled clear identification of the distribution, abundance and nature of suitable topsoil and root zone (subsoil) resources for stripping and salvage. In addition, soil attributes contributing to pre-mining land suitability (dryland cropping and grazing), SCL status and inherent erodibility have been investigated, analysed and reported on.

Specific objectives and milestones completed during the study include:

- **preliminary photo interpretation and digital elevation model (DEM) analysis** to investigate differences in soil distribution associated with lithology, landscape position/weathering status and vegetation;
- **detailed soil characterization and field mapping** at a suitable scale (1:25000);
- **field logging of undisturbed soil cores** to characterize the morphology of surface soil and subsoil materials (e.g. texture, colour, structure, behavioural properties in the field);
- **representative sampling and laboratory analyses** to quantify physical and chemical characteristics of topsoil and subsoil materials;
- identification of the nature and depth of suitable **topsoil materials** available for salvage;
- identification of the presence of **benign root zone materials** that are potentially useful as additional rehabilitation media;
- assessment of **pre-mining land suitability for dryland cropping and grazing**;
- assessment of **Agricultural Land Class (ALC)** status
- assessment of **Strategic Cropping Land (SCL)** status;
- assessment of **inherent erosion potential**;
- presentation of **detailed mapping** showing the distribution and spatial extent of soil resources, pre-mining land suitability, ALC status, SCL status and inherent erosion potential within the investigation area; and
- **documentation** of all methodology, soil data, interpreted soil characteristics, stripping recommendations and land suitability/ALC/SCL/erosion assessment findings.

Twenty three soil types are recognized within the 2013 BNCOP Soil Investigation survey area. Field site locations were based initially on a combination of air photo interpretation (1:25000 1952 B&W photography) and DEM analysis and were designed to investigate differences in soil distribution associated with changes in lithology, landscape position, weathering status and pre-clearing vegetation patterns.

Field logging and sampling (from 75mm undisturbed soil cores) were undertaken at 113 field sites. Comprehensive field data was collected at each site to fully describe and characterize the soil resource present. All sites were fully sampled and strategic laboratory analysis was undertaken at a select number of representative sites.

Each of the soils delineated during mapping varies significantly in terms of origins and spatial extent, and this is reflected in the depth, thickness and quality of topsoil and subsoil horizons that have developed. Differences in soil attributes have been carefully mapped, analysed and documented during the investigation. **Topsoil stripping and management recommendations**, assessment of **pre-mining land suitability** for dryland cropping and grazing land uses, **Agricultural Land Class (ALC)** determinations, **Strategic Cropping Land (SCL)** status and assessment of **inherent erosion potential** are discussed for each soil in the sections that follow.

In addition, detailed description and characterisation data for each soil type, including stripping recommendations and pre-mining suitability findings are summarized for quick reference in the **Soil Characterisation Section** of this report. All relevant data is presented both in the text (where appropriate) and also in the Appendices attached to this report.

2. Study area

The 2013 BNCOP Soil Investigation survey area collectively covers 2970ha, and extends mapping coverage eastwards, westwards and northwards from previous soil mapping undertaken within ML80169 and ML80170 (Soil Mapping and Monitoring (SMM) 2010b; North Queensland Soil Assessment (NQSA) 2011a, 2011b). Study area boundaries and naming conventions are presented in **Figures 1 and 2**.

The completed 2013 BNCOP Soil Investigation survey area encompasses the following entities:

- buffer areas external to the BNCOP EIS Operational Area;
- the proposed BNCOP Disturbance Footprint (external to ML80169 and ML80170) that occupies the eastern and northern parts of the BNCOP EIS Operational Area; and the
- existing Baralaba/Wonbindi North Mine Lease (ML80169/ML80170) that occupies the western section of the BNCOP EIS Operational Area.

The BNCOP EIS Operational Area is wholly contained within the 2013 survey boundary and comprises two existing leases, namely ML80169 and ML80170, as well as the proposed BNCOP Disturbance Footprint that lies adjacent. Whilst soils information across the entire 2013 Soil Investigation survey area (2970ha) is presented, only new information relating directly to the BNCOP Disturbance Footprint, plus previously assessed findings within ML80169 and ML80170, are relevant to the BNCOP Operational Area Environmental Impact Statement (EIS).

Pre-existing soil mapping covering areas within ML80169 and ML80170 (NQSA 2011a, 2011b), is presented to demonstrate continuity between assessment stages and complete soils coverage within the BNCOP, but is not discussed as part of this report. Detailed technical assessments, findings and discussion for soils in the pre-existing leases is available from the relevant reports and documentation submitted during approval of ML80169 and ML80170 (NQSA 2011a, 2011b).

The detailed technical assessments, findings and discussion presented in this report specifically target the proposed BNCOP Disturbance Footprint which covers an area of 1486ha and lies immediately north-east and external to ML80169 and ML80170. New work has not been undertaken within ML80169 and ML80170.

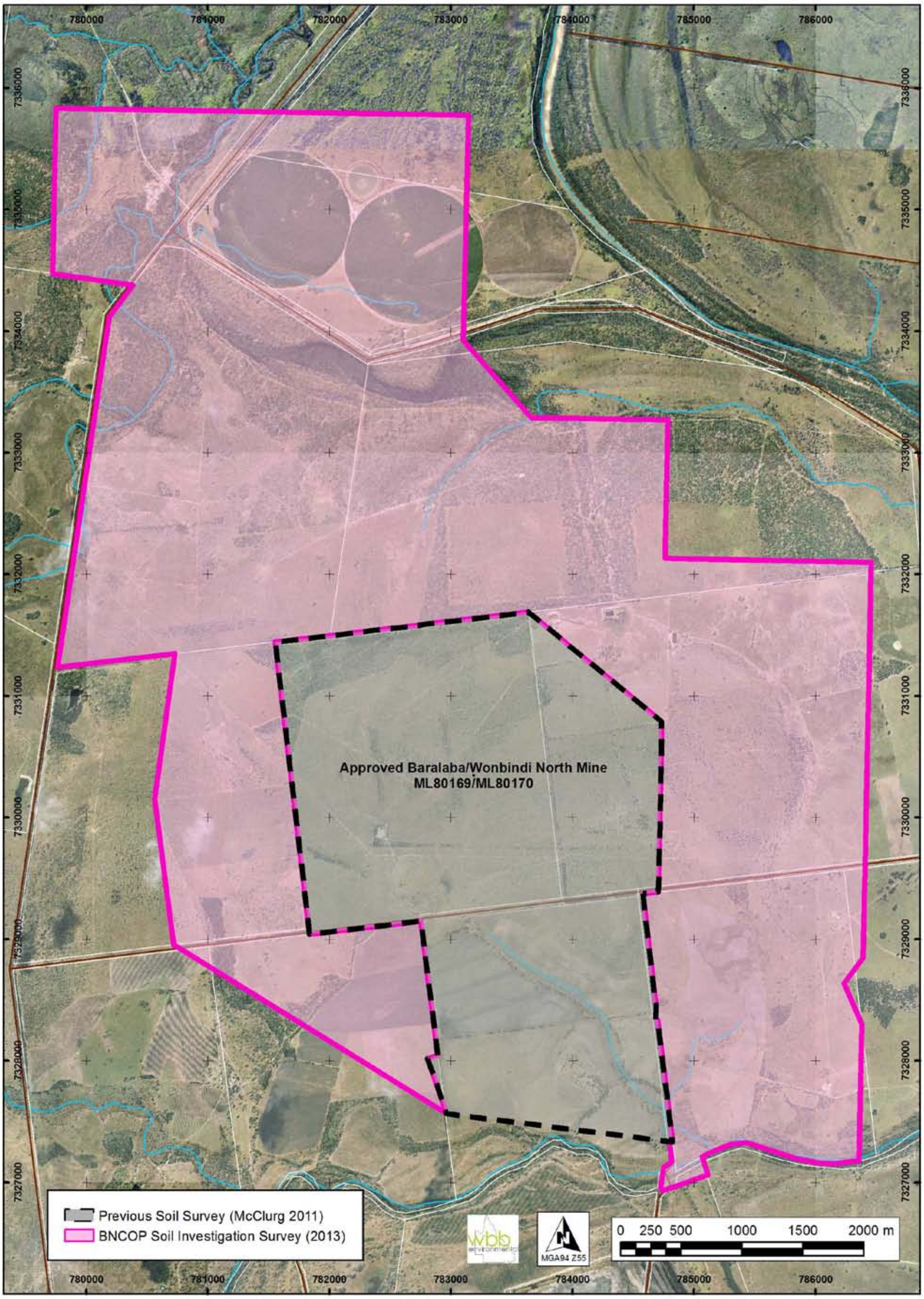


Figure 1. Baralaba North location showing the extent of the 2013 BNCOP Soil Investigation survey area (pink) in relation to the approved Baralaba/Wonbindi North Mine Lease - ML80169 and ML80170 (grey).

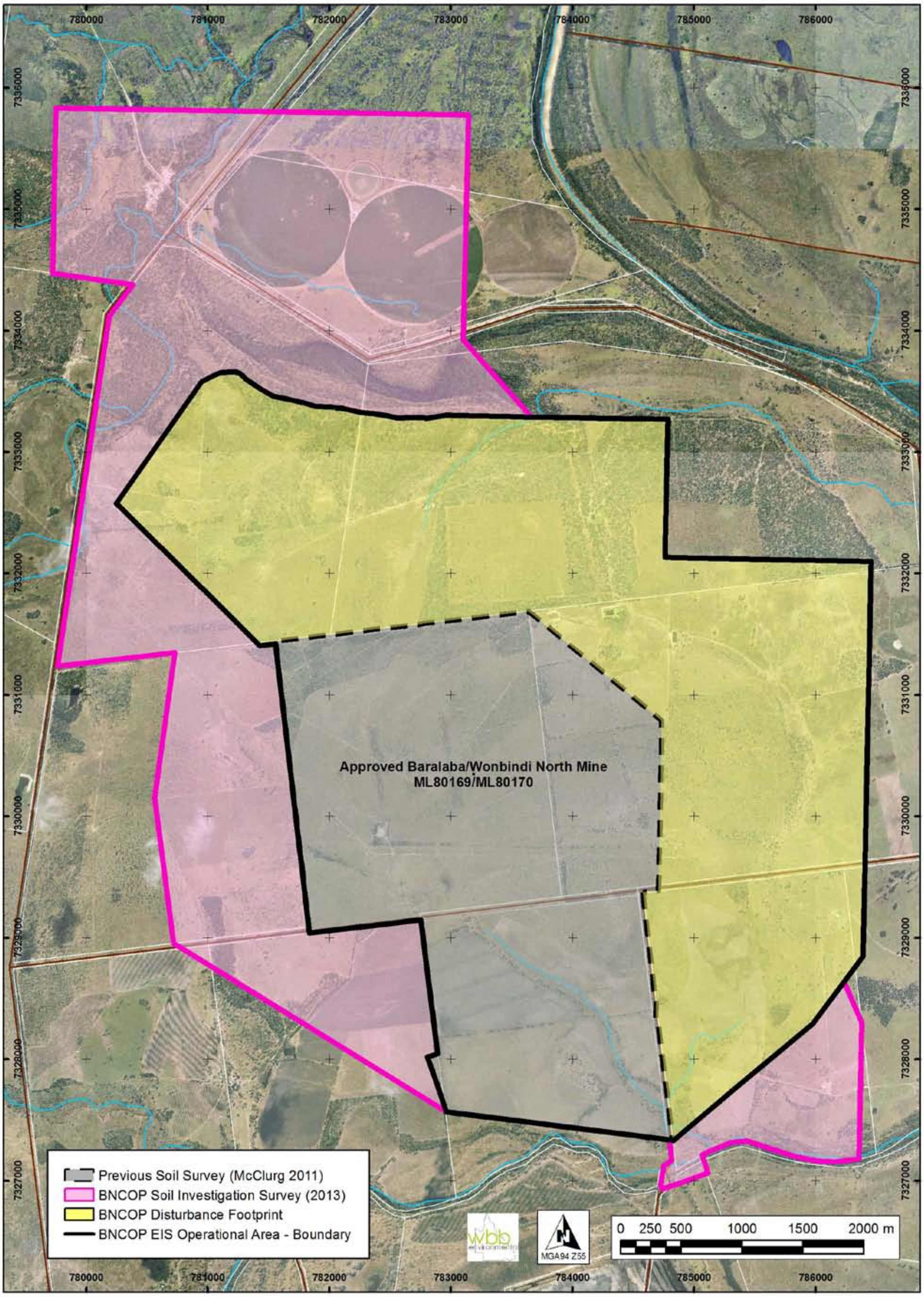


Figure 2. Location and extent of the BNCOP Disturbance Footprint (yellow), ML80169 and ML80170 (grey) and the BNCOP EIS Operational Area (yellow + grey) nested within the 2013 BNCOP Soil Investigation survey area (pink).

3. Previous land resource studies

Previous broadscale geologic and/or land resource studies that are either spatially relevant or provide a descriptive soil-landscape framework relevant to the current BNCOP investigation include:

- Balfe *et al* (1988). *Bowen Basin Solid Geology 1:500 000 Map series*, Queensland Department of Mines, Brisbane.
- Olgers *et al* (1963). *1:250 000 Geological Map Series - Baralaba Sheet SG 55-4*. Bureau of Mineral Resources, Geology and Geophysics, Canberra in conjunction with Geological Survey Queensland , Brisbane.
- Perry *et al* (1968). *Land Systems of the Dawson Fitzroy area.* CSIRO Land Research Series Number 21. Canberra. (1:500 000 land system mapping).
- Burgess JW (2003a). *Land Resource Assessment of the Windeyers Hill Area, Isaac – Connors and Mackenzie River Catchments, Central Queensland, Volume 1*, Department of Natural Resources and Mines, Land Resources Bulletin Series QNRM02189, Brisbane.
- Burgess JW (2003b). *Land Resource Assessment of the Windeyers Hill Area, Isaac – Connors and Mackenzie River Catchments, Central Queensland, Volume 2 - Appendices*, Department of Natural Resources and Mines, Land Resources Bulletin Series QNRM02189, Brisbane.
- Muller PG (2008). *Soils of the Banana Area, Central Queensland*. Department of Natural Resources and Water, Land Resources Bulletin Series, Brisbane.

The broadscale land system mapping of Perry *et al* (1968) indicates alluvial landscapes within the investigation area comprise either Coolibah (C), Dakenba (D) or Juandah (J) land systems, while more elevated landscapes are mapped as Thomby (T), Eurombah (E), and Peach (P) land systems. Thomby (T) land system is developed on unconsolidated Tertiary-Quaternary sediments (Cz, TQr) and sits above any recent alluvial influences. Eurombah (E) is associated mainly with relatively intact areas of weathered Tertiary substrate, while Peach (P) is developed on little weathered, moderately dissected, medium to coarse grained siliceous Tertiary sandstones.

More recent detailed soil studies associated with previous EIS investigations for the Baralaba Mine, that lie adjacent to or overlap the current investigation (and are at similar scales and survey intensities to the current study), include:

- Soil Mapping and Monitoring (SMM) (2010a). *Soil mapping, stripping recommendations and pre-mining suitability for Stage 1 of the Baralaba Coal Mine Lease Extension*, Consultancy Report, Soil Mapping and Monitoring Pty Ltd, Qld.
- Soil Mapping and Monitoring (SMM) (2010b). *Soil mapping, stripping recommendations and pre-mining suitability for Stage 2 of the Baralaba Coal Mine Lease Extension*, Consultancy Report, Soil Mapping and Monitoring Pty Ltd, Qld.
- North Queensland Soil Assessment (NQSA) (2011a). *Pre-mining Agricultural Land Suitability and Soil Reuse Recommendations - Wonbindi North area, Baralaba, Queensland.* Consultancy Report, North Queensland Soil Assessment Pty Ltd, Qld.
- North Queensland Soil Assessment (NQSA) (2011b). *Strategic Cropping Land Report - Baralaba Coal, Queensland*. Consultancy Report, North Queensland Soil Assessment Pty Ltd, Qld.

Of these, SMM (20010a, 2010b) completed detailed soil mapping and associated land suitability assessments for initial expansion at Baralaba Mine, while more recently NQSA (2011a, 2011b) completed additional detailed soil studies, including assessment of Strategic Cropping Land (SCL) status, within the approved Baralaba/Wonbindi North Mine Lease (ML80169 and ML80170). All of the previous detailed soils studies are directly relevant to the current investigation, either because of close proximity, or through continuity of landscapes between adjacent expansion stages.

A number of soils mapped in the previous studies have been encountered during current investigations, and correlation between studies has been undertaken to ensure consistency between project stages. Of the 23 soils mapped within the 2013 BNCOP Soil Investigation survey area, 8 have been previously described by SMM (2010a, 2010b) and a further 5 by NQSA (2011a). Soils presented in the current report that have been similarly mapped within previous studies include Soils 1, 2b, 3a, 4a, 4b, 4c, 5, 6b, 7a, 7b, 7c, 8a and 8b. Further description and characterization of these soils within the current study builds on the understanding and knowledge already available.

4. Methodology

Field survey methodologies used during the study have followed recognized standard procedures detailed in the *Australian Soil and Land Survey Handbook Series* (Isbell 1996; McKenzie *et al* 2002; McKenzie *et al* 2008; National Committee on Soil and Terrain (NCST) 2009; Rayment and Lyons 2011), the *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland* (QDME 1995) and the *Guidelines for Applying the Proposed Strategic Cropping Land Criteria* (DNRM 2011d), as specified in the BNCOP Operational Area EIS terms of reference.

Industry standards and guidelines used in the investigation

Technical assessments undertaken during the investigation are in accordance with the following standards, guidelines and texts:

Soil and landscape field assessment

National Committee on Soil and Terrain (2009). *Australian Soil and Land Survey Field Handbook, Third Edition.* Australian Soil and Land Survey Handbook Series. CSIRO Publishing, Melbourne.

Soil survey specifications

McKenzie NJ, Grundy MJ, Webster R and Ringrose-Voase (2008). *Guidelines for Surveying Soil and Land Resources.* Australian Soil and Land Survey Handbook Series. CSIRO Publishing, Melbourne.

Soil classification

Isbell RF (1996). *The Australian Soil Classification*. Australian Soil and Land Survey Handbook Series. CSIRO Publishing, Melbourne.

Field vegetation assessment

Hnatiuk RJ, Thackway R and Walker J (2009). Vegetation. In *Australian Soil and Land Survey Field Handbook, Third Edition.* Australian Soil and Land Survey Handbook Series. National Committee on Soil and Terrain, CSIRO Publishing, Melbourne

Soil chemistry/analysis methodology

Rayment GE and Lyons D (2011). *Soil Chemical Methods – Australasia*. Australian Soil and Land Survey Handbook Series. CSIRO Publishing, Melbourne.

Soil physics

Mckenzie NJ, Coughlan KJ and Cresswell HP (2002). *Soil Physical Measurement and Interpretation for Land Evaluation.* Australian Soil and Land Survey Handbook Series. CSIRO Publishing, Melbourne.

Topsoil stripping assessment and management

QDME (1995). *Technical guidelines for Environmental Management of Exploration and Mining in Queensland*. Queensland Department of Mines and Energy, Brisbane, Queensland.

Pre-mining land suitability

DNRM/DSITIA (2013a). *Guidelines for Agricultural Land Evaluation in Queensland*, Second edition, Queensland Government, Brisbane, Queensland.

DNRM/DSITIA (2013b). *Regional Land Suitability Frameworks for Queensland*, *Chapter 10 - Suitability framework for the Inland Fitzroy and Southern Burdekin area*, Queensland Government, Brisbane, Queensland.

QDME (1995). *Technical guidelines for Environmental Management of Exploration and Mining in Queensland*. Queensland Department of Mines and Energy, Brisbane, Queensland.

Agricultural Land Class (ALC) assessment and land use conflict

DNRM/DSITIA (2013a). *Guidelines for Agricultural Land Evaluation in Queensland*, Second edition, Queensland Government, Brisbane, Queensland.

Queensland Government (1992). *State Planning Policy 1/92: Development and the Conservation of Agricultural Land.* Queensland Government, Brisbane, Queensland.

DPI/DHLGP (1993). *Planning Guidelines: The identification of Good Quality Agricultural Land*. Department of Primary Industries and Department of Housing and Local Government and Planning, Brisbane, Queensland.

Strategic Cropping Land (SCL) assessment

DNRM (2011a). *Protecting Queensland's Strategic Cropping Land – Statewide Strategic Cropping Land Trigger Mapping 2011 – Map Sheet C2/C5.* Department of Natural Resources and Mines, Brisbane, Queensland.

DNRM (2011b). *Protecting Queensland's Strategic Cropping Land – Proposed Criteria for Identifying Strategic Cropping Land, April 2011.* Department of Natural Resources and Mines, Brisbane, Queensland.

DNRM (2011c). *Strategic Cropping Land – Strategic Cropping Protection Areas and Strategic Cropping Management Areas, DNRM Fact Sheet July 2011.* Department of Natural Resources and Mines, Brisbane, Queensland.

DNRM (2011d). *Protecting Queensland's Strategic Cropping Land – Guidelines for Applying the Proposed Strategic Cropping Land Criteria, September 2011.* Department of Natural Resources and Mines, Brisbane, Queensland.

DNRM (2012). *Protecting Queensland's Strategic Cropping Land – Cropping History Assessment Guidelines.* Department of Natural Resources and Mines, Brisbane, Queensland.

Queensland Government (2011). *Strategic Cropping Land Act 2011 – Act No. 47 of 2011, December 2011*. Queensland Government, Brisbane, Queensland.

All methodologies employed during the study are in accordance with the recognized industry standards listed above, and have been aligned with the requirements and recommendations specified by the regulator (DNRM and DEHP) in the Terms of Reference for the BNCOP Operational Area. This has ensured all information and outcomes from the project satisfy expected requirements for contemporary resource industry EIS assessment in Queensland.

Mapping methodology

Preliminary photo interpretation incorporating geological mapping, DEM analysis, landscape features and pre-clearing soil–vegetation photo patterns (1952) was used to delineate potential soil type changes within the investigation area. Proposed field sampling locations were selected during this process. Preliminary linework boundaries were verified and/or adjusted during fieldwork and final linework was scanned and digitized in GIS following completion of fieldwork. Based on available time and resources, the degree of landscape complexity and the outcomes required from the project a final published mapping scale of 1:25000 was considered appropriate to meet the technical requirements specified in the BNCOP EIS Terms of Reference. Fieldwork site intensities reflect the investigation density required to validate mapping at this scale. Maps included with the report have been reduced to a scale of 1:40000 for presentation purposes only.

Mapping at 1:25000 scale requires a minimum recommended ground observation density of 1 site/12.5 ha. This equates to approximately 235 field observations across the 2013 BNCOP Soil Investigation survey area (2970ha). At large mapping scales such as 1:25000, McKenzie *et al* (2008) recommend data collection include both detailed soil profile descriptions (about 35% of observations) and representative sampling sites for laboratory analysis (about 5% of observations), but with an emphasis on map boundary observations (about 60% of observations) to accurately delineate soil changes on the ground. As such, predicted data requirements within the BNCOP Soil Investigation survey area (2970ha) necessitated a minimum of at least 83 detailed soil profile descriptions, 12 fully analysed representative sample sites and up to 143 map boundary observations (captured by GPS and recorded as brief field description notes for direct incorporation into final linework) to meet minimum recommended site densities.

Completed survey statistics from the field investigation are presented in the tables below and confirm completed ground observation densities surpass the minimum mapping requirements of McKenzie *et al* (2008) for detailed soil mapping at a scale of 1:25000. Fieldwork was targeted during the survey program to ensure the relative representation of detailed and analysed representative sites within the BNCOP Disturbance Footprint and associated SCL trigger area was sufficient to guarantee the quality, reliability and robustness of soil data in areas earmarked for ground disturbance and/or SCL validation. Australian map grid co-ordinates (GDA94) for all detailed field site locations (Sites 1-113) are presented in **Appendix 1**.

Recommended and actual survey statistics for the 2013 BNCOP Soil Investigation survey area

Minimum recommended observations McKenzie *et al* (2008)	**Detailed sites (35%)**	**Rep. sample sites (5%)**	**Mapping obs. (60%)**	**Total (100%)**
2013 BNCOP survey area (2970ha)	83	12	143	238
BNCOP Disturbance Footprint (1486ha)	42	6	71	119
SCL trigger area (118ha)	3	1	6	10

Actual ground observations completed	**Detailed sites (35%)**	**Rep. sample sites (5%)**	**Mapping obs. (60%)**	**Total (100%)**
2013 BNCOP survey area (2970ha)	97 (32%)	16 (6%)	188 (62%)	301 (100%)
BNCOP Disturbance Footprint (1486ha)	44 (32%)	14 (10%)	81 (58%)	139 (100%)
SCL trigger area (118ha)	6 (40%)	5 (33%)	4 (27%)	15 (100%)

While gross soil distribution was relatively predictable across much of the investigation area, localised soil complexity associated with subtle lithological or weathering variations, depth of colluvial cover and localised drainage characteristics required greater ground observation densities in some areas than predicted. This was particularly the case with relict alluvium in landscape 7 and the sedimentary rocks of landscapes 8 and 9. During fieldwork, map boundary observations were recorded either as brief field notes or as annotations on field maps. Where landscapes or soil distributions were complex (and time and resources allowed), detailed field descriptions and representative sampling in excess of the minimum requirements were undertaken.

Experience with similar unconsolidated and insitu sedimentary landscapes elsewhere in the Bowen Basin (Burgess 2003a, 2003b; SMM 2010a, 2010b) mean completed site intensities are considered adequate to fully understand and investigate the soil catenary relationships occurring within the investigation area. The presence of remnant vegetation in some areas, distinct landform/lithological changes and clearly recognizable soil - vegetation relationships from pre-clearing aerial photography greatly increased the efficiency and reliability of field mapping.

Field descriptions

All field descriptions were collected in accordance with standards outlined by the National Committee on Soil and Terrain (2009), Hnatiuk *et al* (2009) and Isbell (1996). Field observations recorded included geology/parent material, landform (pattern and element), slope, relief/modal slope class, substrate lithology, site disturbance, erosion, microrelief, surface rock, surface condition, dominant vegetation (tallest, mid and lower strata where important) detailed soil profile morphology, site drainage and permeability characteristics. Field assessment of soil profile morphology included description of soil horizons, boundaries, texture, colour, mottling, bleaching, structure, consistence, gravel, segregations and substrate material (where present); as well as field assessment of sodicity, dispersive behaviour and pH.

Soil profiles were examined and described from 75mm intact (or augered soil cores where access was limited) to a depth of 1.5m; or to depth of hard rock or impenetrable gravel where shallower. Soil cores were described in detail and sampled in the field. Representative sites for subsequent laboratory analysis to determine physical and chemical characteristics were selected post fieldwork. Where gilgai were present, mounds were preferentially described and sampled because of their potentially larger relative contribution to final stripping volumes and typically shallower depth to saline/sodic subsoil materials. Previous work in Central Queensland has shown conclusively that subsoil constraints such as inherent salinity, elevated sodicity and undesirable dispersive behaviour are far more limiting and at shallower depths in mound profiles (Burgess 2003a, 2003b). Investigation of mound characteristics is critical therefore to successfully determine potential stripping reserves.

Sampling program

Sampling of surface soil and subsoil materials at standard depth intervals (0-0.1m, 0.25-0.35m, 0.55-0.65m, 0.85-0.95m and 1.15-1.25m, plus selected intermediate depths where required) was undertaken during the course of field investigations at all detailed field sites. Following the completion of fieldwork and finalization of mapping units, at least one representative site from all spatially dominant soil landscapes was selected for laboratory analysis. In all, 85 sample depths from 17 representative field sites were submitted for analysis (BNCOP field sites – 27, 29, 30, 36, 38, 40, 43, 65, 66, 69, 71, 74, 87, 88, 90, 99 and 110). All sites were sampled at 0.1m increments to a maximum depth of 1.25m (or depth to hard rock or other impenetrable layer where shallower). Sample depths selected for analysis at each representative site were chosen to characterize the range of materials present within the profile. Sampling intervals were correlated with soil profile descriptions and altered where necessary to allow for thin surface horizons (if important) and to ensure sampling depths did not compromise major subsoil horizon boundaries (Baker and Eldershaw 1993).

Laboratory analyses

In any soil investigation, laboratory analyses are required to reliably quantify the quality of topsoil and subsoil materials for salvage, establish the depth and nature of unsalvageable materials and to calculate soil parameters/attribute values required for pre-mining land suitability, SCL and erosion potential assessments. As such, a range of physical and chemical laboratory analyses were undertaken on surface and subsoil samples from each representative site. Analytical data collected at selected depths within each profile included pH, electrical conductivity (EC), soluble chloride (Cl), cation exchange capacity (CEC), exchangeable cations (Ca, Mg, Na, K), exchangeable sodium percentage (ESP), dispersive behaviour (R1), particle size analysis (clay, silt and sand fractions), clay mineralogy/clay activity and fine sand/silt fractions (%). In addition, surface soil fertility (Total Nitrogen (%), Available Phosphorous (ppm), Exchangeable Calcium (meq/100g) and Exchangeable Potassium (meq/100g)) was measured from bulk 0-0.1m samples at each representative site. A brief explanation of the analyses undertaken and the use and interpretation of the data is presented in **Table 1**.

Prior to sample submission for representative characterization and specific SCL analyses, laboratory pH $_{1:5}$ and EC $_{1:5}$ measurements were undertaken on samples at standard depth intervals (0.1m, 0.3m, 0.6m, 0.9m and 1.2m plus selected intermediate depths where required) from all 113 field sites to provide a low cost, comprehensive set of screening data with a spatial distribution spanning the entire 2013 BNCOP Soil Investigation survey area. Salt profiles generated from $EC_{1:5}$ measurements provide valuable information about leaching characteristics and subsoil salt loads across the landscape, and are particularly useful when determining effective rooting depth (ERD) or formulating practical stripping depths that are spatially relevant. $pH_{1:5}$ and EC $_{1:5}$ results for all sites and depths are presented in **Appendix 2**. Effective rooting depth (ERD) and plant available water capacity (PAWC) estimates are presented for soils mapped within the BNCOP Disturbance Footprint in **Appendix 3.** These estimates use a combination of salinity screening data and morphological field data (horizon depths and field texture ranges) in their calculation (DNRM 2011d, Queensland Government 2011).

Using pH and EC screening data to guide sample selection, a total of 17 representative sites (27, 29, 30, 36, 38, 40, 43, 65, 66, 69, 71, 74, 87, 88, 90, 99 and 110) were selected for full laboratory characterization and samples from depth ranges corresponding to surface soil (0-0.1m), upper subsoil (0.25-0.35m and 0.55-0.65m) and lower subsoil/substrate where present (0.85-0.95m ± 1.15-1.25m) were submitted for analysis. Standard depths were sampled to enable direct comparison of analytical results between sites. All samples were air dried at 40^0C and ground and sieved to <2mm prior to analysis. All analytical results are expressed on an air dry basis unless otherwise indicated.

All laboratory analyses (ph, EC, Cl, CEC/cations, ESP, PSA, R1 dispersion, Organic C, Total N, Bicarb. P, Exch. Ca and Exch. K) performed on samples from the 17 representative sites were undertaken by the Agricultural Chemistry Pty Ltd Laboratory in Ipswich, near Brisbane. This is an ASPAC accredited laboratory with extensive experience in agricultural soil and water testing for government and industry. Methodologies used by this laboratory are outlined in **Table 1** and **Appendix 4** and follow the procedures described by Rayment and Lyons (2011) and McKenzie *et al* (2002). Detailed descriptions of the methods are available from the ACLEP laboratory handbooks *Soil Chemical Methods - Australasia* (Rayment and Lyons 2011) and *Soil Physical Measurement and Interpretation for Land Evaluation* (McKenzie *et al* 2002). Additional pH $_{1:5}$ and EC $_{1:5}$ analyses completed on samples from all 113 field sites were undertaken by B.R. Emmerton Pty Ltd and follow the procedures described for Standard Methods 4A1 and 3A1 in Rayment and Lyons (2011). Interpreted analyses from selected depths have been correlated with recorded soil horizons at each site to quantify the characteristics, depth and thickness of surface soil and subsoil/substrate materials present in each soil. Completed analytical data for all representative sites and depths are presented in **Appendix 5**. Field data recorded at each of the 17 representative sites (particularly horizon depths and nomenclature, field texture, bolus behaviour and structure), is presented in **Appendix 6**. Assessment criteria defined by Baker and Eldershaw (1993), Bruce and Rayment (1982), Peverill *et al* (1999), Burgess (2003a, 2003b) and QDME (1995) have been used to rate the analytical data collected during the investigation.

SCL Zonal Criteria within the Western Cropping Zone (WCZ) require sampling and analysis of 0.3m and 0.6m depth intervals for **$pH_{1:5}$** and **soluble Cl (ppm)** at all detailed field sites within areas triggered for SCL assessment. Sites sampled and analysed from triggered lands within the BNCOP Disturbance Footprint include Sites 65, 66, 67, 68, 69, 70, 71, 72, 73, 74 and 75. The data is requirement of the legislation and is necessary to satisfy regulatory provisions associated with compliance for WCZ Zonal Criteria 6 and 7.

Table 1. Explanation of laboratory analyses undertaken on surface soil and subsoil samples from representative sites

Laboratory analyses	Use and interpretation of data
Cation chemistry	
Cation Exchange Capacity (CEC/ECEC meq/100g)	• CEC is a measure of a soils capacity to retain cations based on the surface area and surface charge of the clay fraction. Influences physical and chemical properties particularly in the clay subsoil
Exchangeable Calcium (meq/100g)	• Measure of the amount of Ca on the clay exchange complex
Exchangeable Magnesium (meq/100g)	• Measure of the amount of Mg on the clay exchange complex
Exchangeable Sodium (meq/100g)	• Measure of the amount of Na on the clay exchange complex
Exchangeable Potassium (meq/100g)	• Measure of the amount of K on the clay exchange complex
Ca/Mg ratio	• Measure of the relative dominance of magnesium, useful in explaining soil physical behaviour
Clay Activity Ratio (CEC/clay %)	• Used to infer clay mineralogy and reactivity of the clay fraction.
Sodicity and dispersion	
Exchangeable sodium % (ESP)	• Measure of soil sodicity, which affects the physical behaviour (permeability/density/strength) and dispersive nature of soils. ESP measures the relative abundance of Na on the exchange complex
Dispersion ratio (R1)	• Measure of soil dispersion based on the amount of dispersed silt and clay during testing compared with total silt and clay levels
pH and salinity	
pH (1:5 soil/water)	• Measure of the acidity or alkalinity of soil material
Electrical Conductivity (EC)(1:5 soil/water)	• Estimate of the concentration of total soluble salts in the soil solution
Soluble Chloride (Cl) (mg/kg)	• Measure of the level of soluble Cl in the soil solution. Provides a direct estimate of the soluble NaCl salt concentration in the soil solution.
Particle size analysis (PSA)	
% Coarse sand (0.2 - 2mm)	• Visible sand range, open pore spaces, friable, permeable
% Fine sand (0.02 – 0.2mm)	• Non-visible sand, causes packing, increased density, intractable, “bulldust”, hardsetting, erodible
% Silt (0.002 - 0.02mm)	• Causes increased packing and density, highly erosive fraction, surface sealing, intractable, dilatancy, “bulldust”, hardsetting
% Clay (< 0.002mm)	• Colloidal fraction, determines CEC, moisture holding capacity, shrink-swell characteristics, soil structure and cracking behaviour
Surface soil fertility	
Organic Carbon (%C)	• Provides an estimate of the total store of carbon (C) in the surface soil and can be used in surrogate calculations to estimate organic matter (OM%)
Total nitrogen (%N)	• Provides an estimate of the total store of nitrogen (N) in the surface soil that can potentially be mineralised
Bicarbonate extractable phosphorus (mg/kg P)	• Provides a reliable and consistent estimate of plant available phosphorus (P) in the surface soil across a range of pH conditions
Exchangeable Calcium (meq/100g Ca)	• Provides an estimate of the relative abundance of potentially available calcium (Ca/CEC %) within the fine earth fraction in the surface soil
Exchangeable Potassium (meq/100g K)	• Provides an estimate of the relative abundance of potentially available potassium (K/CEC %) within the fine earth fraction in the surface soil

Topsoil stripping assessment

Multi stage stripping and replacement is widely recognized as best management practice for the salvage and reuse of soil/rehabilitation media from areas of mining disturbance. Accordingly, stripping recommendations from the current investigation are presented on a two stage preferred basis. For the purposes of this report, surface materials to be stripped during a two stage process will be referred to as **topsoil**, while additional subsoil resources that may be suitable for salvage will be referred to as **root zone material**.

In practice, two stage stripping involves the removal and subsequent reinstatement of the most biologically active topsoil material separately from the underlying root zone material. Two stage removal and replacement is recommended because it better mimics natural soil systems, minimizes the surface presentation of detrimental or unmanageable materials, optimizes surface physical conditions and enhances the utilization of natural seed sources that may be present.

It is recognized however, that **single stage stripping,** which involves the salvage of maximum quantities of useable soil material, irrespective of its source depth, is often the preferred stripping methodology for many mines. As such, recommendations for single stage stripping outlining one off salvage depths for the retrieval of all useable materials are also presented. It is important to note, that single stage stripping by its very nature will result in greater mixing of discordant materials and a dilution of soil quality. When compared with two stage reinstatement, single stage material will be subject to slower infiltration and higher runoff rates, with plant establishment typically slower and less successful overall.

Analytical criteria and ratings used in the evaluation of stripping criteria presented below have been adapted from those reported by Burgess (2003a, 2003b) and Baker and Eldershaw (1993) for the assessment of soil data in inland Central Queensland.

1. Two stage stripping – topsoil material

The following generalized goals apply when determining the suitability of topsoil materials for salvage and subsequent surface reinstatement on reshaped spoil. Suitable **topsoil material** should ideally conform to most, if not all, of the following characteristics:

- represent that part of the natural soil profile with maximum biological activity and seed source potential (i.e. immediate surface soil);
- have a particle size distribution that is dominated either by the coarse sand fraction or alternatively an active clay fraction; preferably with limited fine sand and/or silt fractions;
- have a pH range appropriate for plant growth;
- be characterized by non-sodic/non-dispersive physical behaviour (particularly clays); and
- have very low levels of soluble salts.

Materials conforming to these general principles would typically be considered appropriate for salvage as topsoil during two stage stripping operations. In cases where materials are suitable except for elevated fine sand/silt fractions, salvage may still be possible but reinstatement will be restricted to very low slope angles because of increased runoff and erosion risk.

2. Two stage stripping – root zone material

Generalized goals for determining the suitability of subsoil materials for salvage as **root zone media** differ somewhat. During the two stage stripping process, root zone materials are specifically salvaged for the purpose of constructing a surrogate subsoil cover over reshaped spoil prior to final topsoiling. Suitable root zone material should ideally conform to most, if not all, of the following characteristics:

- have a particle size distribution that is dominated either by the clay loam fraction or clay fraction; preferably with limited fine sand and/or silt fractions;
- have a pH range appropriate for plant growth;
- have a non-sodic (optimal) to weakly sodic (acceptable) clay fraction;
- be characterized by non-dispersive (optimal) or low to moderately dispersive (acceptable) physical behaviour, particularly where clay materials are being considered for stripping; and
- have very low (optimal) to moderate (acceptable) levels of soluble salts.

Materials conforming to these general principles would typically be considered appropriate for salvage as root zone material during two stage stripping operations. In cases where materials are suitable except for elevated fine sand/silt fractions, salvage may still be possible but reinstatement will be restricted to lower slope angles because of reduced permeability and increased erosion risk.

3. Single stage stripping – topsoil and/or subsoil material

The primary objective with single stage stripping is the one off salvage of maximum volumes of useable material, irrespective of original soil depth or origins (i.e. salvage of all suitable topsoil, subsoil and/or substrate material in one operation). Typically, surface soil and subsoil materials with differing characteristics are not kept segregated and are subject to significant mixing during stripping operations. Because any of the stripped material, whether topsoil or subsoil, can potentially be exposed as final surface cover on reshaped spoil, all materials to be salvaged should have characteristics capable of supporting this use. For these reasons, generalized goals for single stage stripping are similar in many ways to those presented above for topsoil materials under two stage stripping. Materials to be stripped during single stage operations should ideally conform to most, if not all, of the following characteristics:

- have a particle size distribution that is dominated either by the coarse sand fraction or active clay fraction; preferably with limited fine sand and/or silt fractions;
- have a pH range appropriate for plant growth;
- be characterized by non-sodic/non-dispersive physical behaviour, (particularly clays); and
- have very low levels of soluble salts.

Materials conforming to these general principles would typically be considered appropriate for salvage during single stage stripping. In cases where materials are suitable except for elevated fine sand/silt fractions, salvage may still be possible but reinstatement will be restricted to very low slope angles because of increased runoff and erosion risk.

Whilst these goals provide a useful framework for selecting soil materials for salvage, the reality in many situations is that the only available resources are inferior with behavioural characteristics that are less than optimal. In such cases, relaxation of stripping guidelines may be necessary to ensure quantities of salvaged topsoil and root zone media are sufficient to service the mines rehabilitation requirements. Careful identification of the limitations and undesirable attributes associated with inferior soil resources is essential however, to ensure only the most appropriate media are selected, and that such materials are used in accordance with their capability (i.e., capable of sustaining the end use to which they are put).

Pre-mining land suitability assessment

Pre-mining land suitability for soils within the BNCOP Disturbance Footprint has been assessed for dryland cropping and grazing (the dominant existing land uses in the local area) to establish a record of the agricultural potential of the land prior to disturbance or development. The assessment has utilised spatially accurate mapping (1:25000) and detailed soil attribute data, and follows the suitability methodology defined by the Queensland Government (DNRM/DSITIA 2013a, 2013b), in accordance with the requirements of the BNCOP Terms of Reference. All explanation, terminology and abbreviations used in the land suitability assessments presented come directly from or are consistent with QDME (1995), Isbell (1996), McKenzie *et al* (2002), Mckenzie *et al* (2008), the NCST (2009), Rayment and Lyons (2011), DNRM (2011d) and DNRM/DSITIA (2013a, 2013b).

Land suitability assessment for dryland cropping within the BNCOP Disturbance Footprint follows the framework, methodology, criteria and decision rules (without change or addition) described in the documents:

- *Guidelines for Agricultural Land Evaluation in Queensland*, Second edition (2013a). DNRM/DSITIA, Queensland Government, Brisbane, Queensland; and
- *Regional Land Suitability Frameworks for Queensland*, *Chapter 10 - Suitability framework for the Inland Fitzroy and Southern Burdekin area* (2013b). DNRM/DSITIA, Queensland Government, Brisbane, Queensland.

Whilst the framework itself has not been reproduced as part of this report the dryland cropping suitability assessment tables presented later in this document provide a clear record of the limitations, attributes and subclass rules used in the assessment.

Land suitability assessment for grazing within the BNCOP Disturbance Footprint follows the framework, methodology, criteria and decision rules (without change or addition) described in the document:

- *Technical guidelines for Environmental Management of Exploration and Mining in Queensland* (1995). Queensland Department of Mines and Energy (QDME), Brisbane, Queensland.

The limitations, attribute values and suitability subclass rules for grazing suitability presented originally in "A*ttachment 2*" from the "*Land Suitability Assessment Techniques*" section within the "*Technical guidelines for Environmental Management of Exploration and Mining in Queensland"* (QDME 1995) are reproduced without change or addition in **Appendix 8** of this report.

Both suitability frameworks present limitations, attribute values and subclass rules appropriate for assessing the agricultural potential (either dryland cropping or grazing) of lands within inland Central Queensland. The schemes use a standard land suitability framework (DNRM/DSITIA 2013a) with a common set of attributes/limitations, but separate decision rules for each land use.

Five land suitability classes are defined for use in Queensland (DNRM/DSITIA 2013a), with land suitability decreasing progressively from Class 1 to Class 5. These classes are used to describe an area of land in terms of suitability for a particular land use which allows optimum, sustainable production with current technology, while minimising degradation to the land resource in the short, medium or long-term. Land is considered less suitable as the severity of limitations affecting a particular land use increases, reflecting either:

- reduced potential for production and/or;
- increased inputs required to achieve an acceptable level of production and/or;
- increased inputs required to prepare the land for successful production and/or;
- increased inputs required to prevent land degradation.

The five land suitability classes defined for Queensland are:

Class 1	**Suitable land with negligible limitations.** This is highly productive land requiring only simple management practices to maintain economic production.
Class 2	**Suitable land with minor limitations** which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production.
Class 3	**Suitable land with moderate limitations** which either further lower production or require more than the management practices of Class 2 land to maintain economic production.
Class 4	**Marginal land, which is presently considered unsuitable due to severe limitations**. The long term significance of these limitations on the proposed land use is either unknown or currently not quantified. The use of this land is dependent upon undertaking additional studies to determine whether the effect of the limitation(s) can be reduced to achieve sustained economic production.
Class 5	**Unsuitable land with extreme limitations** that preclude its use.

Classes 1, 2 and 3 are considered suitable for a specified land use, as the benefits from using the land for that use in the long term should outweigh the inputs required to initiate and maintain production. **Class 4 land is regarded as marginal (currently unsuitable)** for a specified land use, due to the severity of one or a number of limiting factors. It is probable that the inputs required to achieve and maintain production in the long-term will outweigh the benefits. Class 4 land may sometimes be upgraded to a suitable class in cases where future agronomic, soil or engineering advances make production economically viable and environmentally sustainable. Changes in climate, economic conditions, or technology may significantly alter the level of management inputs required to achieve satisfactory productivity on Class 4 lands.

Class 5 land is regarded as unsuitable for a specified land use because it has limitations that singularly or in aggregate are so severe that the benefits would not justify the inputs required to initiate and maintain sustainable production in the long term. It would require a major change in economics, technology or management expertise before Class 5 land could be considered suitable. However, some Class 5 land such as mountains, deeply incised landscapes and steep escarpments, will always remain unsuitable for agriculture.

DNRM/DSITIA (2013a) have defined a set of Queensland wide land use requirements for dryland cropping, that relate to plant growth, machinery use, land preparation, irrigation and the prevention of land degradation (where relevant); while QDME (1995) have defined a similar set for grazing. To assess the suitability of any parcel of land for a particular land use, it is necessary that each of the relevant land use requirements be considered. Attributes of land which cause the specified land to have less than optimal conditions for a particular use are known as limitations. Management is concerned with overcoming or reducing the effects of such limitations.

In inland Central Queensland, where dryland cropping and grazing are the predominant land uses, a total of 8 land use requirements and associated limitations (E, Es, M, Pm, Ps, R, Tm, W) have been identified as important for dryland cropping by the Inland Fitzroy - South Burdekin Region suitability framework (DNRM/DSITIA 2013b); while for grazing QDME (1995) recognises a total of 13 land use requirements and associated limitations (E, M, Ps, R, Tm, W, Nd, Sa, Tg, F, V, pH, ESP). A brief outline of the combined dryland cropping and grazing requirements and associated limitations relevant to inland Central Queensland are listed below.

Land use requirements		Limitations	Soil and land attributes used to assess each limitation
1.	Minimum soil loss from erosion	water erosion (E)	slope/surface soil stability group combinations
2.	Minimum soil loss from erosion	erosion hazard (Es) - subsoil erodibility	slope/subsoil stability group combinations
3.	Adequate water supply	water availability (M)	PAWC, ERD (including effects of subsoil sodicity and inherent salinity), deep drainage losses, infiltration rate, crop modelling
4.	Soil workability, suitable timing for cultivation	narrow moisture range (Pm)	surface condition, surface soil texture, surface soil drainage
3.	Ease of seedbed preparation and plant establishment	surface condition (Ps)	surface soil structure, surface condition, surface soil texture
6.	Rock-free	rockiness (R)	size and content (%) of coarse fragments, % rock outcrop
7.	Level land surface	microrelief (Tm)	size and frequency of microrelief, % land surface
8.	Adequate soil aeration	wetness (W)	field based soil drainage and permeability classes
9.	Adequate nutrient supply	nutrient deficiency (Nd)	surface soil (0.1m) levels of Bicarb P (ppm), vegetation surrogate for Total N (%)
10.	Salinity free root zone	root zone salinity (Sa)	average salinity within the root zone (ERD)
11.	Trafficable, stable land surface	topography (Tg)	size, depth and frequency of gullies
12.	Absence of damaging floods	flooding (F)	frequency of flooding based on average recurrence interval (ARI)
13.	Absence of undesirable vegetation	vegetation (V)	vegetation type, regrowth potential, potential for shrubby thickening, soil fertility
14.	Non limiting surface soil pH	surface soil pH (pH)	surface soil pH suitable for pasture growth (4.5-9.0)
15.	Absence of surface soil dispersion	surface soil dispersive potential (ESP)	surface soil ESP <15

The **suitability classification defined by DNRM/DSITIA (2013b) for dryland cropping** evaluates the potential of land to grow a range of broadacre summer and/or winter crops (predominantly sorghum, wheat and other equivalent broadacre crops) under rainfed conditions within the Inland Fitzroy and Southern Burdekin Region. It assesses soil and land based limitations that may impact on production and assigns a final suitability class based on the most limiting factor. For the purposes of the classification, dryland cropping in inland Central Queensland is defined as summer or winter cropping that is fallow dependent, subject to highly variable/unreliable seasonal rainfall (particularly for planting opportunities) and is grown almost entirely on stored moisture. Cropping systems are largely opportunistic and the actual crops planted are dependent upon the timing and variability of rainfall, as well as previous cropping history and fallow management. The limitations, associated soil and land attributes and limitation subclasses used in the assessment of dryland cropping suitability in this investigation have been implemented (without change or addition) directly from the published DNRM/DSITIA (2013b) framework for the Inland Fitzroy and Southern Burdekin Region.

The **suitability classification defined by QDME (1995) for grazing** evaluates soils in terms of the potential to graze and finish cattle on improved pastures. It assesses a range of soil or land based limitations that either affect the establishment of improved pastures or impact directly on the grazing productivity of the land (predominantly soil fertility based). Typically, grazing systems in inland Central Queensland aim to produce finished, grassfed cattle, without inputs other than pasture development. The limitations, associated soil and land attributes and limitation subclasses used in the assessment of grazing suitability in this investigation have been implemented (without change or addition) directly from the published QDME (1995) framework for Central Queensland.

It is important to note that the QDME scheme (1995) specifies a maximum ERD (in the absence of rock or salinity >800ppm Cl) of 0.6m for pasture growth in grazing situations. However, PAWC sub-class values for the assessment of moisture availability in grazing situations (described in Table 2.2 of the original QDME (1995) scheme) are presented on a per 1.0m soil basis. Sub-class cut-offs and moisture availability ranges have been re-calculated on a 0.6m basis and adjusted accordingly. As a result, PAWC cut-off values used to rate moisture availability for grazing suitability of individual soils in the current study represent only 60% of those originally presented (i.e. on a 1.0m soil depth basis in Table 2.2 of the QDME (1995) scheme).

Pre-mining Agricultural Land Class (ALC) assessment

Agricultural Land Class status (ALC) has been assessed using ALC criteria and rules relevant to Central Queensland as defined by:

- *State Planning Policy 1/92: Development and the Conservation of Agricultural Land.* (1992). Queensland Government, Brisbane, Queensland;
- *Planning Guidelines: The identification of Good Quality Agricultural Land* (1993). Department of Primary Industries and Department of Housing and Local Government and Planning, Brisbane, Queensland; and the
- *Guidelines for Agricultural Land Evaluation in Queensland*, Second edition (2013a). DNRM/DSITIA, Queensland Government, Brisbane, Queensland.

Agricultural Land Classification (ALC) in Queensland has recently been revised (DNRM/DSITIA 2013a) and now follows a simple, consistent hierarchical scheme that is applicable across the State. Adoption of the new classification allows the standardized re-interpretation of complex and detailed land suitability data to more simply identify agricultural land that is capable of being used sustainably for a wide range of uses with a minimum of land degradation. As such, it provides a concise and meaningful statement about the status and extent of recognised Agricultural Land prior to disturbance.

Three classes of agricultural land and one class of non-agricultural land are defined for Queensland (DNRM/DSITIA 2013a):

- Class A – Crop land;
- Class B – Limited crop land;
- Class C – Pasture land; and
- Class D – Non-agricultural land.

The classes indicate a decreasing range of land use choice, an increasing level of land use limitations and an increasing land degradation hazard. The classification is hierarchical, with crop land having the greatest potential for the production of the widest array of produce through to non-agricultural land which is unsuitable for any type of agricultural pursuit. Definition of Agricultural Land Classes A, B, C and D as described by DNRM/DSITIA (2013a) are summarised below:

Agricultural Land Class (ALC)	Definition and description
Class A – Crop Land	• Land that is suitable for a wide range of current and potential crops with nil to moderate limitations to production.
Sub-class – A1	• Land that is suitable for a wide range[1] of current and potential broadacre and horticulture crops with limitations to production that range from none to moderate levels.
Sub-class – A2	• Land that is suitable for a wide range of current and potential horticultural crops only, with limitations to production that range from none to moderate levels.
Class B – Limited Crop Land	• Land that is suitable for a narrow range[2] of current and potential crops. Land that is marginal for current and potential crops due to severe limitations, but is suitable for pastures. Land may be suitable for cropping with engineering and/or agronomic improvements.
Class C – Pasture Land	• Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment.
Sub-class – C1	• Suitable for grazing sown pastures (with ground disturbance for establishment); or native pastures on higher fertility soils.

Agricultural Land Class (ALC)	Definition and description
Sub-class – C2	• Suitable for grazing native pastures with or without the introduction of pasture species; lower fertility soils than C1.
Sub-class – C3	• Suitable for light grazing of native pastures in accessible areas; includes steep land more suited to forestry/catchment protection.
Class D – Non-Agricultural Land	• Land not suitable for agricultural uses due to extreme limitations. Includes undisturbed land with significant conservation and/or catchment values; or land that is unsuitable because of very steep slopes, shallow soils, rock outcrop, poor drainage, salinity, acidity or severe degradation; also includes stream beds, channels, water bodies and disturbed lands (e.g. urbanised, industrial, mining voids, quarries, aquaculture and feedlots).

Note 1. A wide range of crops is defined as four or more existing crops of local commercial significance. In areas where there is an infrastructure requirement to support an industry, the land need only be suitable for two or more crops, providing the crop is considered to be a regionally significant crop.

Note 2. A narrow range of crops is defined as three or less existing crops of local commercial significance, with the exception of areas where there is an infrastructure requirement to support an industry.

Class A – Crop Land (DNRM/DSITIA 2013a) is defined as any soil for which the number of suitable crops (i.e. suitability classes 1, 2 and 3) exceeds 4 or more. Further sub-division of Class A to distinguish between broadacre cropping (Class A1 – Crop Land) and horticultural cropping (Class A2 – Crop land) has not been required within the BNCOP Disturbance Footprint because horticultural production is not practised in the Baralaba area.

Soils that are suitable for 3 or less crops, or have been assessed as marginal for dryland cropping (Class 4), are classified as **Class B – Limited Crop Land** (DNRM/DSITIA 2013a); except in cases where a crop of regional significance with specific infrastructure requirements is locally important. No crops of regional significance are relevant to lands within the BNCOP Disturbance Footprint.

Class C – Pasture Land is defined in terms of grazing suitability outcomes and 3 pasture land sub-divisions are recognised that reflect differences in inherent fertility, pasture type and carrying capacity (DNRM/DSITIA 2013a); namely

- Class C1 – Pasture Land which is suitable for beef cattle fattening and/or growing out younger cattle (grazing suitability Classes 1-3);
- Class C2 – Pasture Land which is suitable for year round breeding herd utilization (grazing suitability Class 4); and
- Class C3 – Pasture Land which is restricted to seasonal grazing use, limited geographical access or capable of only very low stocking rates (grazing suitability Class 5).

Class D non-agricultural land is defined as undisturbed land with significant conservation and/or catchment values and includes land too steep, rocky, wet, flooded or degraded to be used for any agricultural purpose. Class D land has not been identified within the BNCOP Disturbance Footprint.

Assessment of ALC status within the BNCOP Disturbance Footprint has utilised the detailed land suitability findings for dryland cropping and grazing presented in this investigation. ALC assessment follows the methodology and conventions prescribed by DNRM/DSITIA (2013a), without change or addition, and provides an accurate and succinct summary as to the pre-mining agricultural potential of lands present within the project area prior to disturbance. ALC outcomes for the BNCOP Disturbance footprint are presented later in this report. Findings for the already approved Baralaba/Wonbindi North Mine Lease (ML80169 and ML80170) have been previously presented by NQSA (2011a) and are not re-presented or discussed as part of this report.

Strategic Cropping Land (SCL) assessment

Within the wider 2013 BNCOP Soil Investigation survey area only those parts intersected by both the BNCOP EIS Operational Area boundary and the state wide Strategic Cropping Land (SCL) trigger mapping (DNRM 2011a) are triggered for SCL assessment. Triggered areas that lie within the western section of the BNCOP EIS Operational Area (i.e. already approved Baralaba/Wonbindi North Mine Lease – ML80169 and ML80170) have been previously mapped and assessed by NQSA (2011a, 2011b). Findings from these studies have been the subject of previous SCL mitigation and they are not considered further or re-presented as part of this report. Only triggered land within the BNCOP Disturbance Footprint, lying to the east of (but adjacent to) the previously mitigated lands within ML80169 and ML80170, has been assessed for SCL status during the current investigation.

Strategic Cropping Land (SCL) data collection methodology

The SCL analysis presented in this report has used detailed soil profile data, representative analytical data and large scale soil mapping (1:25000 scale) collected in accordance with recognized standard land resource survey methodologies and analytical procedures (Isbell 1996; McKenzie *et al* 2002; McKenzie *et al* 2008; National Committee on Soil and Terrain 2009 and Rayment and Lyons 2011). In addition, all recorded field data, measured analytical data and calculated parameters for triggered lands have been collected in accordance with the procedures prescribed by DNRM for SCL assessment as at December 2013 (DNRM 2011b, DNRM 2011d, Queensland Government 2011) and are consistent with all necessary data requirements.

It is important to note that field site and sampling locations selected during 2013 fieldwork were carefully chosen to best represent the soil landscapes being investigated within the BNCOP Disturbance Footprint. While SCL Zonal Criteria, guidelines and legislation were taken into consideration during this process, final field site selection was based predominantly on aerial photo-interpretation, DEM characteristics, mapping scale, site intensity requirements and on-ground variability. In addition to prescribed SCL data requirements, site selection and sampling regimes focused on characterization of soil attributes that would inform stripping recommendations, land suitability evaluations and inherent erosion potential assessments (both inside and outside of the triggered land).

As such, sites did not specifically target the presence or absence of flatter landscapes ≤3% (SCL Zonal Criteria 1), localised surface rockiness (SCL Zonal Criteria 2) or gilgai microrelief (SCL Zonal Criteria 3). Site locations were selected in all cases to be as representative as possible of the soils and landscapes being mapped, while still addressing the necessary data requirements listed in the BNCOP EIS Operational Area Terms of Reference. As a result, soil data relevant to SCL assessment within the BNCOP Disturbance Footprint in some cases, comes from sites that are located nearby or adjacent to (but effectively outside) areas of mapped SCL potential. Irrespective, it is the contention of this report that the scale, robustness and integrity of the baseline soil investigation means that all data collected and presented is entirely consistent with and relevant to the prescribed requirements for SCL assessment in Queensland, and should be considered both representative and appropriate for such purposes.

All field, laboratory and assessment methodologies employed during the study were in accordance with recognized industry standards. In addition, they meet the requirements for assessment of Strategic Cropping Land (SCL) status as defined by the *Strategic Cropping Land Act 2011* (Queensland Government 2011); and also all methodology/data provisions articulated in the BNCOP Operational Area EIS Terms of Reference. Compliance with all the requisite methodologies listed has ensured collection and documentation of the information and findings used to assess SCL status within the BNCOP Disturbance Footprint are robust and in accordance with expected outcomes for contemporary SCL assessment in Queensland. Relevant morphological and analytical soil profile data used in SCL calculations and criteria compliance assessments are presented in full in **Appendices 2-7** and summarised in the **Soil Characterization Section** of this report.

Strategic Cropping Land (SCL) zone and trigger mapping status

The BNCOP Disturbance Footprint (excluding ML80169 and ML80170) lies within the **Western Cropping Zone (WCZ)** of the **Strategic Cropping Management Area** (DNRM 2011a, DNRM 2011c). SCL trigger mapping from the DNRM website 2013 (DNRM 2011a) has been used to identify areas of 'likely' (or potential) SCL that will be triggered by the project. The ***Strategic Cropping Land Act 2011*** (Queensland Government 2011), requires any such triggered areas be assessed for relevant Cropping History (Queensland Government 2011, DNRM 2012), and also against WCZ SCL Zonal Criteria 1-8 before final SCL status can be determined.

Strategic Cropping Land (SCL) assessment process

SCL assessment for triggered land within the BNCOP Disturbance Footprint has involved the following steps:

1. Identification of SCL zone and relevant Zonal Criteria relating to the BNCOP Disturbance Footprint;
2. Identification of the spatial extent of 'likely' SCL within the BNCOP Disturbance Footprint from currently available trigger mapping (DNRM 2011a);
3. Assessment of cropping history for any triggered properties within the BNCOP Disturbance Footprint as prescribed by DNRM (2012);
4. Delineation of triggered areas complying with Zonal Criteria 1 (slope ≤3%) following DEM based spatial analysis;
5. Identification of mapped soil types within Zonal Criteria 1 compliant areas (slope ≤3%);
6. Collection of relevant representative morphological and analytical data for each soil in accordance with the requirements of the *Strategic Cropping Land Act 2011* (Queensland Government 2011);
7. Collation and analysis of relevant data against Zonal Criteria 2-7 for all mapped soils within triggered lands;
8. Determination of effective rooting depth (ERD) for all mapped soils within triggered lands, based on the soil depth and physico-chemical limitation criteria specified in Section 4.82 of the SCL Guidelines (DNRM 2011d) as at December 2013;
9. Assessment soil water status for all mapped soils within triggered lands, based on the procedure outlined in Section 4.8.3 of the SCL Guidelines (DNRM 2011d) as at December 2013;
10. Assessment of relevant data and calculated parameters for each soil against Zonal Criteria 8;
11. Spatial presentation of SCL Zonal Criteria compliance outcomes using sequential images to display eligible soil areas as each Zonal Criteria is addressed;
12. Assessment of SCL Zonal Criteria compliant land parcels against SCL minimum size requirements for the Western Cropping Zone;
13. Identification of decided SCL land parcels within the BNCOP Disturbance footprint (i.e. soil parcels that satisfy cropping history, Zonal Criteria 1-8 and minimum size requirements);
14. Identification of decided non-SCL land parcels within the BNCOP Disturbance footprint (i.e. soil parcels that do not satisfy cropping history, Zonal Criteria 1-8 or minimum size requirements).

Cropping History Assessment

The *Strategic Cropping Land Act 2011* (Queensland Government 2011) requires SCL Zonal Criteria compliant land within the Western Cropping Zone meet required cropping history criteria before SCL status can be decided. **Section 49** of the ***Strategic Cropping Land Act 2011*** (Queensland Government 2011) defines required cropping history as 3 or more cropping events having occurred on a property in the 12 year period between 1 January 1999 and 31 December 2010. Spatial examination of natural colour Landsat imagery between the years 1999 and 2010 has been used to establish the presence and frequency of cropping events within any triggered properties.

SCL WCZ Zonal Criteria Assessment

Assessment of SCL Zonal Criteria compliance (or non-compliance) for triggered land within the BNCOP Disturbance Footprint has required assessment against SCL Zonal Criteria 1-8 as defined for the **Western Cropping Zone** of the **Strategic Cropping Management Area** (DNRM 2011d, Queensland Government 2011). Representative analytical data designed to satisfy Zonal Criteria data requirements is presented in **Appendix 5** for all triggered soils within the BNCOP Disturbance Footprint. The analytical data is also summarized and further discussed in the **Soil Characterization Section** of this report. Field morphology descriptions for all detailed field sites within triggered portions of the BNCOP Disturbance Footprint are presented in **Appendix 7.**

SCL Minimum Size Requirements

The *Strategic Cropping Land Act 2011* (Queensland Government 2011) requires SCL Zonal Criteria compliant land within the Western Cropping Zone meet minimum size requirements before SCL status can be decided. Prior to any decision, the Act requires criteria compliant polygons be >100ha in extent, at least 80m wide, and where <100ha be contiguous with decided SCL or potential SCL (either internal to or external to the triggered area) to ensure a collective SCL extent >100ha (DNRM 2011d, Queensland Government 2011). As such, criteria compliant lands within triggered portions of the BNCOP Disturbance Footprint were assessed against minimum size criteria prior to final determination of the decided SCL and decided non-SCL extents.

Inherent erosion potential assessment

Inherent erosion potential (following insitu disturbance) has been assessed for soils within the BNCOP Disturbance Footprint (excluding ML80169 and ML80170), based on a range of surrogate soil characteristics thought to contribute to or influence surface erodibility (rill and gully erosion) and predisposition to tunnelling. The assessment qualitatively ranks soils in terms of inherent erosion potential and likely behaviour following insitu disturbance, and is based on the soil erodibility classes and criteria of Murphy (1984) and Charman and Murphy (2007). It considers only susceptibility to longer term post disturbance gully and tunnel erosion and does not evaluate short term sheet erosion losses that are common immediately after insitu disturbance and prior to and during rehabilitation works.

The original scheme presented by Charman and Murphy (2007) uses a range of inherent field and laboratory measured soil characteristics, particularly clay content, sand content, soil density, clay dispersion and degree of aggregation and cracking, to infer and rank relative rill, gully and/or tunnel erodibility hazard. As such, the assessment provides an estimate of insitu post disturbance erosion potential based on soil characteristics as described and sampled prior to disturbance.

The original methodology, soil data attributes, criteria and decision rules described by Charman and Murphy (2007) have been adopted in full, but modified slightly (as described below) to better reflect soil and landscape characteristics (and associated erosive behaviour) typically experienced in Central Queensland. Three classes of inherent erosion hazard (low, moderate and high) were originally proposed by Charman and Murphy (2007), but this has been expanded to include a fourth very high category to cover soils with extremely sodic and dispersive subsoils, that are relatively common within Central Queensland (when compared with NSW). Whilst some explanation of the intent and scope of the methodology originally proposed by Charman and Murphy (2007) has been presented in this report, it is not in the scope of the current document to fully describe the rationale and reasoning behind the original scheme. The reader is directed to the source documents by Murphy (1984) and Charman and Murphy (2007) for greater detail.

The **four categories used to assess inherent erosion potential within the BNCOP Disturbance Footprint** are described below. It is important to note that assessments do not take into account external parameters such as topography, catchment area, gradient, slope length and a range of surface management factors. Spatial or temporal factors such as these directly influence erosion risk (as opposed to hazard) and mitigate erosion potential in some cases and worsen it in others. They are not inherent characteristics of the insitu soils however, and as such have not been considered.

Relevant morphological and analytical soil profile data used in the assessment of inherent erosion potential criteria are presented in **Appendices 2-7** and discussed more fully in the discussion section of this report.

Category 1 – Low erosion hazard

In general, soils in this category (Charman and Murphy 2007) have surface materials that are either:

- very organic (>3% OM); and/or
- very sandy (particularly medium to coarse fractions); or
- very strongly structured, loams/clay loams (not prone to dispersion or slaking); or
- calcium rich, fine, very strongly self-mulching clays (not prone to dispersion or slaking);

while subsoils are either:

- hard cemented layers;
- very sandy materials (particularly medium to coarse fractions); or
- very well structured, calcium dominated non dispersive clays that are stable and do not readily slake; with
- upper and lower subsoil clay fractions that are non-sodic (ESP <6) and non-dispersive (R1 <0.4) throughout.

Soils in this category have only limited potential to develop gully or tunnel erosion under natural conditions, particularly on slopes <5%. This group typically includes soils such as red Ferrosols, deep loose sandy soils, very friable non-sodic Chromosols/Dermosols and highly structured, non-sodic, calcium dominated, highly reactive cracking clays. Erosion features will only develop where significant surface flows are allowed to concentrate on long slope lengths. Where gullies do develop, repair and rehabilitation will often occur naturally either through shrink-swell movement or natural re-battering of gully sidewalls from the accumulation of strongly aggregated scree materials. Works to rehabilitate gullied areas typically only require surface flow diversion and minimal gully reshaping and revegetation for success. Tunnel erosion is not expected to be a significant issue in natural situations (but may occur in poorly compacted earthwork structures that are strongly cracked when dry, and are subject to lateral water flows from upslope water sources/storages).

Category 2 – Moderate erosion hazard

Soils in this category (Charman and Murphy 2007) have surface materials that either have:

- moderate levels of organic matter (1.5-3% OM);
- moderate levels of fine sand and/or silt (40-60% combined); or are
- strongly structured clay loam materials and self mulching clay surface soils that are prone to slaking;

while subsoils are either:

- stable/flocculated, non-dispersive loams/clay loams (often high in sesquioxides, but with variable FS/Z fractions); or
- non-dispersive to weakly dispersive (R10.4-0.6), structured clays that are prone to slaking; with
- subsoil clay fractions that are non-sodic (ESP <6) and non-dispersive (R1 <0.4) in the upper subsoil, but grade to weakly sodic (ESP 6-12) and weakly dispersive (R1 0.4-0.6) in the lower subsoil.

These soils have the potential to develop moderate gully erosion on slopes greater than 3% or where significant surface flows are allowed to concentrate on long slope lengths. Typically soils in this group include red Chromosols and Kandosols with significant fine sand/silt fractions, and a range of well structured Dermosols and self mulching clay soils that are non-dispersive (to weakly dispersive at depth), but are prone to slaking. Soils in this category that lack vertic properties are effectively rigid and less able to accommodate and repair erosion damage in areas of concentrated flow, particularly when compared with the ameliorative abilities common in highly structured, non-sodic, calcium dominated, strongly cracking clays (low erosion hazard). Gully shapes are typically steeper and sidewalls more sheer and prone to collapse. Where gullies do develop, repair and rehabilitation through surface flow diversion, gully reshaping, battering and revegetation will typically be successful. Tunnel erosion is not expected to be a significant issue with these soils in natural situations, (but may occur in poorly compacted earthwork structures that are strongly cracked when dry, and are subject to lateral water flows from upslope water sources/storages).

Category 3 – High erosion hazard

Soils in this category (Charman and Murphy 2007) have surface materials with:

- low to very low levels of organic matter (<0.9-1.5% OM), particularly soils with bleached sub-surface horizons; and/or
- high to very high levels of fine sand and/or silt (>60% combined);

while subsoils are:

- sodic, dispersive clays; with
- upper subsoil clay fractions that are non-sodic to weakly sodic (ESP <6-12) and non-dispersive to weakly dispersive (R1 <0.4-0.6); and grade to
- lower subsoil clay fractions that are moderately to strongly sodic (ESP 12-20) and moderately dispersive (R1 0.6-0.8); or
- unstable, structureless/dispersive sandy loam to sandy clay materials; or
- unstable materials high in fine sand and/or silt (>60% combined), such as unconsolidated sediments and alluvial materials.

Category 4 – Very high erosion hazard

Soils in this category (Charman and Murphy 2007) have similar characteristics to those defined for Category 3 but are characterized by extreme levels of subsoil sodicity and dispersion. Typically, they have surface soils with:

- low to very low levels of organic matter (<0.9-1.5% OM), particularly soils with bleached sub-surface horizons; and/or
- high to very high levels of fine sand and/or silt (>60% combined);

while subsoils are relatively shallow :

- sodic, dispersive clays, typically high in fine sand/silt (>60% combined); with
- upper subsoil clay fractions that are strongly to extremely sodic (ESP 15->20%) and highly to extremely dispersive (R1 0.8-0.99); and
- lower subsoil clay fractions that are extremely sodic (ESP >20%) and extremely dispersive (R1 >0.95) throughout.

Soils in both the high and very high categories essentially have similar characteristics, but the magnitude and speed with which erosion features develop is likely to be far more severe and much more difficult to control and stabilise in the very high category. Soils in both categories have the potential to develop significant gully erosion on slopes greater than 1-2%, particularly where surface flows are allowed to concentrate on long slope lengths.

Soils in the high and very high categories include clays with shrink swell characteristics, as well as a range of rigid soils less able to accommodate and repair erosion damage once it has started. Irrespective of soil type, gully shapes are typically very steep and sidewalls mostly vertical and prone to severe undercutting and gully wall collapse. In addition, alluvial soils in this category (such as Soil 3b within the BNCOP Disturbance Footprint) may experience significant problems associated with disturbance around creek channels, alluvial benches and local creek flats, because of localised channel incision, steep bank slopes and concentrated surface flows.

Where gullies do develop in these materials they are normally difficult to stop or repair, and rehabilitation requires surface flow diversion and significant gully reshaping, battering, lining and revegetation to minimise future exposure of dispersive material. Diversion of surface drainage away from the gully head is essential. Surface erosion and undercutting at the gully head must be stopped and reshaping and battering of sidewalls to very low gradients (<3%) is normally required. Reinstatement of a thick cover of topsoil and successful revegetation are necessary if stabilization of the repaired gully is to occur. Where sodic clay material remains exposed in batters post rehabilitation, surface drainage down batter slopes may initiate lateral gully formation. Wherever subsequent surface erosion re-exposes dispersive subsoil material on reshaped batter walls gully erosion is likely to re-initiate.

Tunnel erosion may also be a significant issue in the sodic, texture contrast soils within the high and very high categories, particularly where infrastructure construction requires significant levelling, cut and fill works or steeply sloping batters within undulating terrain. Water sources above such structures must be removed and surface flows diverted if piping and associated gully formation are to be avoided. Rehabilitation requirements are similar to those described above for gully sidewalls.

5. Geological landscapes

Surficial geology within the 2013 BNCOP Soil Investigation survey area **(**Olgers *et al* 1963, Jell 2013**)** is mapped predominantly as:

- recent alluvium (Qa) associated with the Dawson River and associated tributaries, including the Dawson River anabranch;
- older unconsolidated undifferentiated Tertiary-Quaternary sediments (Cz, TQr) that sit 3-5 m higher in the landscape than the alluvium; and
- unnamed/undifferentiated Tertiary sandstone (Ta, Tm).

Folding in the region has resulted in the presence of a relatively shallow, Permian sedimentary rock basement immediately below the surficial sediments. Two Permian sedimentary geological units are mapped, namely the Baralaba Coal Measures (Pwj - sandstone, siltstone, mudstone, coal, conglomerate) predominantly in the western half of the study area; and the Gyranda Formation (Pwy - siltstone, shale, volcanilithic sandstone, calcareous sediments), predominantly in the eastern half of the study area (Balfe *et al* 1988, Jell 2013).

Nine distinct soil landscapes are recognised within the geologic framework described above and soil development within each landscape strongly reflects the lithological and localised depositional environment that exists in the upper part of the regolith. Soil landscapes 1, 2, 3 and 4 are all developed directly from and strongly influenced by recent alluvial deposition (Qa), and are typically still subject to flooding. Soil Landscape 5 is transitional between recent alluvium (Qa) and adjacent older, more elevated landscapes, while Soil Landscape 6 is associated with high level, relict alluvial deposits (Qa). Soil Landscape 7 is developed on unconsolidated Tertiary-Quaternary residual sediments and clay sheets (Cz, TQr), and soils in this landscape are widespread across the Bowen Basin. Soil Landscape 8 is developed on intact to dissected, residual Tertiary sediments (Ta, Tm), dominated locally by medium to coarse grained siliceous sandstones. Soil Landscape 9 is of limited occurrence and appears related to the presence of outcropping calcareous sediments (unmapped), possibly of Permian origins.

6. Soil landscapes

Soil distribution within the 2013 BNCOP Soil Investigation survey area

Twenty three soil types were recognized and mapped within the 2013 BNCOP Soil Investigation survey area (which includes additional buffer areas external to the BNCOP EIS Operational Area) and are presented in **Figure 3**. Of these, 12 have been previously mapped and described within ML80169 and ML80170 (NQSA 2011a), 10 are newly described and 1 has been described in previous stages of mine expansion (SMM 2010a, 2010b), prior to the Baralaba/Wonbindi North Mine Lease (ML80169 and ML80170).

Soils 1, 2b and 3a are young hardsetting to self-mulching alluvial clays that occupy the lowest terraces and floodplains of the Dawson River anabranch, and are associated with riverine vegetation or coolibah woodland. These soils have a spatial extent that is limited to relatively minor areas just north of the Dawson River anabranch. **Soils 3b and 3c** are also developed on recent alluvium, but have very different loamy or sandy characteristics relating to localised depositional provenance and sediment source. They are characterized by eucalypt woodland, particularly bloodwoods and poplar box, and dominate the creek flats, scroll features and local alluvial plains of the main tributaries in the area, particularly Saline Creek.

Soils 4a-4e occur exclusively on the upper terraces and floodplains of the main Dawson River system (including the southern anabranch). They are predominantly cracking clay soils with coolibah or brigalow - coolibah vegetation. Soils 4a, 4b and 4c are predominantly deep self-mulching clays with coolibah or brigalow vegetation and distribution in the current study is restricted to minor areas immediately north of the southern anabranch. Soils 4d and 4e are brigalow or brigalow - Dawson gum soils that occupy significant tracts of level floodplain north of the relict oxbow wetland. Soil 4d is a weakly melonholed alluvial grey clay, while soil 4e is a sandy to loamy surfaced texture contrast soil. While a small portion of Soil 4d occurs within the BNCOP Disturbance Footprint, these soils are more common on the floodplain further north.

Soil 5 is transitional between the young alluvial clay landscapes on the floodplains flanking the southern anabranch and the older elevated, unconsolidated Tertiary-Quaternary land surface that is extensive north of the anabranch. Its distribution is specifically associated with dissection along the margins of the older elevated Tertiary-Quaternary clay sheet, primarily as a result of ongoing incision by local tributary streams. Soil 5 is a self-mulching brigalow clay, with upper profile features that are indicative of regular flooding and clay alluviation (i.e. similar to soils in Landscape 4), but lower subsoil features that are clearly related to the older Cainozoic clay sheets to the north. As such, it represents a hybrid between the two landscapes and is characterized by attributes of both.

Soils 6b-6c are thick, sandy or loamy surfaced profiles that are characterized by eucalypt woodland, and occupy high level, elevated alluvium on relict levees and scroll plains of the main Dawson River system (including the anabranch). Soil 6b is associated with high level (almost stranded) levee/terrace alluvium along the anabranch, while Soil 6c is restricted to high relict levees adjacent to the oxbow wetland in the north of the survey area.

The remaining soils 7a-7d, 8a-8d and 9a-9b are non-alluvial and are developed either on relict, unconsolidated Tertiary-Quaternary transported sediments or from older insitu Tertiary sediments. **Soils 7a-7d** are predominantly clay soils that occupy extensive, level to gently undulating plains developed on relict, unconsolidated Tertiary-Quaternary transported clayey sediments, north of the anabranch. Soil 7a is a strongly melonholed grey clay with uniform brigalow scrub. It typically occurs in large uniform blocks but can also be mixed intimately with the hardsetting non-cracking clays and loamy surfaced texture contrast profiles of Soil 7b. Vegetation grades from pure brigalow to a very shrubby eucalypt - brigalow scrub or woodland across the 7a-7b soil boundary.

Soil 7c is associated with relatively elevated, gently undulating plains and low rises developed on unconsolidated relict alluvial deposits of indeterminate age. These sediments stratigraphically overlie the flatter Cainozoic clay sheets on which Soils 7a, 7b and 7d are developed. Soil 7c typically occurs as a hardsetting, thick sandy surfaced, bleached, mottled, brown, non-sodic to weakly sodic texture contrast soil. Vegetation ranges from a shrubby eucalypt woodland through to eucalypt-softwood scrub. Soil 7d is similar in many respects to Soil 7b, but presents only as a clay loamy surfaced, black sodic texture contrast soil and does not grade towards a non-cracking or cracking clay. Associated vegetation is also specific and is restricted to Dawson gum - brigalow scrub. Whilst the soils in Landscape 7 are spatially extensive and occupy a significant proportion of the BNCOP EIS Operational area, their distribution is largely contained between the southern anabranch and the relict oxbow wetland in the north.

In the north of the survey area, the unconsolidated Tertiary - Quaternary sheets are underlain by older outcropping insitu Tertiary sediments (predominantly sandstones) that have been significantly dissected and eroded since exposure. In addition, the landscape has been intensively weathered at some stage, although evidence of deep weathering profiles and kaolinization was not observed. Subsequent dissection has left a subtle distribution of relatively fresh and more weathered substrates exposed, without obvious landform changes to mark the differences. Soils largely reflect grain size, mineralogy and fabric of the original sandstones ± the effects of intense weathering in more intact remnants.

Soils 8a-8d are closely related to each other and together occupy extensive areas of undulating plains and distinct low rises underlain by insitu sandstones in the north west of the survey area. Soil 8a is a deep red earth with a shrubby to open eucalypt woodland and is associated with intact remnant plateau surfaces on more weathered sandstones. Soil 8b, in contrast, is a sandy surfaced, mottled, grey texture contrast soil that occurs on dissected slopes and rises underlain by relatively fresh insitu sandstones. This soil is characterized by eucalypt woodland, but with a distinctive understory dominated by quinine bush (*Petalostigma pubescens*). Soils 8c and 8d are deep sandy colluvial variants developed on footslopes and outwash areas where localised sand accumulation has occurred.

Soils 9a-9b are of limited occurrence, and appear related to localised outcropping calcareous sediments (unmapped). Although origins are inconclusive, soil and vegetation response within the landscape is nonetheless distinctive. They are located in the vicinity of underlying folded Permian strata, in particular the Gyranda Formation (Pwy - siltstone, shale, volcanilithic sandstone, calcareous sediments), but field evidence is limited. Soil 9a grades from a loamy surfaced texture contrast soil to areas of reddish brown non-cracking clay, with a distinctive bloodwood dominated eucalypt woodland. Soil 9b is a deep, weakly gilgaied black cracking clay typically with an open grassland.

Soil distribution within the BNCOP Disturbance Footprint

A total of 20 soils are recognised within the BNCOP EIS Operational Area, but only 16 of these occur within the BNCOP Disturbance Footprint (external to ML80169 and ML80170). More specifically, 9 soils have been previously mapped and described within ML80169 and ML80170 (NQSA 2011a) but are common to both areas, while a further 7 soils are newly described and occur only within the BNCOP Disturbance Footprint. The spatial distribution of the 16 soils within the BNCOP Disturbance Footprint is presented in **Figure 4**. Soil variation associated with each of the operational or project entities described is summarized below.

Area of interest	Soils	Total
All soils - BNCOP Operational EIS Area	2a, 2b, 3/3a, 3b, 4a, 4b, 4c, 4d, 5, 6b, 7a, 7b, 7c, 7d, 8a, 8b, 8c, 8d, 9a, 9b	20
All soils - ML80169 and ML80170	2a, 2b, 3/3a, 4a, 4b, 4c, 5, 6b, 7a, 7b, 7c, 8a, 8b	13
All soils - BNCOP Disturbance Footprint	2b, 3a, 3b, 4c, 4d, 5, 7a, 7b, 7c, 7d, 8a, 8b, 8c, 8d, 9a, 9b	16
Soils common to ML80169/ML80170 and the BNCOP Disturbance Footprint	2b, 3a, 4c, 5, 7a, 7b, 7c, 8a, 8b	9
New soils - BNCOP Disturbance Footprint	3b, 4d, 7d, 8c, 8d, 9a, 9b	7

7. Soil characterization

Outline and explanation of terms – Soil Characterization Section

The following section provides a comprehensive summary of field descriptions, analytical data and interpreted attributes for soils within the BNCOP Disturbance Footprint (excluding ML80169 and ML80179). The **landscape framework** developed during mapping is presented in **Tables 2 and 3.** The spatial extent and distribution of individual soil units within the entire 2013 BNCOP Soil Investigation survey area is presented in **Figure 3,** while soil mapping specific to the BNCOP Disturbance Footprint is presented in **Figure 4**.

Table 2. Map legend — brief soil concepts and dominant vegetation for soil landscapes mapped within the 2013 BNCOP Soil Investigation survey area.

Soil	Landscape framework and soil concept	Dominant vegetation
Quaternary alluvium (Qa)		
Active river channels and banks		
1	Firm to hardsetting, silty surfaced black cracking clay	Coolibah
Active, channelled lower floodplain		
2b	Moderately self-mulching (often silty) black cracking clay	Coolibah ± brigalow
Active levees and alluvial plains of tributary drainage lines		
3a	Hardsetting to coarsely self mulching (poached) black cracking clay	Coolibah ± shrubs ± brigalow
3b	Hardsetting, clay loamy surfaced, brown sodic texture contrast soil	Shrubby poplar box ± brigalow
3c	Brown sand to soft, sandy surfaced, brown non-sodic texture contrast soil	Moreton Bay ash – forest red gum
Elevated, upper floodplain, terraces and backplains		
4a	Hardsetting to firm, silty black cracking clay	Coolibah ± other eucalypts
4b	Moderately to strongly self-mulching (coarse) black cracking clay	Coolibah
4c	Moderately to strongly self-mulching black cracking clay	Brigalow ± minor softwood species
4d	Weakly to moderately self-mulching grey cracking clay	Brigalow ± coolibah (emergent)
4e	Hardsetting, sandy to clay loamy surfaced, grey/brown texture contrast soil	Shrubby brigalow – Dawson gum
Gently undulating Qa –TQr transitional sideslopes		
5	Firm pedal or weakly to moderately self-mulching black cracking clay	Brigalow ± shrubby species
High level alluvial plain, levees and relict scroll plains		
6b	Hardsetting, loamy to clay loamy surfaced, brown/red texture contrast soil	Very shrubby eucalypt ± coolibah
6c	Soft, sandy surfaced, mottled, brown/grey texture contrast soil	Moreton Bay ash – forest red gum
Older unconsolidated Tertiary–Quaternary sediments (Cz/TQr)		
Level to gently undulating plains and low rises		
7a	Hardsetting to weakly self-mulching, grey cracking clay with strong melonhole	Brigalow
7b	Hardsetting, clay loamy surfaced, grey/brown sodic texture contrast soil grading to a grey or brown non-cracking/cracking clay ± occ. weak gilgai	Very shrubby poplar box
7c	Hardsetting, sandy surfaced, bleached, mottled, brown non-sodic to weakly sodic texture contrast soil	Shrubby eucalypt grading to eucalypt – softwood scrub
7d	Hardsetting, clay loamy surfaced, bleached, black sodic texture contrast soil	Brigalow ± Dawson gum
Internally drained closed depressions		
swp 7a	Hardsetting, silty, mottled, grey non-cracking/cracking clay ± weak gilgai	Forest red gum
Older insitu consolidated Tertiary sandstone (Ta/Tm)		
Level to gently undulating plains/remnant plateau surface		
8a	Hardsetting, massive, gradational loamy red earth	Eucalypt
Undulating to rolling dissected rises		
8b	Soft/loose, sandy surfaced, bleached, mottled, grey non-sodic texture contrast soil on sandstone	Eucalypt
Colluvial footslopes and pediments		
8c	Loose, massive, bleached, grey coarse sand	Eucalypt
8d	Loose, red/brown sand to sandy surfaced, red/brown texture contrast soil	Eucalypt
Older insitu calcareous sediments (Pwy)		
Gently undulating plains and low rises		
9a	Hardsetting, loamy to clay loamy surfaced, brown non-sodic texture contrast soil grading to a brown non-cracking clay	Eucalypt
9b	Hardsetting to moderately self-mulching black cracking clay ± weak gilgai	Open grassland

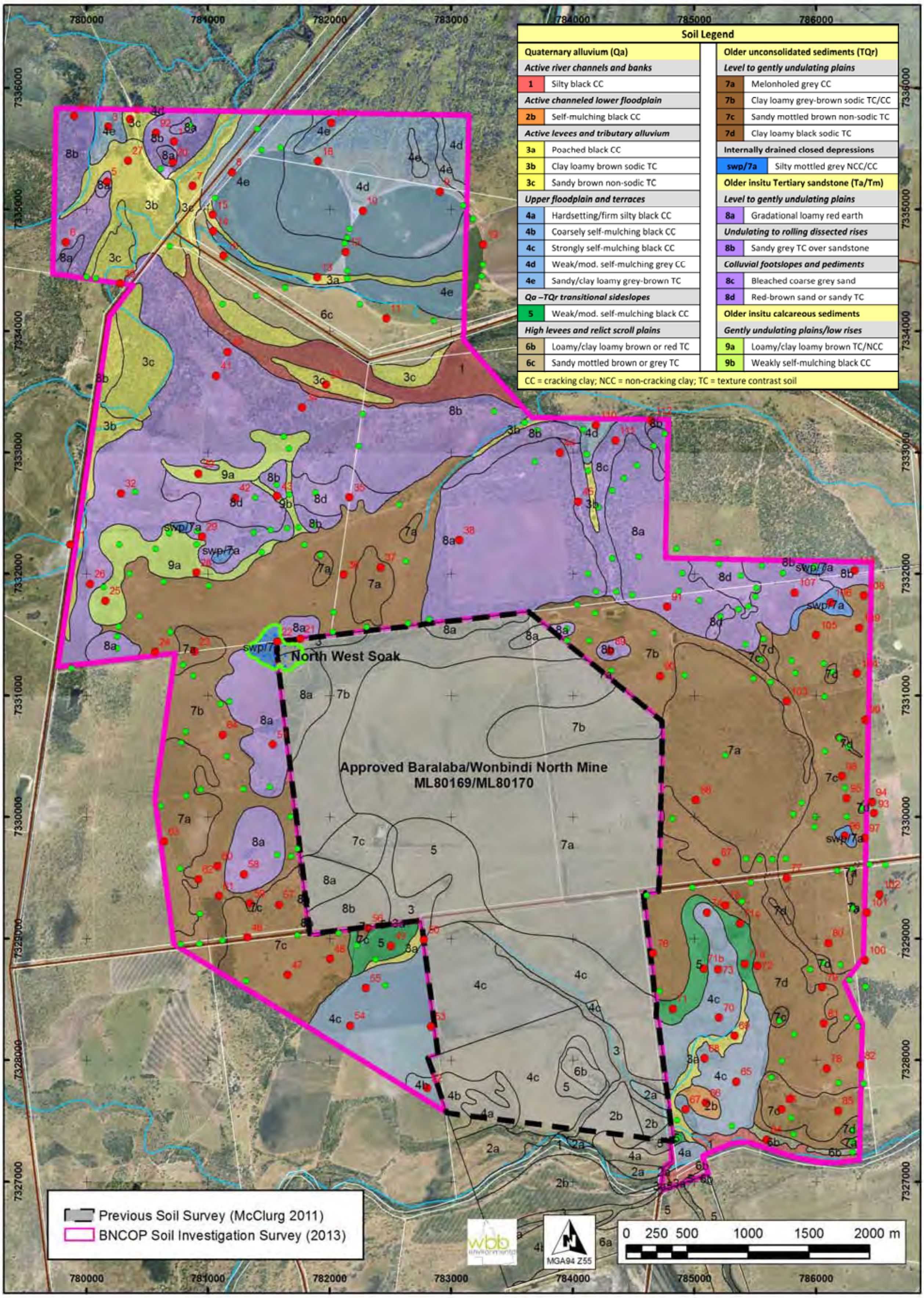


Figure 3. Soil landscapes mapped within the 2013 BNCOP Soil Investigation survey area.

Table 3. Soil landscapes within the 2013 BNCOP Soil Investigation survey area (incl. regional soil correlation, vegetation, field site summary and Land Zone).

Unit	Soil landscape description	Regional soil name[1]	Vegetation summary	Detailed field sites	LZ[1]
Soils derived from Quaternary alluvium (Qa)					
Active river channel of the Dawson River and associated anabranches; includes banks and low-lying channel benches subject to frequent flooding					
1	Firm to hardsetting, silty surfaced, black cracking clay on low-lying channel benches and banks.	Isaac (Is)	Coolibah	na	3
Active, channelled lower floodplain of the Dawson River and associated anabranches; relatively low lying, undulating unit adjacent to the main channel and subject to regular flooding					
2b	Moderately self-mulching, often silty, black cracking clay on level backplains within the lower floodplain.	Bluchers (Bc), Lindsay (Ld)	Coolibah ± brigalow	**66**	3
Active levees and alluvial plains of tributary drainage lines and floodplain drainage features within or at the margins of elevated terraces and backplains; subject to both local and wider flooding					
3a	Hardsetting to coarsely self-mulching, (poached), black cracking clay in narrow terrace drainage lines of the upper floodplain.	Bluchers (Bc), Lindsay (Ld)	Coolibah ± shrubs ± brigalow	13, 15, 50, **69**	3
3b	Hardsetting, clay loamy surfaced (0.2-0.4m), bleached, brown sodic texture contrast soil on level alluvial plains of Saline Creek and associated tributaries.	Roper (Rp)	Shrubby poplar box ± brigalow	**27**, 31	3
3c	Deep brown uniform sand grading to a very thick, soft sandy surfaced (1.0->1.5m), brown non-sodic texture contrast soil on active terrace flats, levees and scroll plains of Saline Ck and other tributaries.	German (Gm), Parrot (Pr)	Moreton Bay ash – forest red gum	2, 7, 33, 39	3
Elevated, backplains, terraces and indistinct levees of the upper floodplain of the Dawson River and associated anabranches; typically level and extensive; commonly flooded					
4a	Hardsetting to firm, silty, black cracking clay on upper floodplain levees and terrace sideslopes.	Stephens (St)	Coolibah ± other eucalypts	13 (ML80157)	3
4b	Moderately to strongly self-mulching (coarse), black cracking clay to 1.2m (over brown or grey clay) on elevated level backplains.	Lindsay (Ld)	Coolibah	52	3
4c	Moderately to strongly self-mulching, black cracking clay on elevated level backplains.	Langley (Lg)	Brigalow ± minor softwood species	53, 54, 55, **65**, 67, 68, 70, 73, 74	3
4d	Weakly to moderately self-mulching, grey cracking clay with weak to moderate melonhole gilgai (VI <0.3-0.6m, HI 10-25m) on level backplains of the Dawson River.	Langley (Lg), Tralee (Tl)	Brigalow ± coolibah (emergent)	9, 10, 18, **110**	3
4e	Hardsetting, sandy to clay loamy surfaced (0.2-0.5m), grey or brown texture contrast soil on level backplains of the Dawson River.	Honeycomb (Hy)	Shrubby brigalow – Dawson gum	3, 8, 12, 14, 17, 19	3
Gently undulating side slopes and dissected margins transitional between recent alluvium of the upper floodplain and older more elevated landscapes adjacent; rarely flooded					
5	Firm pedal or weakly to moderately self-mulching, black cracking clay on gently undulating sideslopes/plains that mark the transition from recent alluvium to older elevated plains.	Affinities with Tralee (Tl)	Brigalow ± shrubby species	49, **71,** 71a, 71b, 71c	3/4
Intact, elevated alluvial plain, high levees and relict scroll plains and prior stream channels and floodways; rarely flooded					
6b	Hardsetting, loamy to clay loamy surfaced (0.25m), sporadically bleached, brown or red texture contrast soil on elevated terrace/levee remnants.	Affinities with Roper (Rp)	Very shrubby eucalypt ± coolibah	84	3
6c	Thick, soft sandy surfaced (1.0-1.5m), mottled, brown or grey texture contrast soil on high levees.	Parrot (Pr)	Moreton Bay ash – forest red gum	11, 16	3

Unit	Soil landscape description	Regional soil name[1]	Vegetation summary	Detailed field sites	LZ[1]
Soils derived from older unconsolidated Tertiary–Quaternary sediments (Cz/TQr – elevated Cainozoic clay sheets and relict sandy alluvial deposits)					
Older, elevated, level to gently undulating plains and low rises ; not flooded					
7a	Hardsetting or firm pedal to weakly self mulching, grey cracking clay with strongly developed melon-hole gilgai (VI 0.3-0.8m, HI 12-20m) on older clay sheets; saline, sodic and acidic at depth.	Turon (Tr)/Greycliffe melonhole phase (GcMp)	Brigalow	23, 37, 63, 75, 76, **88**	4
7b	Hardsetting, thin clay loamy surfaced (<0.05-0.2m), bleached, grey or brown sodic texture contrast soil grading to a grey or brown non-cracking/cracking clay ± occasional weak gilgai (VI 0.1m, HI 10m) on older unconsolidated sediments and clay sheets.	Foxleigh clay loamy phase (FxLp) grading to Warwick (Ww)/Greycliffe (Gc)	Very shrubby poplar box	24, **36**,59, 60, 61, 62, 64, **90**, 103	4
7c	Hardsetting, thick sandy surfaced (0.4-0.7m), bleached, often mottled, brown non-sodic to weakly sodic texture contrast soil on elevated relict alluvial deposits.	Collawmar (Cm)	Shrubby eucalypt grading to eucalypt – softwood scrub	46, 47, 48, 56, 57, 77, 80, 83, 85, 86, 93, 95, 97, 98, **99**, 100, 101, 104, 105, 108, 109	5a
7d	Hardsetting, clay loamy surfaced (0.10-0.2m), bleached, black sodic texture contrast soil on older unconsolidated sediments and clay sheets.	Racetrack (Rt)/Kokotungo (Kk)	Brigalow ± Dawson gum	72, 78, 79, 81, 82, **87**, 94, 102	4
Local seasonal swamps and closed depressions – occasional landscape features sitting between elevated sandstone units (Landscape 8) and lower lying clay sheets (Landscape 7)					
swp 7a	Hardsetting, silty surfaced, mottled, grey non-cracking/cracking clay ± weak gilgai (VI <0.1-0.3m, HI 8-12m) etched within the Cainozoic clay sheets and subject to localized alluvial deposition.	Thirteenmile (Tt)	Forest red gum	22, 96, 106	3
Soils derived from older consolidated Tertiary sandstone (Ta/Tm)					
Elevated and relatively intact, level to gently undulating plateau surface					
8a	Hardsetting, massive, gradational loamy red earth overlying weathered Tertiary sandstone (>1.5m).	Bills Hut (Bh)/Spear (Sp)	Eucalypt	5, 20, 21, **38**, 44, 51, 58, 91, 107	10
Elevated and dissected, undulating to rolling remnant rises					
8b	Soft to loose, thick sandy surfaced (0.3-1.0m), bleached, strongly mottled, grey non-sodic texture contrast soil overlying insitu Tertiary sandstone from 0.8->1.5m.	Wyndham (Wm), affinities with Emoh (Em)	Eucalypt	1, 4, 6, 26, **29**, 32, 34, **40**, 41, 89, 92, 112, 113	10
Colluvial footslopes and pediments					
8c	Loose, massive, bleached, grey coarse sand on steeper colluvial footslopes.	Wyndham (Wm), affinities - Cherwell (Cw)	Eucalypt	45, 111	10
8d	Loose, massive red or brown earthy sand grading to a very thick sandy surfaced (1.0->1.5m), red or brown non-sodic texture contrast soil on gentle colluvial pediments and outwash deposits.	Wyndham (Wm), Bills Hut sandy variant (BhSv)	Eucalypt	35, 42	10
Soils derived from older calcareous sediments (possibly Pwy)					
Level to gently undulating plains and low rises					
9a	Hardsetting, loamy to clay loamy surfaced (0.2-0.3m), brown non-sodic texture contrast soil grading to a structured, brown non-cracking clay overlying calcareous sediments from 0.7m->1.5m.	Mayfair (Mf), Kirkcaldy (Kc)	Eucalypt	25, 28, **30**	4/9
9b	Hardsetting to moderately self-mulching, black cracking clay with weak normal gilgai (VI <0.1-0.2m, HI 8-15m) overlying calcareous sediments from >1.2m.	Kirkcaldy (Kc), Affinities with Carfax (Cx)	Open grassland	**43**	4/9

Note 1. Regional soil names are from Burgess (2003a, 2003b); except for Greycliffe (Gc) and Kokotungo (Kk) which come from Muller (2008); land zones (LZ) are after Sattler and Williams (1999).

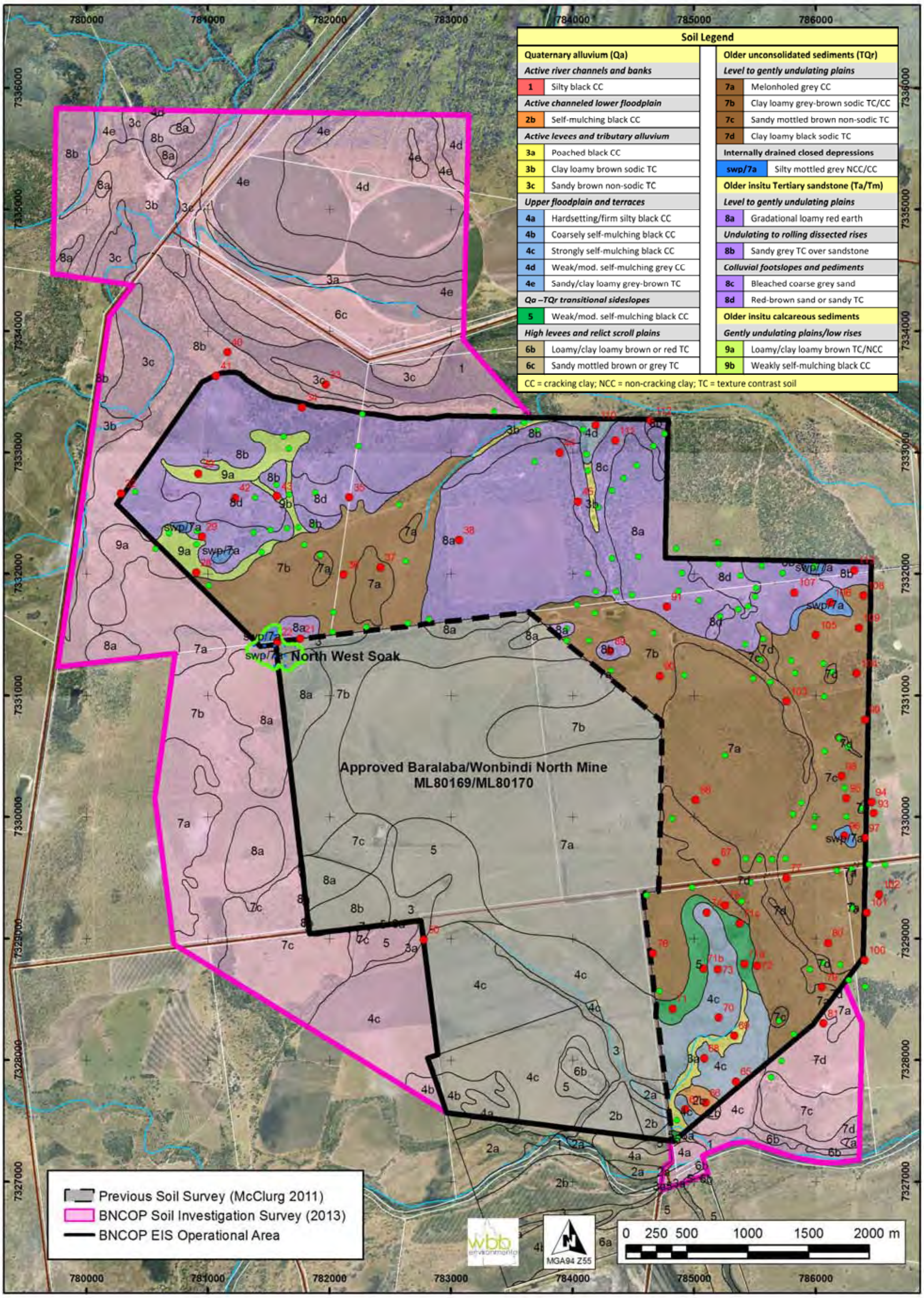


Figure 4. Soil landscapes mapped within the BNCOP Disturbance Footprint. Previous soil mapping within M80169 and ML80170 is also shown to complete coverage for the BNCOP EIS Operational Area.

Soil types within each landscape unit were split initially according to lithology/parent material, and then further sub-divided in terms of landscape age (youngest to oldest), landscape position (lowest to highest) and broad vegetation category (eucalypt, brigalow or other Acacia based scrub). **Soil mapping codes** consist of a primary number code corresponding to lithological units ordered from youngest to oldest, followed by a letter code for subdivisions based on topographical position (lowest to highest). Soils described within each landscape unit have also been assigned a Regional Soil Name according to Burgess (2003a, 2003b) and/or Muller (2008).

Information presented for each soil in the soil characterization pages that follow includes description of the overriding landscape framework (geology/lithology, landform and vegetation), detailed soil profile morphology, soil fertility data, physical soil attributes, subsoil chemistry, data interpretation, topsoil stripping recommendations, pre-mining suitability for dryland cropping and grazing and SCL status. Data interpretation uses ratings and classes defined for inland Central Queensland by Burgess (2003b). An outline of the information provided for each soil with a brief explanation of its purpose and meaning is given below.

Soil/landscape attribute	Brief explanation
Regional Soil Name	• Regional soil type – Burgess (2003a, 2003b) and Muller (2008).
Soil landscape concept	• Conceptual description incorporating soil type, parent material, landscape position and vegetation.
Soil concept	• A conceptual soil description summarizing distinguishing profile features and parent material.
Soil Classification	• Australian Soil Classification – Suborder/Soil Order (Isbell 1996). • Principal Profile Form (Northcote 1979).
Geology/parent material	• Geological formation, dominant lithology of the parent material and degree of alteration.
Land zone	• Broad geological landscape as defined by the Regional Ecosystem framework (Sattler and Williams 1999).
Landform	• Dominant relief/modal slope class, landform pattern and typical slope range.
Vegetation	• Dominant vegetation and regional ecosystem (if required).
Microrelief	• Presence of microrelief including type, degree of development (weak to strong), size (vertical interval – VI (m) and horizontal interval – HI (m)) and dominance of individual components.
Runoff, permeability and drainage	• Estimates as defined by the National Committee on Soil and Terrain (2009).
Surface gravel, stone, rock outcrop	• Estimates as defined by the National Committee on Soil and Terrain (2009).
Surface condition	• Description as defined by the National Committee on Soil and Terrain (2009). • Self-mulching behaviour is further described in terms of strength of pedality, fineness of aggregates and thickness of the self-mulching layer (where applicable).
Distinguishing profile features	• Descriptions of the depth, horizon designation, dominant colour, mottling, texture, structure, segregations, gravel and field pH of the major soil horizons and underlying substrate as defined by the National Committee on Soil and Terrain (2009).
Surface soil fertility status	• Summary of the fertility status at each site including measured levels and ratings for organic carbon, total nitrogen, available phosphorus, and exchangeable potassium, and calcium.
Physical soil characteristics	• Important physical soil characteristics including clay content, sand fraction, clay mineralogy, dispersion and plant available water capacity (PAWC).
Soil chemistry	• Important soil chemistry attributes of the surface soil and subsoil including pH, electrical conductivity, soluble chloride, cation exchange capacity, exchangeable cations, cation dominance, ESP, sodicity and dispersive behaviour (R1).

Soil 2b — Moderately self-mulching black clay on lower floodplains + coolibah

Soil concept: Moderately self-mulching, often silty, black cracking clay on level backplains within the lower floodplain.

Regional Soil Name: Bluchers (Bc), Lindsay (Ld)

Aust. Soil Classification: Black Vertosol **Principal Profile Form:** Ug5.17

Landform: Level backplains of the lower floodplain of the Dawson River anabranch; relatively low lying, active backplains characterized by flood channels/runners; subject to regular flooding. Slopes mostly <1.0%.

Geological landscape: Quaternary alluvium (Qa). Sand, clay and gravel.

Land zone: Cainozoic alluvial plains (LZ 3).

Vegetation: Coolibah ± brigalow.

Runoff, perm., & drainage: Slow runoff; slow permeability; moderately well drained.

Surface features: Thin, coarse (2-5mm), moderately self-mulching, silty clay surface; cracking; non-gilgaied; no surface gravel or stone.

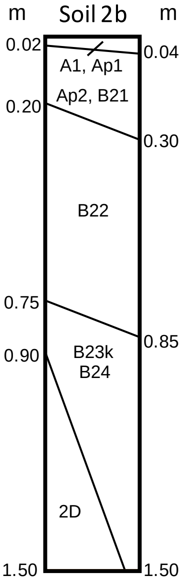
Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
	high (0.140)	very high (73)	very high (2.5)	very high (27)

Moisture Characteristics: **ERD:** >1.0m (no restrictions) **PAWC:** 120mm/1.0m

Investigation sites: **Field sites** – 66 **Analysed sites** – 66

Coolibah ± brigalow cropping area on the lower floodplain, north of the anabranch at Site 66.

Moderately self-mulching, silty, black cracking clay on the lower floodplain at Site 66.



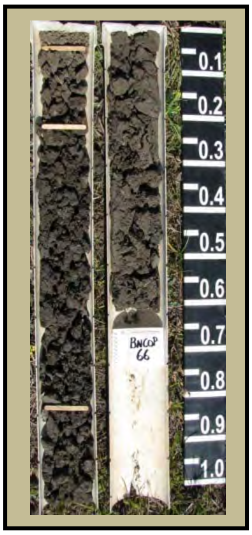
Profile description

The **surface soil** (A1, Ap1) is a black (10YR 3/1-3/2) silty light medium to silty medium clay with fine blocky structure parting to a moderate granular self-mulching surface; field pH 7.0-7.5. Clear change to

The **upper subsoil** (Ap2, B21) is a black (2.5Y, 10YR 2/1-3/1) medium heavy clay with moderate coarse blocky grading to strong lenticular structure; sometimes with minor soft or nodular carbonate; field pH 7.0-8.5. Clear or gradual change to

The **lower subsoil** (B22, B23k, B24) is a black or grey (2.5Y, 10YR 3/1, 3/2, 4/1) medium heavy to heavy clay with coarse lenticular structure; and <20% soft or nodular carbonate; field pH 8.0-9.0.

Buried layers (2D) where present are typically brown (7.5YR, 10YR 3/3-4/6) fine sandy light medium to fine sandy medium clay materials with weak to moderate blocky structure and variable levels of soft or nodular carbonate; field pH 8.0-9.0.



Subsoil Chemistry – representative data from BNCOP Site 66

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	7.2	0.346	210	38	27.0	8.4	2.50	0.47
0.25 – 0.35	8.1	0.078	<5	41	34.1	9.3	1.00	0.81
0.55 – 0.65	8.5	0.160	<5	42	32.5	12.0	0.73	1.90
0.85 – 0.95	8.7	0.180	5	43	27.7	13.9	0.67	3.74
1.15 – 1.25	8.9	0.236	15	-	-	-	-	-

pH in the surface soil is neutral, while subsoil material is alkaline. EC and Cl analyses (see Appendices 2 and 5) indicate profile salinity is consistently low (Cl <20ppm). CEC levels are very high (>38-43meq/100g) throughout, and moderately high CEC/clay ratios (0.57-0.60), obvious cracking behaviour and strong lenticular structure suggest the clay fraction is active, has significant shrink-swell characteristics and is of mixed mineralogy with a significant proportion of smectites. ESP data indicate surface and upper subsoil horizons to about 0.9m are non-sodic (ESP<6), while the lower subsoil is only moderately sodic (ESP <10). Ca/Mg ratios are very high suggesting stable structural integrity.

Physical Soil Characteristics – representative data from BNCOP Site 66

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	1	10	23	66	-	0.58	0.37	3.2	1	low
0.25 – 0.35	1	9	22	68	-	0.60	0.39	3.7	2	low
0.55 – 0.65	2	6	19	72	-	0.58	0.44	2.7	5	low
0.85 – 0.95	1	6	18	75	-	0.57	0.58	2.0	9	moderate

Clay content is uniformly very high (66-75%) throughout. Silt contents are markedly elevated in surface horizons (22-23%), and reflect regular depositional history. The surface soil/upper subsoil to about 0.5m is strongly structured, non-sodic (ESP <2), with significant shrink-swell capacity, Ca dominant cation chemistry and very low dispersion (R1 0.37-0.39). The lower subsoil to about 1.2m is similar, but with weak to moderate sodicity (ESP 5-9) and increasing dispersion (R1 0.44-0.58). Below 1.2m, sodicity, dispersion, salinity and coarse macro lenticular structure are expected to increase significantly and adverse physical behaviour and poor establishment response is likely post-disturbance.

Summary

Surface soil/upper subsoil material to 0.8m has high to very high fertility and is strongly aggregated and finely structured. It is further characterised by very high clay content (65-72%), active clay behaviour (CEC/Clay ratio 0.58-0.60), low sodicity (ESP <5), low dispersion (R1 <0.45), Ca dominant cation chemistry and low salinity (<0.2dS/m). These attributes suggest material to 0.8m will be relatively benign and physically stable/resilient following disturbance. It is likely however, to experience shrink-swell behaviour, strong cracking and significant root zone shearing (depending on placement thickness). Salvaged topsoil materials to 0.8m are suitable for replacement on low to moderate gradients. **Subsoil material between 0.8-1.2m** has similar physical characteristics, but with increasing sodicity (ESP 9) and dispersive behaviour (R 0.58). Salvage of this material is recommended, but only as root zone media for sub-surface replacement. **Lower subsoil material below 1.2m** is considered increasingly undesirable with moderate levels of salinity and worsening sodicity and dispersive behaviour. It is not recommended for salvage.

Soil 2b – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.3m	Strip structured surface soil/subsoil clay to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.2m	Strip additional root zone media 0.3-1.2m for sub-surface replacement only.
Single stage	Combined	0-0.8m	Strip structured surface soil/subsoil clay to 0.8m as surrogate topsoil material. Avoid increasingly undesirable grey/brown clay below 0.8m.

Soil 2b – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	2	Suitable with minor limitations	e2, es2, m2, ps2, w2	A1
Grazing	2	Fattening – suitable for improved pastures, attains max grazing productivity in most seasons	m2, nd2, ps2, w2, f2, v2, ph2	-

Soil 2b – Strategic Cropping Land – WCZ Zonal Criteria Assessment (Queensland Government 2011)

Soil	ZC 1	ZC 2	ZC 3	ZC 4	ZC 5	ZC 6	ZC 7	ZC 8	SCL status
2b	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	**Decided SCL (slope ≤ 3%)**

Soil 3a — Flooded black clay in upper floodplain drainage lines + coolibah

Soil concept: Hardsetting to coarsely self-mulching, (poached), black cracking clay in narrow terrace drainage lines of the upper floodplain; subject to both local and flood inundation.

Regional Soil Name: Bluchers (Bc), Lindsay (Ld)
Aust. Soil Classification: Black Vertosol **Principal Profile Form:** Ug5.17

Landform: Indistinct narrow drainage lines, runners and secondary floodways within upper floodplain terraces; subject to both local and flood inundation. Slopes <1.0% within drainage lines, 3-5% on sideslopes.
Geological landscape: Quaternary alluvium (Qa). Sand, clay and gravel.
Land zone: Cainozoic alluvial plains (LZ 3).
Vegetation: Coolibah ± shrubs ± brigalow.

Runoff, perm., & drainage: Very slow to slow runoff; slow permeability; moderately well drained.
Surface features: Hardsetting to moderately self-mulching (very coarse 5-10mm); strong cracking; non-gilgaied; no surface gravel or stone.

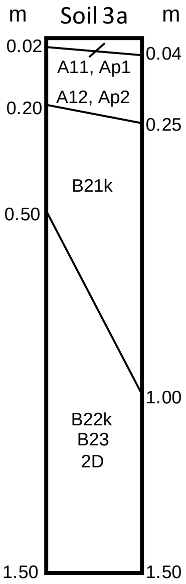
	Total N (%)	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
Surface soil fertility:	high (0.195)	very high (83)	very high (1.33)	very high (18.1)

Moisture Characteristics: **ERD:** 0.8->1.0m (salinity >0.8dS/m or >800ppm Cl) **PAWC:** 95-120mm/1.0m

Investigation sites: **Field sites** – 13, 15, 50, 69 **Analysed sites** – 69


Open coolibah ± brigalow woodland in a narrow upper floodplain drainage line at Site 69.

Hardsetting to weakly self-mulching, silty, black cracking clay in a narrow drainage line at Site 69.



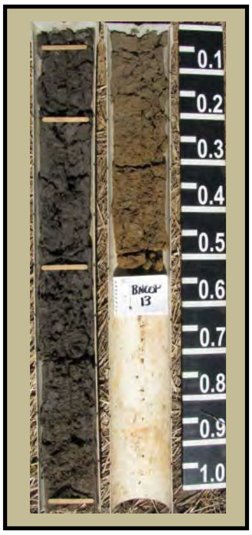
Profile description

The **surface soil** (A11, Ap1) is a black (10YR 3/1) light medium to medium clay (sometimes silty) with moderate to strong coarse granular to blocky structure ± minor <2% nodular carbonate; field pH 6.5-7.0. Clear change to

The **plough zone where cultivated** (A12, Ap2) is a black (10YR, 2.5Y 2/1-3/1) medium heavy clay with strong fine blocky or lenticular structure ± minor <2% nodular carbonate; field pH 7.0-8.5. Clear change to

The **upper subsoil** (B21k) is a black (10YR, 2.5Y 3/1) medium heavy to heavy clay with strong coarse lenticular parting to fine lenticular structure ± minor <2% nodular carbonate; field pH 7.5-9.0. Gradual/diffuse change to

The **lower subsoil** (B22k, B23, 2D) is a grey or brown (10YR, 2.5Y 4/1-4/3, 5/4) fine sandy medium to fine sandy medium heavy clay with strong very fine lenticular structure and increasing salinity; occasional sandy clay buried horizons (2D) with weak to moderate blocky structure may be present below about 1.25m; field pH 5.5-9.0.



Subsoil Chemistry – representative data from BNCOP Site 69

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.6	0.081	30	30	18.1	9.8	1.33	0.418
0.25 – 0.35	7.5	0.057	<5	30	22.8	7.5	0.330	0.764
0.55 – 0.65	8.4	0.094	10	33	23.8	10.1	0.273	1.85
0.85 – 0.95	8.6	0.288	280	30	17.6	10.9	0.230	3.91
1.15 – 1.25	6.2	0.453	650	-	-	-	-	-

pH is neutral to alkaline throughout. EC and Cl analyses (see Appendices 2 and 5) indicate low levels of soluble salts (<0.3dS/m) to about 0.9m, but moderate to high levels below this depth. CEC levels are high (>30meq/100g) throughout. Moderately high CEC/clay ratios (0.49-0.58) and the presence of cracking and strong lenticular structure suggest the clay fraction is active, has significant shrink-swell characteristics and is of mixed mineralogy with a significant proportion of smectites. ESP data indicate surface and upper subsoil horizons to about 0.9m (0.8-1.0m = start of B22/2D) are non-sodic (ESP<6), while the lower subsoil below 1.0m is moderately sodic (ESP 13). Ca/Mg ratios are very high throughout.

Physical Soil Characteristics – representative data from BNCOP Site 69

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	2	17	18	61	-	0.49	0.44	1.8	1	low
0.25 – 0.35	10	24	15	52	-	0.58	0.36	3.0	3	low
0.55 – 0.65	9	21	12	59	-	0.56	0.45	2.4	6	low
0.85 – 0.95	12	22	16	52	-	0.58	0.72	1.6	13	moderate

Clay content is uniformly high (52-61%) throughout. Silt contents are slightly elevated in surface horizons (15-18%), and reflect depositional history. The surface soil/upper subsoil to about 0.6-0.7m is strongly structured, non-sodic (ESP <6), with significant shrink-swell capacity, Ca dominant cation chemistry and low to very low dispersion (R1 0.36-0.45). The lower subsoil to about 1.0m is similar, but with weak to moderate sodicity (ESP 6-13) and increasing dispersion (R1 0.72). Below 1.0m, increasing sodicity, worsening dispersion and moderate to high salinity suggest adverse physical behaviour and poor establishment response is likely post-disturbance.

Summary

Surface soil/upper subsoil material to 0.7m has high to very high fertility and is strongly aggregated and finely structured. It is further characterised by high clay content (52-61%), active clay behaviour (CEC/Clay ratio 0.49-0.56), low sodicity (ESP <6), low dispersion (R1 <0.45), Ca dominant cation chemistry and low salinity (<0.3dS/m). These attributes suggest material to 0.7m will be relatively benign and physically stable/resilient following disturbance. It is likely however, to experience shrink-swell behaviour, strong cracking and significant root zone shearing (depending on placement thickness). Salvaged topsoil materials to 0.7m are suitable for replacement on low to moderate gradients. **Subsoil material between 0.7-1.0m** has similar physical characteristics, but with moderate levels of salinity (EC 0.3-0.5dS/m), and increasing sodicity (ESP 6-13), and dispersive behaviour (R 0.72). Salvage of this material is recommended, but only as root zone media for sub-surface replacement. **Lower subsoil material below 1.0m** is considered increasingly undesirable, with moderate to high levels of salinity and worsening sodicity and dispersive behaviour. It is not recommended for salvage.

Soil 3a – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.3m	Strip structured surface soil/subsoil clay to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.0m	Strip additional root zone media 0.3-1.0m for sub-surface replacement only.
Single stage	Combined	0-0.7m	Strip structured surface soil/subsoil clay to 0.7m as surrogate topsoil material. Avoid increasingly undesirable grey or brown clay below 0.7m.

Soil 3a – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	3	Suitable with moderate limitations	e2, es2, m3, ps3, w2	A1
Grazing	2	Fattening – suitable for improved pastures, attains max grazing productivity in most seasons	m2, nd2, ps2, w2, f2, v2, ph2	-

Soil 3a – Strategic Cropping Land – WCZ Zonal Criteria Assessment (Queensland Government 2011)

Soil	ZC 1	ZC 2	ZC 3	ZC 4	ZC 5	ZC 6	ZC 7	ZC 8	SCL status
3a	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	**Decided SCL (slope ≤ 3%)**

Soil 3b — Loamy brown sodic texture contrast soil on tributary alluvium + poplar box

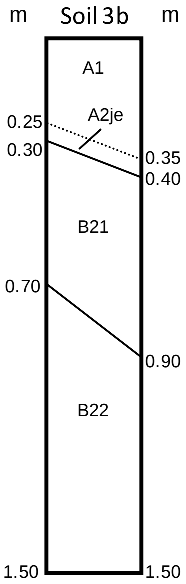
Soil concept:	Hardsetting, clay loamy surfaced (0.2-0.4m), bleached, brown sodic texture contrast soil on level alluvial plains of Saline Creek and associated tributaries.
Regional Soil Name:	Roper (Rp)
Aust. Soil Classification:	Brown Sodosol **Principal Profile Form:** Db1.33, 1.43, Db2.33, 2.43
Landform:	Level alluvial plains of local tributaries of the Dawson River, particularly Saline Creek; relatively narrow, ephemeral floodplains and local creek flats characterized by provenance derived fine sandy sedimentation from local upstream catchments. Slopes mostly <1.0%.
Geological landscape:	Quaternary alluvium (Qa). Sand, clay and gravel.
Land zone:	Cainozoic alluvial plains (LZ 3).
Vegetation:	Shrubby poplar box ± brigalow.
Runoff, perm., & drainage:	Slow runoff; slow permeability; moderately well drained.
Surface features:	Hardsetting; non-cracking/rigid; non-gilgaied; no surface gravel or stone.

Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
	high (0.105)	high (28)	mod.-high (0.63)	mod.-high (5.3)

Moisture Characteristics:	**ERD:** 0.5-0.6m (rigid soil – ESP >15%)	**PAWC:** 45-55mm/1.0m
Investigation sites:	**Field sites** – 27, 31	**Analysed sites** – 27

Shrubby poplar box regrowth at Site 27 on the alluvial plain of Saline Creek in the north-west of the survey area.

Clay loamy surfaced, brown sodic texture contrast soil on the alluvial plain of Saline Creek at Site 27.



Profile description

The **surface soil** (A1) is a brown (10YR 3/3-4/3), fine sandy clay loam to clay loam fine sandy with weak subangular blocky to massive structure; field pH 5.5-6.5. Clear change to

The **sub-surface layer** (A2je) is a thin, sporadically or conspicuously bleached, brown (7.5YR, 10YR 4/4-5/4), fine sandy clay loam to clay loam fine sandy with massive structure; field pH 5.5-6.5. Abrupt change to

The **upper subsoil** (B21) is a brown (10YR 4/3-4/4), fine sandy light to light medium clay with weak prismatic to moderate blocky structure; field pH 7.0-8.0. Gradual change to

The **lower subsoil** (B22) is a grey or brown (10YR 5/2-5/4), mottled (orange), clay loam sandy to sandy light clay with weak to moderate blocky or prismatic structure; field pH 8.0-8.5.

Subsoil Chemistry – representative data from BNCOP Site 27

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.2	0.059	40	9	5.3	2.6	0.629	0.199
0.25 – 0.35	5.6	0.021	5	4	2.2	1.5	0.132	0.242
0.55 – 0.65	6.8	0.070	35	9	3.6	4.0	0.142	1.69
0.85 – 0.95	7.9	0.096	73	9	3.6	3.8	0.13	1.67
1.15 – 1.25	8.3	0.255	265	-	-	-	-	-

pH is acidic in surface horizons and neutral to alkaline throughout the subsoil. EC and Cl analyses (see Appendices 2 and 5) indicate low salinity (EC <0.3dS/m) throughout. CEC levels are also low (4-9 meq/100g) throughout and CEC/clay ratios in the subsoil (0.31-0.38) suggest the clay fraction is largely un-reactive and of mixed mineralogy. Sodicity data indicates loamy surface soil to about 0.3-0.4m is non sodic (ESP 2-6), while subsoil clay below this depth is strongly sodic. Magnesium (Mg) levels co-dominate cation chemistry in the subsoil and are likely to enhance any dispersive behaviour.

Physical Soil Characteristics – representative data from BNCOP Site 27

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	8	45	29	21	-	0.43	0.65	2.0	2	low
0.25 – 0.35	9	49	25	21	-	0.19	0.75	1.5	6	low
0.55 – 0.65	14	46	13	29	-	0.31	0.99	0.9	18	high
0.85 – 0.95	19	50	10	24	-	0.38	0.92	0.9	19	high

Clay content increases sharply between surface horizons (21%) and the underlying subsoil (29%). The surface soil is massive to very weakly structured and is characterized by high levels of fine sand and silt (70-75% combined). This suggests significant slaking and pulverescent/hardsetting behaviour is likely following disturbance. PSA data indicates physical characteristics within the subsoil are co-dominated by fine sand (46-50%) and clay fractions (24-29%). Disturbed subsoil materials are likely to be un-reactive and prone to pulverescent behaviour (when dry), dense particle packing and severe compaction and crusting behaviour post disturbance. Laboratory measured dispersion is moderate (R1 0.65-0.75) in the surface soil (due to high levels of silt and fine sand), but increases to extreme levels (R1 0.92-0.99) throughout the subsoil.

Summary

Surface soil material to 0.3-0.4m has high fertility, massive to very weak structure, moderately low clay content (21%), elevated levels of fine sand/silt (70-75% combined), low salinity (EC <0.1dS/m) and low sodicity (ESP<6) characteristics. It is likely this material will be prone to pulverescent/hardsetting behaviour following disturbance and will be subject to slaking and high erosion risk. Salvaged materials are recommended only for replacement on level terrain or very low gradients. **Subsoil material below 0.3-0.4m** has unfavourable physical attributes. It is characterized by coarse, dense structure and a strongly sodic (ESP 18-19), dispersive (R1 0.92-0.99), un-reactive clay fraction. Salvaged subsoil materials would be subject to dense packing and compaction, severe slaking, dispersion, crusting and extreme erosion risk following replacement and subsequent exposure. Subsoil material is not recommended for salvage.

Soil 3b – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.35m	Strip loamy surface soil to 0.35m and segregate as primary topsoil to preserve topsoil/seed source material. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
	Root zone	nil	Subsoil clay below 0.35m is dispersive and should be avoided.
Single stage	Combined	0-0.35m	Strip loamy surface soil to 0.35m (maximum) as topsoil/seed source material. Avoid dispersive subsoil clay below 0.35m. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.

Soil 3b – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	5	Unsuitable due to extreme limitations	es3, m5, pm3, ps4, w2	-
Grazing	3	"Grower" country – suitable for improved pastures, but less productive than Classes 1 & 2	m3, nd2, ps2, w2, f2, v2	C1

Soil 4c — Strongly self-mulching black clay on upper floodplains + brigalow

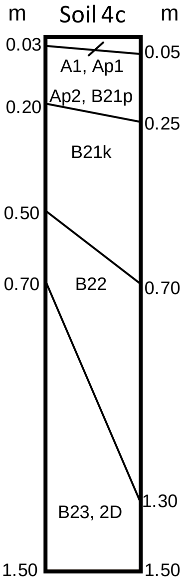
Soil concept:	Moderately to strongly self-mulching, black cracking clay on elevated level backplains within the upper floodplain of the Dawson River anabranch**.**
Regional Soil Name:	Langley (Lg)
Aust. Soil Classification:	Black Vertosol **Principal Profile Form:** Ug5.15, 5.16, 5.17
Landform:	Level backplains within elevated, upper floodplain terraces; typically level and extensive; less severely and less regularly flooded than lower floodplain areas. Slopes <1.0%.
Geological landscape:	Quaternary alluvium (Qa). Sand, clay and gravel.
Land zone:	Cainozoic alluvial plains (LZ 3).
Vegetation:	Brigalow ± minor softwood species.
Runoff, perm., & drainage:	Very slow to slow runoff; slow permeability; moderately well drained.
Surface features:	Thick (>0.03m), moderately to strongly self-mulching surface (2-5mm) with a weak surface flake after rain; strong cracking; non-gilgaied; no surface gravel or stone.

Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
	very high (0.149)	very high (56)	very high (1.33)	very high (34.1)

Moisture Characteristics:	**ERD:** 0.75->1.0m (salinity >0.8dS/m or >800ppm Cl)	**PAWC:** 90-120mm/1.0m
Investigation sites:	**Field sites** – 53, 54, 55, 65, 67, 68, 70, 73, 74	**Analysed sites** – 65


Brigalow backplains within the upper floodplain developed to cropping (Soil 4c – Site 65).

Strongly self-mulching, black cracking clay typical of Soil 4c (Site 67).



Profile description

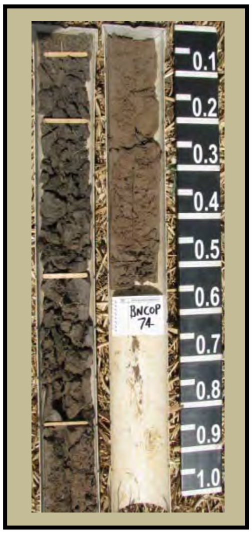
The **surface soil** (A1, Ap1) is a black (10YR, 2.5Y 3/1-3/2) medium clay with strong fine granular structure; field pH 7.0-8.5. Clear change to

The **plough zone where cultivated** (Ap2, B21p) is a black (10YR, 2.5Y 2/1-3/1) medium heavy to heavy clay with strong fine blocky or lenticular structure ± <2% nodular carbonate; field pH 8.0-8.5. Clear change to

The **upper subsoil** (B21k, B22) is a black (10YR, 2.5Y 2/1-3/1) medium heavy to heavy clay with strong fine blocky structure grading to strong fine lenticular structure with depth; and minor <2-10% soft or nodular carbonate; field pH 8.5-9.0. Gradual or diffuse change to

The **lower subsoil** (B23) is a black or grey (10YR, 2.5Y 3/1-4/2) medium to medium heavy clay with strong lenticular structure ± slickensides ± <2-10% soft or nodular carbonate; field pH 8.5 decreasing with depth to 5.0-7.0.

Buried layers (2D) where present are brown (7.5YR, 10YR 3/3-4/6) fine sandy medium to medium heavy clays with moderate blocky or strong lenticular structure; field pH 5.0-7.0.



Subsoil Chemistry – representative data from BNCOP Site 65

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	8.4	0.165	40	37	34.1	7.5	1.33	0.966
0.25 – 0.35	8.8	0.218	40	40	31.9	10.6	0.609	3.35
0.55 – 0.65	9.0	0.307	80	39	24.7	12.1	0.496	5.24
0.85 – 0.95	8.6	0.458	420	35	19.0	11.9	0.462	6.17
1.15 – 1.25	7.1	0.907	1030	-	-	-	-	-

pH is alkaline in the upper profile to about 0.7-1.2m, but becomes acidic (pH 6.5-5.0) below this. EC and chloride (Cl) data (see Appendices 2 and 5) confirm low salinity (<0.3dS/m) to about 0.6m, moderate levels (0.3-0.6dS/m) between 0.6-0.9m and increasing salinity below 0.9m. High CEC levels (35-40meq/100g), moderately high CEC/clay ratios (>0.6) and the presence of cracking and strong lenticular structure suggest the clay fraction is active, has significant shrink-swell characteristics and is of mixed mineralogy with a high proportion of smectites. ESP data indicate soil material is effectively non-sodic to 0.4m, moderately sodic (ESP 8-13) from 0.4-0.8m and strongly sodic (ESP 13-18) below about 0.8m.

Physical Soil Characteristics – representative data from BNCOP Site 65

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	2	14	23	60	-	0.62	0.39	4.5	3	low
0.25 – 0.35	2	12	21	63	-	0.63	0.47	3.0	8	low-mod.
0.55 – 0.65	3	11	22	65	-	0.60	0.68	2.0	13	mod
0.85 – 0.95	1	12	27	63	-	0.56	0.79	1.6	18	high

Clay content is very high and uniform throughout (60-65%). Silt contents are consistently elevated (21-27%) throughout and reflect depositional history. The surface soil/upper subsoil to about 0.4m is strongly structured and non-sodic to only weakly sodic (ESP 3-8), with significant shrink-swell capacity, Ca dominant cation chemistry and low dispersion (R1 0.39-0.47). The upper subsoil to about 0.8m is similar, but with moderate sodicity (ESP 8-13) and increasing dispersion (R1 0.47-0.68). Below 0.8m, increasing sodicity, worsening dispersion and moderate to very high salinity suggest adverse physical behaviour and poor establishment response is likely post-disturbance.

Summary

Surface soil/upper subsoil material to 0.4m has very high fertility and is strongly aggregated, finely structured and non-sodic to very weakly sodic (ESP 3-8). It is further characterised by high clay content (60-63%), active clay behaviour (CEC/Clay ratio 0.62-0.63), low dispersion (R1 0.39-0.47), Ca dominant cation chemistry and low salinity (<0.3dS/m). These attributes suggest material to 0.4m will be relatively benign and physically stable/resilient post disturbance. It is likely however, to experience significant shrink-swell behaviour, cracking and root zone shearing (depending on placement thickness). Salvaged topsoil materials to 0.4m are suitable for replacement on low to moderate gradients. **Subsoil material between 0.4-0.8m** has similar physical characteristics, but with low to moderate levels of salinity (EC 0.3-0.6dS/m) and sodicity (ESP 8-13), and increasing dispersive behaviour (R 0.47-0.68). Salvage of this material is recommended, but only as root zone media for sub-surface replacement. **Lower subsoil material below 0.8m** is considered undesirable, with high to very high levels of salinity and worsening sodicity and dispersive behaviour. It is not recommended for salvage.

Soil 4c – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.3m	Strip structured surface soil/subsoil clay to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-0.8m	Strip additional root zone media between 0.3-0.8m for sub-surface replacement only. Avoid grey or brown clay below about 0.7-0.9m.
Single stage	Combined	0-0.4m	Strip structured surface soil/subsoil clay to 0.4m as primary topsoil. Avoid increasingly undesirable subsoil material below 0.4m.

Soil 4c – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	3	Suitable with moderate limitations	e2, es2, m3, ps2, w2	A1
Grazing	2	Fattening – suitable for improved pastures, attains max grazing productivity in most seasons	m2, ps2, sa2, f2, ph2	-

Soil 4c – Strategic Cropping Land – WCZ Zonal Criteria Assessment (Queensland Government 2011)

Soil	ZC 1	ZC 2	ZC 3	ZC 4	ZC 5	ZC 6	ZC 7	ZC 8	SCL status
4c	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	**Decided SCL (slope ≤ 3%)**

Soil 4d — Weakly melonholed grey clay on upper floodplains + brigalow

Soil concept: Weakly to moderately self-mulching, grey cracking clay with weak to moderate melonhole gilgai (VI <0.3-0.6m, HI 10-25m) on level backplains of the Dawson River.

Regional Soil Name: Langley (Lg), Tralee (Tl)
Aust. Soil Classification: Grey Vertosol **Principal Profile Form:** Ug5.16

Landform: Level backplains within the upper floodplain of the Dawson River; relatively elevated, active backplains characterized by weakly to moderately developed melonhole gilgai and a lack of obvious flood channels/runners; subject to occasional flooding. Slopes <1.0%.
Geological landscape: Quaternary alluvium (Qa). Sand, clay and gravel.
Land zone: Cainozoic alluvial plains (LZ 3).
Vegetation: Brigalow ± coolibah (emergent).

Runoff, perm., & drainage: Slow runoff; slow permeability; moderately well drained.
Surface features: Thin, weakly to moderately self-mulching surface (2-5mm); strong cracking; weak to moderate melonhole gilgai (VI 0.3-0.6m, HI 10-25m); no surface gravel or stone.

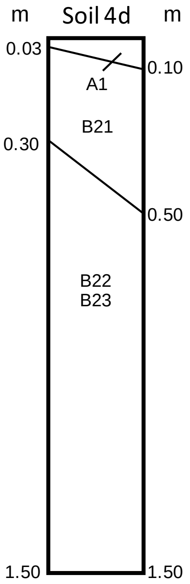
Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
	very high (0.255)	high (36)	very high (1.02)	very high (22.2)

Moisture Characteristics: **ERD:** 0.7 >1.0m (salinity >0.8dS/m or >800ppm Cl) **PAWC:** 85-120mm/1.0m

Investigation sites: **Field sites** – 9, 10, 18, 110 **Analysed sites** – 110

Brigalow ± coolibah upper floodplain adjacent to the Dawson River, north of the oxbow (Site 9).

Weakly to moderately self-mulching, weakly melonholed, grey cracking clay at Site 110.

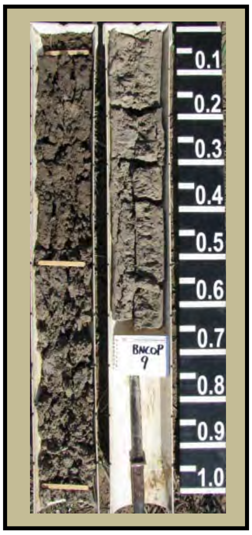


Profile description

The **surface soil** (A1, Ap where cultivated) is a black or grey (10YR 3/1-4/2) light medium to medium clay (often fine sandy) with moderate to strong granular or fine blocky structure; field pH 7.5 - 8.5. Clear change to

The **upper subsoil** (B21, B21p where cultivated) is a black or grey (10YR 3/1-5/2) medium to medium heavy clay with moderate to strong blocky or lenticular structure; and <2->20% fine, soft or nodular carbonate; field pH 8.0-9.0. Gradual or diffuse change to

The **lower subsoil** (B22, B23) is a grey or greyish brown (10YR, 2.5Y 4/2-5/3), medium to medium heavy clay with strong coarse macro lenticular parting to friable fine secondary lenticular structure; and 2-10% soft or nodular carbonate; field pH 8.5-9.0.



Subsoil Chemistry – representative data from BNCOP Site 110

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	7.4	0.128	10	28	22.2	4.9	1.02	0.089
0.25 – 0.35	9.0	0.189	18	26	17.5	11.1	0.407	1.45
0.55 – 0.65	9.0	0.829	525	28	12.2	14.7	0.37	5.06
0.85 – 0.95	8.8	1.391	1600	28	11.5	16.0	0.394	5.85
1.15 – 1.25	8.4	1.700	2250	-	-	-	-	-

pH is alkaline to strongly alkaline throughout. EC and chloride (Cl) data (see Appendices 2 and 5) indicate low salinity (<0.3dS/m) to 0.4-0.5m, moderate to high levels (0.3-0.8dS/m) to between 0.7-1.0m and increasing salinity below 0.7-1.0m. High CEC levels (26-28meq/100g), moderately high CEC/clay ratios (0.52-0.72) and the presence of cracking and strong lenticular structure suggest the clay fraction is active, has significant shrink-swell characteristics and is of mixed mineralogy with a high proportion of smectites. ESP data indicate surface and upper subsoil horizons to about 0.4m are non-sodic (ESP <6), but become strongly to extremely sodic (ESP 18-21) below 0.4m. Magnesium (Mg) dominates cation chemistry in the lower subsoil and is likely to enhance any dispersive behaviour.

Physical Soil Characteristics – representative data from BNCOP Site 110

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	22	26	12	39	-	0.72	0.30	4.5	<1	low
0.25 – 0.35	18	21	13	49	-	0.53	0.50	1.6	6	low
0.55 – 0.65	16	20	14	54	-	0.52	0.70	0.8	18	high
0.85 – 0.95	14	21	9	53	-	0.53	0.61	0.7	21	very high

Clay content in immediate surface/upper subsoil horizons is moderately high (39-49%), with significant levels of fine sand (21-26%). The upper subsoil to about 0.4m is characterized by moderate to strong structure, strong cracking, significant reactivity and shrink-swell behaviour, Ca dominant cation chemistry, low sodicity levels (ESP <6) and low dispersion (R1 0.3-0.5). This material is likely to be relatively stable and resilient following disturbance. Below 0.4m, increasing sodicity, dispersion and salinity suggest adverse physical behaviour and poor establishment response is likely post-disturbance.

Summary

Surface soil/upper subsoil material to 0.4m (on mounds and shelves) has high to very high fertility and is strongly aggregated and finely structured. It is further characterised by high clay content (39-49%), active clay behaviour (CEC/Clay ratio 0.53-0.72), low sodicity (ESP <6), low dispersion (R1 0.3-0.5), Ca dominant cation chemistry and low salinity (<0.3dS/m). These attributes suggest material to 0.4m will be relatively benign and physically stable/resilient post disturbance. It is likely however, to experience shrink-swell behaviour, strong cracking and significant root zone shearing (depending on placement thickness). Salvaged topsoil materials to 0.4m are suitable for replacement on low to moderate gradients. **Lower subsoil material below 0.4m** (on mounds and shelves) has undesirable physical and chemical attributes, characterized by moderate to very high levels of salinity and significant sodicity and dispersive behaviour. It is not recommended for stripping, because salvaged materials are likely to be subject to detrimental salinity, dispersion, slaking and erosion risk following disturbance. Stripping recommendations are based preferentially on soil characteristics within mound profiles due to their potentially greater contribution to final stripping volumes and shallower depth to unfavourable materials (Burgess 2003a).

Soil 4d – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.4m	Strip structured surface soil/subsoil clay to 0.4m and segregate as primary topsoil to preserve seed source material.
	Root zone	nil	Subsoil clay below 0.4m is undesirable and should be avoided.
Single stage	Combined	0-0.4m	Strip structured surface soil/subsoil clay to 0.4m as primary topsoil. Avoid undesirable subsoil clay below 0.4m. Melonhole gilgai (where present) require topsoil be stripped with an excavator and batter bucket; stripping depth should follow surface contours.

Soil 4d – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	3	Suitable with moderate limitations	e2, es3, m3, ps2, tm3, w2	A1
Grazing	2	Fattening – suitable for improved pastures, attains max grazing productivity in most seasons	m2, ps2, sa2, tm2, w2, f2, v2, ph2	-

Soil 5 — Weakly to mod. self-mulching black clay on Qa – TQr sideslopes + brigalow

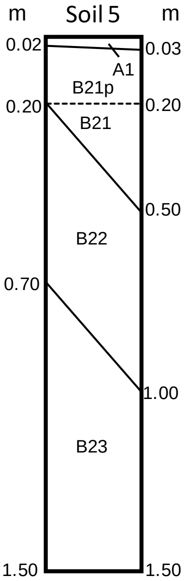
Soil concept:	Firm pedal or weakly to moderately self-mulching, black cracking clay on gently undulating sideslopes/plains that mark the transition from recent alluvium to older elevated plains.
Regional Soil Name:	Affinities with Tralee (Tl)
Aust. Soil Classification:	Black or Grey Vertosol **Principal Profile Form:** Ug5.15, 5.16, 5.17
Landform:	Dissected margins of the upper floodplain of the Dawson River anabranch; typically gently undulating sideslopes that are transitional between recent alluvium of the upper floodplain and older, more elevated TQr landscapes adjacent; subject to occasional flooding in large events. Slopes mostly 1-3%, up to 5% where dissected.
Geological landscape:	Quaternary alluvium (Qa) over insitu TQr clay deposits. Sand, clay and gravel.
Land zone:	Cainozoic alluvial plains (LZ 3)/transitional to Cainozoic clay deposits (LZ4).
Vegetation:	Brigalow ± shrubby species.
Runoff, perm., & drainage:	Slow runoff; slow permeability; moderately well drained.
Surface features:	Thin, firm pedal to moderately self-mulching surface (2-5mm); strong cracking; non-gilgaied; no surface gravel or stone.

Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
	high (0.116)	high (32)	high (0.955)	very high (24.1)

Moisture Characteristics:	**ERD:** 0.6-0.7m (salinity >0.8dS/m or >800ppm Cl)	**PAWC:** 70-85mm/1.0m
Investigation sites:	**Field sites** – 49, 71, 71a, 71b, 71c	**Analysed sites** – 71

Cleared brigalow transitional side slope between the upper floodplain (cropping area) and adjacent elevated TQr landscapes (Site 49).

Weakly to moderately self-mulching, black cracking clay on transitional sideslopes at Site 49.



Profile description

The **surface soil** (A1) is a black (10YR 3/1-3/2) medium clay with moderate to strong blocky grading to fine granular structure; field pH 7.0–8.5. Clear change to

The **upper subsoil** (B21, B21p, B22) is a black (10YR 3/1-3/2) medium heavy clay with moderate to strong blocky grading to strong lenticular structure; and <2-10% soft or nodular carbonate; field pH 8.0–9.0. Clear to diffuse change to

The **lower subsoil** (B22, B23) is a brown or grey (7.5YR, 10YR 4/2-4/4), often mottled, fine sandy medium to fine sandy medium heavy clay with strong lenticular structure; field pH 5.0-7.5.

Subsoil Chemistry – representative data from BNCOP Site 71

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	8.5	0.194	95	33	24.1	9.2	0.955	1.41
0.25 – 0.35	8.9	0.370	155	32	19.2	12.7	0.343	4.35
0.55 – 0.65	8.7	0.821	790	34	15.5	14.7	0.352	6.55
0.85 – 0.95	7.7	1.180	1600	34	12.7	14.7	0.382	6.77
1.15 – 1.25	5.5	1.305	1850	-	-	-	-	-

pH is alkaline to about 1.0m, but becomes acidic or strongly acidic (pH 6.5-5.0) at depth. EC and chloride (Cl) data (see Appendices 2 and 5) indicate low salinity (<0.3dS/m) to 0.4-0.5m, moderate to high levels (0.3-0.8dS/m) to about 0.7m and increasing salinity (>0.8dS/m) below 0.7m. High CEC levels (32-34meq/100g), moderately high CEC/clay ratios (0.50-0.56) and the presence of cracking and strong lenticular structure suggest the clay fraction is active (shrink-swell behaviour) and is of mixed mineralogy with a high proportion of smectites. ESP data indicate surface and upper subsoil horizons to about 0.2m are non-sodic (ESP 4), while the upper subsoil to about 0.4-0.5m is weakly to moderately sodic (ESP 4-14). Subsoil material below this depth is subject to rapidly increasing sodicity (ESP 19-20) and dispersion (R1 >0.75). Magnesium (Mg) co-dominates cation chemistry in the lower subsoil and is likely to enhance any dispersive behaviour.

Physical Soil Characteristics – representative data from BNCOP Site 71

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	9	17	17	59	-	0.56	0.32	2.6	4	low
0.25 – 0.35	9	15	18	60	-	0.53	0.65	1.5	14	moderate
0.55 – 0.65	7	14	15	66	-	0.52	0.75	1.1	19	high
0.85 – 0.95	6	14	14	68	-	0.50	0.78	0.9	20	high

Clay content is consistently very high throughout (59-68%), while silt levels in immediate surface horizons are only marginally elevated (17-18%) and reflect only intermittent depositional history. Surface and upper subsoil materials to about 0.2m are strongly structured, with significant reactivity (shrink swell behaviour), Ca dominant cation chemistry, low sodicity (ESP 4) and low dispersion (R1 0.32). The upper subsoil to about 0.4m is similar, but with weak to moderate sodicity (ESP 4-14) and increasing dispersion (R1 0.65). Below 0.4m, increasing sodicity, worsening dispersion and very high to extreme salinity suggest adverse physical behaviour and poor establishment response is likely post-disturbance.

Summary

Surface soil/upper subsoil material to about 0.2m has high fertility, and is strongly aggregated and finely structured. It is characterised by high clay content (59%), active clay behaviour (CEC/Clay ratio 0.56), low sodicity (ESP 4), low dispersion (R1 0.32), Ca dominant cation chemistry and low salinity (<0.3dS/m). These attributes suggest material to 0.2m will be relatively benign and physically stable/resilient post disturbance. It is however, likely to experience shrink-swell behaviour, strong cracking and significant root zone shearing (depending on placement thickness). Salvaged topsoil materials to 0.2m are suitable for replacement on low to moderate gradients. **Subsoil material between 0.2-0.4m** has similar characteristics, but is moderately sodic (ESP 4-14) and dispersive (R1 0.65). Salvage of this material is recommended, but only as root zone media for sub-surface replacement. **Lower subsoil material below 0.4m** is considered undesirable, with very high salinity and worsening sodicity and dispersive behaviour. It is not recommended for salvage.

Soil 5 – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.2m	Strip structured surface soil/subsoil clay to 0.2m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.2-0.4m	Strip additional root zone media between 0.2-0.4m for sub-surface replacement only. Avoid undesirable subsoil material below 0.4m.
Single stage	Combined	0-0.2m	Strip surface soil/subsoil clay to 0.2m as primary topsoil. Avoid increasingly undesirable subsoil material below 0.2m.

Soil 5 – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	4	Marginal due to severe limitations	e3, es4, m4, ps2, w2	B
Grazing	2	Fattening – suitable for improved pastures, attains max grazing productivity in most seasons	m2, ps2, sa2, f2, ph2	-

Soil 5 – Strategic Cropping Land – WCZ Zonal Criteria Assessment (Queensland Government 2011)

Soil	ZC 1	ZC 2	ZC 3	ZC 4	ZC 5	ZC 6	ZC 7	ZC 8	SCL status
5	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	**Decided non SCL**

Soil 7a — Strongly melonholed grey clay on level TQr plains + brigalow

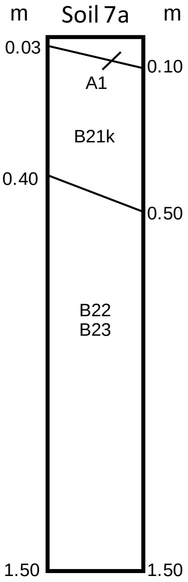
Soil concept:	Hardsetting or firm pedal to weakly self mulching, grey cracking clay with strongly developed melon-hole gilgai (VI 0.3-0.8m, HI 12-20m) on older clay sheets; saline, sodic and acidic at depth.
Regional Soil Name:	Turon (Tr), Greycliffe melonhole phase (GcMp)
Aust. Soil Classification:	Grey Vertosol **Principal Profile Form:** Ug5.24, 25, occ. Ug5.16
Landform:	Level plains associated with elevated Cainozoic clay sheets. Slopes <1%.
Geological landscape:	Unconsolidated Tertiary–Quaternary sediments (Czs, Cza, TQr). Includes insitu and reworked Tertiary clay and widespread reworked local clayey colluvium.
Land zone:	Cainozoic clay deposits (LZ 4).
Vegetation:	Brigalow.
Runoff, perm., & drainage:	Very slow runoff; slow to very slow permeability; imperfectly to mod. well drained.
Surface features:	Hardsetting, firm pedal or weakly self-mulching; cracking; well developed melonhole gilgai (VI 0.3-0.8m, HI 12-20m, proportions about equal); no surface gravel or stone.

	Total N (%)	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
Surface soil fertility:	high (0.140)	high (20)	moderate (0.336)	high (12.3)

Moisture Characteristics:	**ERD:** 0.4-0.6m (salinity >0.8dS/m or >800ppm Cl)	**PAWC:** 50-70mm/1.0m
Investigation sites:	**Field sites** – 23, 37, 63, 75, 76, 88	**Analysed sites** – 88

Brigalow regrowth on a moderately melonholed grey cracking clay on level TQr plains at Site 63.

Hardsetting to weakly self-mulching, moderately melonholed (VI 0.5-0.6m), grey cracking clay at Site 75.

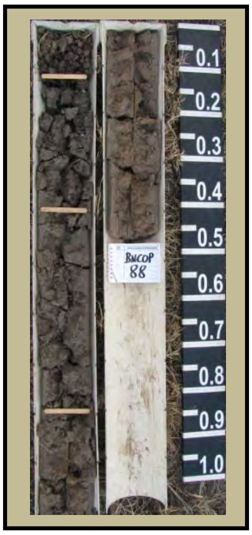


Profile description

The **surface soil** (A1) is a black or grey (10YR 3/1-4/2), fine sandy light medium to fine sandy medium clay with moderate to strong fine blocky structure; field pH 6.5-8.0. Clear change to

The **upper subsoil** (B21k) is a grey or occasionally black (10YR 3/1, 4/1-4/2), fine sandy medium to medium heavy clay with moderate to strong blocky to lenticular structure and <2–10% soft or nodular carbonate; field pH 8.0–8.5. Gradual or diffuse change to

The **lower subsoil** (B22, B23) is a grey or brown (10YR 5/2-5/3), medium clay (typically fine sandy) with weak to moderate coarse lenticular grading to polyhedral structure at depth; field pH 8.5-5.0, becoming increasingly acidic with depth.



Subsoil Chemistry – representative data from BNCOP Site 88

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.8	0.071	45	21	12.3	7.9	0.336	0.782
0.25 – 0.35	8.8	0.629	670	24	11.9	10.6	0.187	3.45
0.55 – 0.65	8.3	1.160	1440	23	9.5	11.1	0.208	4.02
0.85 – 0.95	5.3	1.004	1315	24	6.5	10.8	0.191	6.75
1.15 – 1.25	4.9	0.968	1300	-	-	-	-	-

pH is neutral in surface horizons, strongly alkaline in the upper profile and strongly acidic (pH <5.5) at depth. EC and Cl analyses (see Appendices 2 and 5) indicate low salinity (<0.3dS/m) to 0.1-0.2m, moderate levels (0.3-0.6dS/m) from 0.2-0.4m, and high to extreme salinity (>0.6dS/m) below 0.4-0.6m. CEC levels (21-24meq/100g) and CEC/clay ratios (0.46-0.49) are moderate throughout, and the presence of cracking and severe melonhole gilgai suggest the subsoil clay fraction is active, with significant shrink-swell characteristics and is of mixed mineralogy. Sodicity data indicates surface material to 0.1m is non-sodic (ESP <4), with moderate levels (ESP 4-14) by about 0.4m, and high to extreme levels (ESP 17-28) below 0.4m. Magnesium (Mg) dominates cation chemistry below 0.4m and is likely to enhance dispersive behaviour.

Physical Soil Characteristics – representative data from BNCOP Site 88

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	9	27	18	45	-	0.47	0.41	1.6	4	low
0.25 – 0.35	11	28	16	49	-	0.49	0.60	1.1	14	moderate
0.55 – 0.65	10	27	15	50	-	0.46	0.62	0.9	17	high
0.85 – 0.95	9	24	16	52	-	0.46	0.74	0.6	28	very high

Clay content is relatively uniform throughout (45-52%). Fine sand/silt content is significant throughout (40-45% combined), and slaking and crusting behaviour are likely following disturbance. Surface soil material to about 0.1m is moderately to strongly structured, with Ca dominant cation chemistry, low sodicity (ESP 4) and low dispersion (R1 0.41). The upper subsoil to 0.4m is similar, but has weak to moderate sodicity (ESP 4-14) and increasing dispersion (R1 0.60). Below 0.4m, increasing sodicity, worsening dispersion, very high to extreme salinity and coarse macro lenticular structure suggest adverse physical behaviour and very poor establishment response is likely post-disturbance.

Summary

Surface soil material to 0.1m (on mounds) has high fertility, moderate to strong structure, and is characterised by moderately high clay content (45%), low salinity (<0.3 dS/m), low sodicity (ESP 4), only moderate reactivity and elevated levels of fine sand/silt (45%). It is likely this material will be prone to slaking and crusting behaviour following disturbance and subject to a high erosion risk as a result. Topsoil materials to 0.1m are suitable for replacement only on level terrain or low gradients. **Subsoil material between 0.1-0.4m** (on mounds) has similar physical characteristics, but with moderate levels of salinity (EC 0.3-0.6dS/m) and sodicity (ESP 4-14), and increasing dispersive behaviour (R 0.60). Salvage of this material is recommended, but only as root zone media for sub-surface replacement. **Lower subsoil material below 0.4m** is considered undesirable, with high to very high levels of salinity and worsening sodicity and dispersive behaviour. It is not recommended for salvage. Stripping recommendations are based on melonhole mound characteristics (Burgess 2003a).

Soil 7a – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.1m	Strip structured surface soil/subsoil clay to 0.1m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.1-0.4m	Strip additional root zone media between 0.1-0.4m for sub-surface replacement only. Avoid undesirable subsoil clay below 0.4m.
Single stage	Combined	0-0.1m	Strip surface soil/subsoil clay to 0.1m as primary topsoil. Avoid increasingly undesirable subsoil clay below 0.1m. Stripping with an excavator and batter bucket is recommended; stripping depth to follow surface contours.

Soil 7a – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	5	Unsuitable due to extreme limitations	e4, es3, m5, pm3, ps3, tm4, w2-4	-
Grazing	2	Fattening – suitable for improved pastures, attains max grazing productivity in most seasons	m2, ps2, sa2, tm2, w2, v2, ph2	C1

Soil 7a – Strategic Cropping Land – WCZ Zonal Criteria Assessment (Queensland Government 2011)

Soil	ZC 1	ZC 2	ZC 3	ZC 4	ZC 5	ZC 6	ZC 7	ZC 8	SCL status
7a	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	**Decided non SCL**

Soil 7b — Brown/grey texture contrast soil/clay on TQr plains + shrubby poplar box

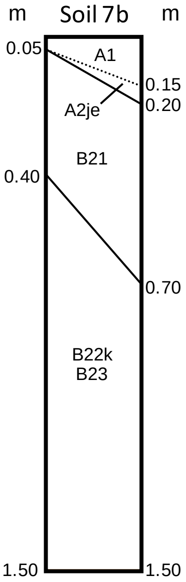
Soil concept:	Hardsetting, thin clay loamy surfaced (<0.05-0.2m), bleached, grey or brown sodic texture contrast soil grading to a grey or brown non-cracking/cracking clay ± occasional weak gilgai (VI 0.1m, HI 10m) on older unconsolidated sediments and clay sheets.
Regional Soil Name:	Foxleigh clay loamy phase (FxLp) grading to Warwick (Ww)/Greycliffe (Gc)
Aust. Soil Classification:	Grey, Brown or Black Sodosol, Dermosol or Vertosol
Principal Profile Form:	Dy2.33/43, Db/Dd1.33/43, Uf6.31/32/33, Ug5.15/16/25
Landform:	Level plains associated with elevated Cainozoic clay sheets. Slopes <1%.
Geological landscape:	Unconsolidated Tertiary–Quaternary sediments (Czs, Cza, TQr). Includes insitu and reworked Tertiary clay and widespread reworked local clayey colluvium.
Land zone:	Cainozoic clay deposits (LZ 4).
Vegetation:	Very shrubby poplar box.
Runoff, perm., & drainage:	Slow runoff; slow or very slow permeability; moderately well drained.
Surface features:	Hardsetting and poached; non-cracking to cracking; non-gilgaied to occ. very weakly gilgaied (VI 0.1m, HI 10m); no surface gravel or stone.

Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
	mod-high (0.90-0.95)	low (6-8)	low (0.2-0.3)	moderate (4.0-4.5)

Moisture Characteristics:	**ERD:** 0.3-0.5m (salinity >0.8dS/m or >800ppm Cl; and/or rigid soil – ESP >15%)	**PAWC:** 30-60mm/1.0m
Investigation sites:	**Field sites** – 24, 36, 59, 60, 61, 62, 64, 90, 103	**Analysed sites** – 36, 90

Shrubby poplar box - brigalow ± belah regrowth on level TQr plains at Site 36.

Thin clay loamy surfaced, grey-brown sodic texture contrast soil overlying brownish unconsolidated TQr sediments at Site 24.



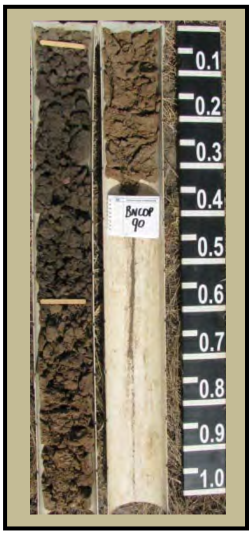
Profile description

The **surface soil** (A1) is a black, grey or brown (10YR 3/1-3/3, 4/1), fine sandy clay loam to fine sandy light clay with weak to moderate subangular blocky to blocky structure; field pH 6.0-6.5. Clear or abrupt change to

The **sub-surface layer where present** (A2je) is a thin, sporadically or conspicuously bleached, grey or brown (10YR 4/2-4/3, 5/2; 7/2 when dry), fine sandy clay loam to clay loam fine sandy with weak subangular blocky to massive structure; field pH 5.5-6.5. Abrupt change to

The **upper subsoil** (B21) is a grey, brown or occ. black (10YR 3/1, 4/1-4/3, 5/2), fine sandy medium to fine sandy medium heavy clay with moderate coarse columnar to moderate or strong blocky structure; field pH 7.0-8.5. Gradual change to

The **lower subsoil** (B22k, B23) is a brown (7.5YR, 10YR 4/3-4/6, 5/3-5/4, 6/3), fine sandy light medium to fine sandy medium clay with weak coarse lenticular to moderate blocky or polyhedral structure; and <2-10% soft or nodular carbonate (in the B22 horizon); field pH 8.0-5.0, becoming increasingly acidic with depth.



Subsoil Chemistry – representative data from BNCOP Site 90

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.4	0.051	30	11	4.3	5.3	0.204	0.75
0.25 – 0.35	8.7	0.642	780	19	7.8	10.2	0.116	3.42
0.55 – 0.65	8.2	0.732	1080	16	5.3	9.0	0.111	3.88
0.85 – 0.95	5.2	0.597	880	14	2.9	5.9	0.069	4.71
1.15 – 1.25	4.7	0.555	815	-	-	-	-	-

pH is slightly acidic in surface horizons, alkaline to strongly alkaline in the upper profile and strongly acidic (pH <5.5) at depth. EC and Cl analyses (see Appendices 2 and 5) indicate low salinity (<0.3dS/m) to 0.2m, moderate levels (0.3-0.6dS/m) from about 0.2-0.4m, and high to very high salinity (0.6->0.8dS/m) somewhere between 0.4-0.8m. Moderate CEC levels (14-19meq/100g) and CEC/clay ratios (0.38-0.49) in the subsoil and only limited cracking suggest the clay fraction is of mixed mineralogy, with limited activity and lacks significant shrink-swell characteristics. Sodicity data (Sites 36 and 90) indicate surface material to about 0.1-0.2m is mostly non-sodic (ESP 4-7), but moderate to extreme levels (ESP 13-35%) are present below this depth. Magnesium (Mg) dominates cation chemistry throughout the subsoil and is likely to enhance dispersive behaviour.

Physical Soil Characteristics – representative data from BNCOP Site 90

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	12	45	17	29	-	0.38	0.58	0.8	7	low-mod.
0.25 – 0.35	10	36	17	39	-	0.49	0.66	0.8	18	high
0.55 – 0.65	10	39	17	37	-	0.43	0.89	0.6	24	very high
0.85 – 0.95	12	41	12	34	-	0.41	0.95	0.5	35	very high

Clay content in texture contrast profiles increases sharply between surface horizons (20%) and the underlying subsoil (34-40%), while in heavier profiles (prone to occasional cracking), clay content in thin surface horizons <0.1m is higher (29%). The surface soil to 0.1-0.2m is very hardsetting, weakly structured and is characterized by high levels of fine sand and silt (62-69% combined). This suggests significant slaking and pulverescent behaviour is likely following disturbance. Similarly, subsoil clays are only moderately structured, with limited reactivity, magnesium dominant cation chemistry, significant dispersive behaviour (R1 0.66-0.95) and elevated levels of fine sand/silt (>50-55 combined). Disturbed subsoil materials will lack shrink-swell behaviour and be subject to pulverescent behaviour (when dry), dense packing, severe compaction and significant crusting behaviour. Laboratory measured dispersion is moderate (R1 0.58-0.66) in the surface soil to about 0.2m, but increases to high or extreme levels (R1 0.85-0.95) below this depth.

Summary

Surface soil material to 0.1-0.2m has moderate fertility and is characterised by low salinity (<0.3 dS/m), relatively low sodicity (ESP 4-7), hardsetting behaviour, weak to moderate structure, moderate clay content (20-35%), very limited reactivity and elevated levels of levels of fine sand/silt (62-69%). It is likely this material will have a high erosion risk and be prone to pulverescent behaviour and severe compaction, slaking and crusting following disturbance. Topsoil materials to 0.1-0.2m are suitable for replacement only on level terrain or low gradients. **Subsoil material below about 0.2m** is considered undesirable and is not recommended for salvage. It is characterized by moderate to very high levels of salinity and extremely sodic/dispersive behaviour. Stripped material will be saline, highly dispersive and prone to compaction, slaking and crusting. It will be subject to significant erosion risk and should be avoided.

Soil 7b – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.15m	Strip surface soil/upper subsoil clay to 0.15m and segregate as primary topsoil to preserve seed source material.
	Root zone	nil	Subsoil clay below 0.15m is undesirable and should be avoided.
Single stage	Combined	0-0.15m	Strip structured surface soil/subsoil clay to 0.15m. Avoid undesirable subsoil clay below 0.15m.

Soil 7b – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

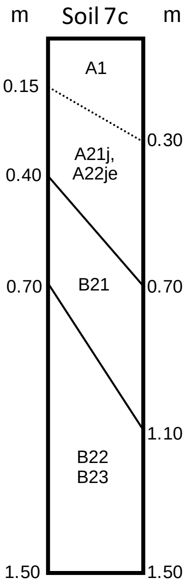
Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	5	Unsuitable due to extreme limitations	e4, es3, m5, pm3-4, ps4, tm2, w2	-
Grazing	3	"Grower" country – suitable for improved pastures, but less productive than Classes 1 & 2	m3, nd3, ps2, sa2, w2, v2, ph2, esp2	C1

Soil 7c — Sandy brown texture contrast soil on relict TQr + eucalypt - softwood

Soil concept:	Hardsetting, thick sandy surfaced (0.4-0.7m), bleached, often mottled, brown non-sodic to weakly sodic texture contrast soil on elevated relict alluvial deposits.			
Regional Soil Name:	Collawmar (Cm)			
Aust. Soil Classification:	Brown Sodosol	**Principal Profile Form:**	Db2.32/33, 2.42/43	
Landform:	Level to gently undulating, relatively elevated, plains and low rises developed on unconsolidated relict alluvial deposits of indeterminate age. Slope range 0.5-2%.			
Geological landscape:	Unconsolidated Tertiary–Quaternary sediments (Czs, Cza, TQr). Includes insitu and reworked relict alluvial deposits and widespread reworked local colluvium; stratigraphically overlies adjacent Cainozoic clay sheets.			
Land zone:	Cainozoic sand deposits not underlain by a deeply weathered surface (LZ 5a).			
Vegetation:	Shrubby eucalypt grading to eucalypt - softwood scrub.			
Runoff, perm., & drainage:	Slow runoff; slow permeability; imperfectly to moderately well drained.			
Surface features:	Hardsetting; non-cracking; non-gilgaied; no surface gravel or stone.			
Surface soil fertility:	**Total N (%)** mod.-high (0.09)	**Available P (ppm)** moderate (11)	**Ex. K (meq/100g)** low (0.423)	**Ex. Ca (meq/100g)** moderate (2.4)
Moisture Characteristics:	**ERD:** >1.0m (no salinity or ESP restrictions)		**PAWC:** 70-75mm/1.0m	
Investigation sites:	**Field sites** – 46, 47, 48, 56, 57, 77, 80, 83, 85, 86, 93, 95, 97, 98, 99, 100, 101, 104, 105, 108, 109		**Analysed sites** – 99	

Shrubby silver-leaved ironbark - softwood scrub on sandy unconsolidated TQr sediments (Site 99).

Thick sandy surfaced, mottled, brown non-sodic texture contrast soil overlying relict alluvial TQr sediments at Site 56.



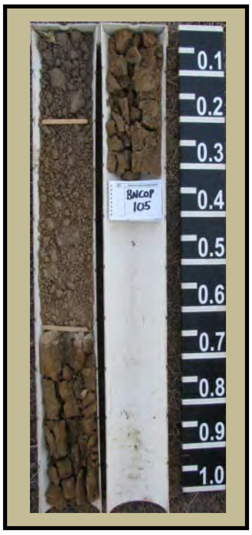
Profile description

The **surface soil** (A1) is a black or occ. brown (7.5YR, 10YR 3/2, 3/3-4/3), loamy sand to sandy loam (medium to coarse sand fraction) with weak subangular blocky to massive structure; field pH 5.5-7.5. Clear change to

The **sub-surface layer** (A21j, A22je) is a sporadically or conspicuously bleached, brown or grey (7.5YR, 10YR 4/3-4/4, 4/2-5/4) loamy sand to sandy loam (medium to coarse sand fraction) with weak subangular blocky to massive structure; field pH 5.5-7.5. Clear or abrupt change to

The **upper subsoil** (B21) is a brown (10YR 4/3, 5/3-5/6), often mottled (<2-10% faint or distinct yellow/orange), sandy light to sandy light medium clay with moderate to strong coarse prismatic/columnar parting to moderate blocky structure; field pH 6.0-8.0. Clear or gradual change to

The **lower subsoil** (B22, B23) is a brown (10YR, 2.5Y 5/3-5/6), mottled (20-50% distinct or prominent orange/grey), sandy light medium to sandy medium clay with weak to moderate blocky or prismatic structure; and occasionally <2-20% soft or nodular carbonate; field pH 6.0-8.5.



Subsoil Chemistry – representative data from BNCOP Site 99

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.3	0.042	15	4	2.4	0.97	0.423	0.041
0.25 – 0.35	6.6	0.024	5	3	2.7	0.44	0.29	0.041
0.65 – 0.75	7.2	0.026	2	10	4.8	4.2	0.202	0.564
0.85 – 0.95	7.2	0.035	8	12	5.6	5.4	0.305	0.884
1.15 – 1.25	8.1	0.073	35	-	-	-	-	-

pH is slightly acidic in surface horizons and neutral to alkaline in the subsoil. EC and chloride (Cl) analyses (see Appendices 2 and 5) confirm very low salinity (<0.1dS/m) throughout. Similarly, CEC levels are very low (3-4 meq/100g) in the sandy topsoil, and increase only marginally (10-12 meq/100g) in the clayey subsoil. CEC/clay ratios in the subsoil are low (0.23) and suggest the clay fraction is un-reactive and of mixed mineralogy (dominantly kaolinite and illite). Sodicity data indicates sandy surface soil (0.4-0.7m) is non sodic (ESP 1), while underlying subsoil clay is non-sodic to weakly sodic (ESP 6-7). Magnesium (Mg) is co-dominant in the subsoil, but is likely to have limited impact because of low ESP.

Physical Soil Characteristics – representative data from BNCOP Site 99

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	29	55	8	10	-	0.40	0.64	2.5	1	low
0.25 – 0.35	31	51	7	11	-	0.27	0.88	6.1	1	low
0.65 – 0.75	20	33	5	44	-	0.23	0.57	1.1	6	low
0.85 – 0.95	15	27	1	53	-	0.23	0.67	1.0	7	low-mod.

Clay content increases sharply between sandy surface horizons (10-11%) and the underlying clay subsoil (44-53%). The surface soil is massive to only very weakly structured and is characterized by significant fine sand ± silt (58-63% combined). Significant slaking and pulverescent/hardsetting behaviour is likely with this material following disturbance. The underlying clayey subsoil (clay fraction 44-53%) is un-reactive, non-sodic to very weakly sodic and moderated significantly by sand content (coarse sand/fine sand 42-53% combined). Salvaged subsoil material, whilst not particularly dispersive, would be subject to dense packing and significant compaction post disturbance. Laboratory measured dispersion is moderate to high (R1 0.64-0.88) in sandy surface horizons (due to high levels of unstable fine sand), but decreases to only low or moderate levels (R1 0.57-67) in the structurally more competent, non-sodic clayey subsoil.

Summary

Surface soil material to 0.4-0.7m has moderate fertility and is characterized by massive to very weak structure, low clay content (<11%), very low salinity (<0.1dS/m) and very low sodicity (ESP 1); but with elevated dispersion (R0.64-0.88) and high levels of fine sand/silt (58-63% combined). It is likely this material will be hardsetting and prone to powdery/pulverescent behaviour, slaking and high erosion risk following disturbance. Salvaged materials are recommended only for replacement on level terrain or very low gradients. **Clayey subsoil material below 0.4-0.7m** has relatively benign physical and chemical characteristics and represents a useful source of additional root zone media. It is characterized by a moderately structured, largely non-sodic (ESP 6-7) but un-reactive clay fraction that lacks noticeable shrink swell characteristics and is moderated by significant sand content (42-53%). Salvaged subsoil materials will lack structural integrity following disturbance, and be subject to dense packing, compaction and elevated erosion risk as a result (post disturbance). Clayey material below 0.4-0.7m is recommended for stripping, but only as root zone media for sub-surface replacement.

Soil 7c – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.5m	Strip sandy surface soil to 0.5m and segregate as primary topsoil to preserve seed source material. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
	Root zone	0.5-1.2m	Strip additional clayey root zone media between 0.5-1.2m for sub-surface replacement only.
Single stage	Combined	0-0.5m	Strip sandy surface soil to 0.5m as primary topsoil. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.

Soil 7c – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	5	Unsuitable due to extreme limitations	e2, es3, m5, pm3, ps4, w2-4	-
Grazing	4	Breeding country – marginal for improved pastures, suitable for grazing native pastures	m4, nd3, ps2	C2

Soil 7d — Loamy black texture contrast soil on TQr plains + brigalow-Dawson gum

Soil concept: Hardsetting, clay loamy surfaced (0.10-0.2m), bleached, black sodic texture contrast soil on older unconsolidated sediments and clay sheets.

Regional Soil Name: Racetrack (Rt)/Kokotungo (Kk)
Aust. Soil Classification: Black Sodosol **Principal Profile Form:** Dd1.33/1.43

Landform: Level to gently undulating plains on elevated unconsolidated Cainozoic sediments and clay sheets. Slope range <1-2%.
Geological landscape: Unconsolidated Tertiary–Quaternary sediments (Czs, Cza, TQr). Includes insitu and reworked Tertiary clay and widespread reworked local clayey colluvium.
Land zone: Cainozoic clay deposits (LZ 4).
Vegetation: Brigalow ± Dawson gum.

Runoff, perm., & drainage: Slow runoff; slow permeability; moderately well drained.
Surface features: Hardsetting; non-cracking; non-gilgaied; no surface gravel or stone.

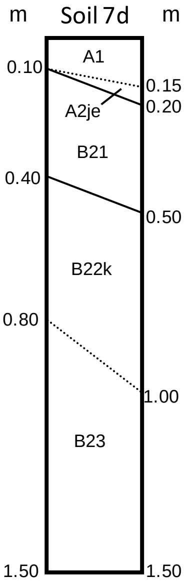
Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
	high (0.140)	high (28)	low (0.194)	high (6.5)

Moisture Characteristics: **ERD:** 0.45m (rigid soil – ESP >15%) **PAWC:** 50mm/1.0m

Investigation sites: **Field sites** – 72, 78, 79, 81, 82, 87, 94, 102 **Analysed sites** – 87

Brigalow - Dawson gum regrowth on level TQr plains at Site 79.

Clay loamy surfaced, black sodic texture contrast soil overlying greyish-brown unconsolidated TQr sediments at Site 79.



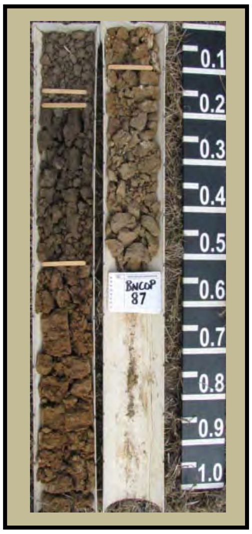
Profile description

The **surface soil** (A1) is a black (10YR 2/1-3/2), sandy clay loam to clay loam sandy (fine to medium sand fraction) with weak subangular blocky to massive structure; field pH 6.0-7.5. Clear change to

The **sub-surface layer where present** (A2je) is a thin, sporadically or conspicuously bleached, grey (10YR 4/1-5/2; 6/1-7/2 when dry), sandy clay loam to clay loam sandy (fine to medium sand fraction) with weak subangular blocky to massive structure; field pH 6.0-7.0. Abrupt change to

The **upper subsoil** (B21) is a black (10YR 3/1-3/2), sandy light medium to sandy medium clay (fine to medium sand fraction) with coarse columnar grading to moderate or strong blocky structure; field pH 8.0-9.0. Clear or gradual change to

The **lower subsoil** (B22k, B23) is a brown or grey (10YR 4/2-4/3, 5/2-5/4), occasionally mottled (<2-20% faint orange/red), sandy light to sandy light medium clay (fine to medium sand fraction) with moderate to strong blocky structure; and <2–10% soft or nodular carbonate (in B22 horizon); field pH 8.5-5.5, becoming increasingly acidic with depth. .



Subsoil Chemistry – representative data from BNCOP Site 87

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.4	0.034	5	10	6.5	3.4	0.194	0.330
0.25 – 0.35	8.5	0.087	60	15	7.4	7.3	0.130	1.83
0.55 – 0.65	9.1	0.672	730	12	3.0	6.6	0.140	3.63
0.85 – 0.95	9.2	0.976	1100	11	2.8	6.3	0.129	3.92
1.15 – 1.25	9.3	0.991	1150	-	-	-	-	-

pH is slightly acidic to neutral in surface horizons and strongly alkaline (pH >9.0) in the subsoil. EC and chloride (Cl) analyses (see Appendices 2 and 5) indicate low salinity (<0.3dS/m) to 0.4-0.5m, moderate levels (0.3-0.6dS/m) between about 0.5-0.8m, and high to very high salinity (>0.8dS/m) below 0.8->1.0m. Low to moderate CEC levels (11-15meq/100g) and CEC/clay ratios (0.36-0.39) in the subsoil and the absence of cracking suggest the clay fraction is of mixed mineralogy, with limited activity and lacks significant shrink-swell characteristics. Sodicity data indicates loamy surface material to about 0.1-0.2m is non-sodic (ESP 3), while moderate to extreme sodicity (ESP 12-36%) is present in the clay subsoil below this depth. Magnesium (Mg) dominates cation chemistry throughout the subsoil and will enhance dispersive behaviour.

Physical Soil Characteristics – representative data from BNCOP Site 87

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	18	42	11	27	-	0.37	0.50	1.9	3	low
0.25 – 0.35	17	35	7	38	-	0.39	0.66	1.0	12	moderate
0.55 – 0.65	19	39	8	33	-	0.36	0.99	0.5	30	very high
0.85 – 0.95	18	40	11	29	-	0.38	0.99	0.4	36	very high

Clay content increases abruptly between loamy surface horizons (27%) and the underlying clayey subsoil (38%). The surface soil is massive to only weakly structured and characterized by elevated levels of fine sand/silt (53% combined). Significant slaking and pulverescent/hardsetting behaviour is likely post disturbance. Clayey subsoil material (below 0.1-0.2m) is dispersive, un-reactive and has equivalent proportions of clay (29-38%) and fine sand (35-40%). It is likely to be pulverescent (when dry) and prone to severe compaction and crusting post disturbance. Laboratory dispersion is low (R1 0.50) in the loamy surface soil to 0.1-0.2m, but increases to extreme levels in the subsoil (R1 0.66-0.99) below about 0.4m.

Summary

Surface soil material to 0.1-0.2m has high fertility and is characterized by massive to weak structure, moderately low clay content (27%), low salinity (EC <0.3dS/m), low sodicity (ESP 3) and elevated levels of fine sand/silt (53% combined). It is likely this material will be hardsetting and prone to powdery/pulverescent behaviour, slaking and high erosion risk following disturbance. Salvaged materials are recommended only for replacement on level terrain or very low gradients. **Subsoil material below 0.1-0.2m** has unfavourable physical attributes. It is characterized by coarse, dense structure and a moderately to extremely sodic (ESP 12-36%) and dispersive (R 0.66-0.99), un-reactive clay fraction. Salvaged subsoil materials will be subject to dense packing and compaction, severe slaking and extreme dispersion, crusting and erosion risk post disturbance. Subsoil material below 0.1-0.2m is not recommended for stripping.

Soil 7d – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.1/0.2m	Strip loamy surface soil to between 0.1-0.2m (maximum) and segregate as primary topsoil to preserve seed source material. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
	Root zone	nil	Subsoil clay below 0.1-0.2m is dispersive and should be avoided.
Single stage	Combined	0-0.1/0.2m	Strip loamy surface soil to between 0.1-0.2m (maximum) as topsoil/seed source material. Avoid dispersive subsoil clay below 0.1-0.2m. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.

Soil 7d – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	5	Unsuitable due to extreme limitations	e2, es4, m5, pm3, ps4, w2	-
Grazing	3	"Grower" country – suitable for improved pastures, but less productive than Classes 1 & 2	m3, ps2, w2, e2	C1

Soil 7d – Strategic Cropping Land – WCZ Zonal Criteria Assessment (Queensland Government 2011)

Soil	ZC 1	ZC 2	ZC 3	ZC 4	ZC 5	ZC 6	ZC 7	ZC 8	SCL status
7d	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Fail	**Decided non SCL**

Soil 8a — Deep loamy red earth on weathered Tertiary sandstone + eucalypt

Soil concept: Hardsetting, massive, gradational loamy red earth overlying weathered Tertiary sandstone (>1.5m).

Regional Soil Name: Bills Hut (Bh)/Spear (Sp)
Aust. Soil Classification: Red kandosol **Principal Profile Form:** Gn2.11/2.12

Landform: Gently undulating to undulating, intact Tertiary plateau surface (lacking elevated mesa/scarp topography). Moderate dissection and footslope development occurs at the northern end of the unit. Slope range <1-5%.
Geological landscape: Medium to coarse grained Tertiary sandstone altered (to some extent) by Tertiary weathering (Ta, Tm). Substrate is weathered/ferruginised sandstone, but without evidence of lateritized profile features.
Land zone: Cainozoic to Proterozoic medium to coarse grained sediments (LZ 10).
Vegetation: Eucalypt.

Runoff, perm., & drainage: Slow to moderately rapid runoff; moderate permeability; well drained.
Surface features: Hardsetting; non-cracking; non-gilgaied; no surface gravel or stone.

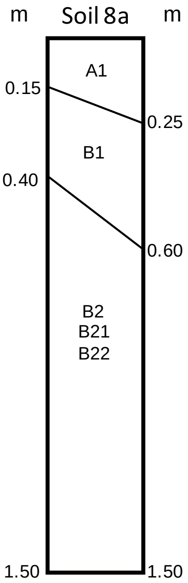
Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
	moderate (0.07)	very low (1.0)	very low (0.307)	moderate (2.7)

Moisture Characteristics: **ERD:** >1.0m (no salinity or ESP restrictions) **PAWC:** 70-85mm/1.0m

Investigation sites: **Field sites** – 5, 20, 21, 38, 44, 51, 58, 91, 107 **Analysed sites** – 38

Selectively cleared silver-leaved ironbark–bloodwood woodland on an intact, gently undulating remnant plateau surface (Site 38).

Deep loamy massive red earth developed on weathered Tertiary sandstone (below 1.5m) at Site 107.



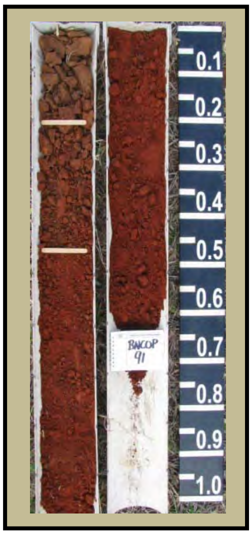
Profile description

The **surface soil** (A1) is a brown or red (2.5YR, 5YR, 7.5YR 3/3-3.4), sandy loam to sandy clay loam with massive structure; field pH 6.0-7.0. Clear change to

The transitional **sub-surface layer** (B1) is a red (2.5YR, 5YR 3/4-3/6, 4/4-4/6), sandy clay loam to clay loam sandy with massive structure; field pH 5.5-7.0. Gradual or diffuse change to

The **lower subsoil** (B2, B21, B22) is a red (10R, 2.5YR 3/6-4/6), clay loam sandy to sandy light clay with massive structure; field pH 5.5-7.0.

Profiles are typically very deep (>1.5-2.0m). Weathered substrate (B3) and/or associated deeply weathered/lateritized profile features (mottling, reticulite) do not present within this depth range.



Subsoil Chemistry – representative data from BNCOP Site 38

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.2	0.020	<5	4	2.7	0.99	0.307	0.021
0.25 – 0.35	6.3	0.010	<5	3	2.1	0.90	0.180	0.028
0.55 – 0.65	6.4	0.010	<5	6	3.2	2.4	0.215	0.043
0.85 – 0.95	6.2	0.011	<5	5	2.6	2.5	0.087	0.058
1.15 – 1.25	6.0	0.007	<5	-	-	-	-	-

pH, EC and Cl analyses (see Appendices 2 and 5) indicate profiles are slightly acidic, with consistently low salinity throughout (EC <0.1dS/m, Cl <5ppm). Similarly, CEC levels (3-6meq/100g) and CEC/clay ratios (0.12-0.27) are low to very low throughout and suggest the clay fraction is un-reactive and predominantly kaolinitic in nature. ESP data confirm both surface soil (ESP 1) and subsoil materials (ESP 1) are completely non-sodic. Magnesium (Mg) is co-dominant in the lower subsoil, but is unlikely to have any effect.

Physical Soil Characteristics – representative data from BNCOP Site 38

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	18	62	6	15	-	0.27	0.74	2.7	1	very low
0.25 – 0.35	16	57	8	20	-	0.15	0.51	2.3	1	very low
0.55 – 0.65	12	38	4	47	-	0.13	0.24	1.3	1	very low
0.85 – 0.95	12	42	5	43	-	0.12	0.17	1.0	1	very low

Clay content increases gradually between surface horizons (15-20%) and the underlying subsoil (43-47%). The surface soil to about 0.5m (A1/B1 horizons) lacks structure (massive), and has elevated levels of fine sand (57-62%) and limited coarse sand (16-18%). Salvaged materials will be pulverescent (when dry) and subject to dense packing, compaction and hardsetting behaviour following disturbance. Clayey subsoil materials below 0.5m are non sodic, non dispersive, strongly flocculated (high sesquioxide content) and completely benign. They are however, rigid and un-reactive and dominated by equivalent fine sand (38-42%) and clay fractions (43-47%). This suggests dense packing, severe compaction and poor establishment response is likely with exposed subsoil mediums post-disturbance. Laboratory measured dispersion is moderate (R1 0.51-0.74) in the surface soil (due to high levels of fine sand), but decreases to very low levels (R1 0.17-0.24) throughout the subsoil. Field morphology suggests sesquioxides play an active flocculation role in this soil.

Summary

Sandy to loamy surface soil material to 0.5m has very low to moderate fertility and is characterized by massive structure, low clay content (15-20%), very low salinity (EC <0.1dS/m), very low sodicity (ESP 1), moderate dispersion (R1 0.51-0.74) and elevated levels of fine sand (57-62%). It is likely this material will be powdery/pulverescent following disturbance and will be subject to dense packing, compaction and hardsetting behaviour. Salvaged materials are recommended only for replacement on level terrain or very low gradients because of potential issues with adverse physical behaviour and rehabilitation establishment. **Loamy/clayey subsoil material below 0.5m** has similar very low salinity and sodicity attributes, as well as a non-dispersive (R1 0.17-0.24), sesquioxide rich, kaolinitic clay fraction. Lower subsoil material is considered completely benign, but is likely to be prone to severe compaction, poor establishment response and elevated erosion risk post disturbance. Subsoil material below 0.5m is recommended for stripping, but only as root zone media for sub-surface replacement.

Soil 8a – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.3m	Strip sandy/loamy surface soil to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.2m	Strip additional loamy/clayey root zone media between 0.3-1.2m for sub-surface replacement only.
Single stage	Combined	0-0.5m	Strip sandy/loamy surface soil to 0.5m as primary topsoil. Avoid clayey subsoil materials below this depth because of undesirable physical attributes and poor establishment response post disturbance.

Soil 8a – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	5	Unsuitable due to extreme limitations	e2-3, es1-3, m5, pm2, ps4	-
Grazing	4	Breeding country – marginal for improved pastures, suitable for grazing native pastures	m4, nd4, ps2, e2, v2	C2

Soil 8b — Sandy grey texture contrast soil on Tertiary sandstone + eucalypt

Soil concept: Soft to loose, thick sandy surfaced (0.3-1.0m), bleached, strongly mottled, non-sodic grey texture contrast soil overlying insitu Tertiary sandstone from 0.8->1.5m.

Regional Soil Name: Wyndham (Wm), affinities with Emoh (Em)
Aust. Soil Classification: Grey (or occ. Brown) Chromosol **Principal Profile Form:** Dy5.41/43, Db4.41/43

Landform: Elevated, moderately dissected, undulating to rolling remnant rises and associated colluvial pediments on relatively fresh, coarse grained Tertiary sandstone. Slope range <1-12%.
Geological landscape: Little weathered, medium to coarse grained Tertiary sandstone, largely unaltered by Tertiary weathering (Ta, Tm).
Land zone: Cainozoic to Proterozoic medium to coarse grained sediments (LZ 10).
Vegetation: Eucalypt.

Runoff, perm., & drainage: Slow to moderately rapid runoff; slow permeability; imperfectly drained.
Surface features: Soft or loose sandy surface; non-cracking; non-gilgaied; no free surface gravel or stone; occ. sandstone outcrop on steeper dissected mid to upper slopes.

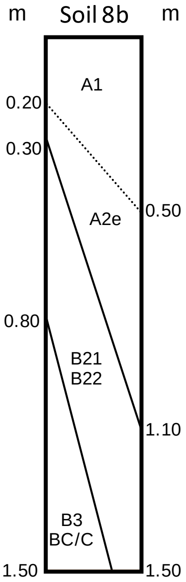
	Total N (%)	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
Surface soil fertility:	low-mod. (0.06)	very low (2.0)	very low (0.147)	moderate (2.3)

Moisture Characteristics: **ERD:** 0.8->1.0m (no salinity or ESP restrictions) **PAWC:** 50-80mm/1.0m

Investigation sites: **Field sites** – 1, 4, 6, 26, 29, 32, 34, 40, 41, 89, 92, 112, 113 **Analysed sites** – 29, 40

Silver-leaved ironbark ± bloodwood ± blue gum with a shrubby quinine bush understorey on dissected Tertiary sandstone at Site 40.

Thick sandy surfaced, mottled, grey non-sodic texture contrast soil developed insitu on Tertiary sandstone and/or related colluvium (Site 29).



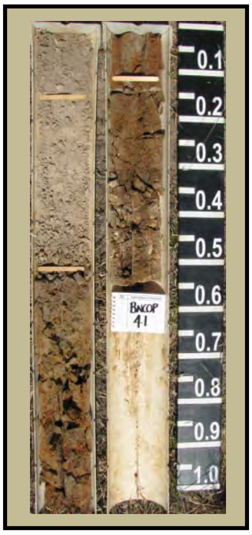
Profile description

The **surface soil** (A1) is a black or brown (10YR 3/2-3/3), sand or loamy sand (medium to coarse sand fraction) with massive structure; field pH 6.0-6.5. Clear or gradual change to

The **sub-surface layer** (A2e) is a conspicuously bleached, grey or brown (10YR 4/2-5/4; 6/2-7/3 when dry), medium to coarse sand with massive or single grain structure; field pH 5.5-6.5. Abrupt change to

The **subsoil** (B21, B22) is a grey or occ. brown (10YR 4/2-6/2, 5/4-6/4), strongly mottled (20-50% distinct or prominent red/orange), sandy light to sandy medium clay (medium to coarse sand fraction) with moderate to strong coarse prismatic to blocky structure; field pH 5.5-7.0. Clear change to

Substrate material (B3, BC/C) is a grey (10YR 5/2-6/2, 6/4), massive, coarse sandy loam to gritty clay loam sandy matrix with >20-90% soft crumbly medium to coarse grained sandstone weathering insitu; field pH 5.0-8.2; hard rock from 1.0->1.5m.



Subsoil Chemistry – representative data from BNCOP Site 40

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.1	0.016	<5	4	2.3	1.0	0.147	0.015
0.25 – 0.35	6.3	0.012	<5	3	1.6	1.4	0.069	0.062
0.55 – 0.65	6.1	0.018	<5	22	12.4	8.2	0.378	0.799
0.85 – 0.95	6.7	0.027	10	23	13.2	8.1	0.298	1.011
1.15 – 1.25	7.6	0.062	50	-	-	-	-	-

pH is acidic in the sandy surface soil and acidic to alkaline in the clayey subsoil. EC and Cl analyses (see Appendices 2 and 5) indicate profile salinity is consistently low throughout (EC <0.1dS/m, Cl <50ppm). CEC levels are very low (3-4 meq/100g) in surface horizons, but increase to moderate levels (22-23 meq/100g) in the clayey subsoil. CEC/clay ratios in the subsoil are moderate (0.46-0.52) and suggest the clay fraction has only limited reactivity and is of mixed mineralogy (mostly kaolinite and illite). Sodicity data indicates both the surface soil (0.3-1.1m) and the underlying clayey subsoil are non sodic (ESP 1-5).

Physical Soil Characteristics – representative data from BNCOP Site 40

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	60	29	3	9	-	0.44	0.89	2.3	1	low
0.25 – 0.35	65	22	5	10	-	0.30	0.87	1.1	2	low
0.55 – 0.65	34	13	8	48	-	0.46	0.38	1.5	4	low
0.85 – 0.95	34	13	10	44	-	0.52	0.63	1.6	5	low

Clay content increases sharply between sandy surface horizons (9-10%) and the underlying clay subsoil (44-48%). The surface soil is massive, dominated by coarse sand (60-65%) and is unlikely to exhibit dispersive tendencies either insitu or after disturbance. Reworked surface materials will be loose and incoherent, and not subject to pulverescent or hardsetting behaviour. In contrast, subsoil characteristics are dominated by a non-sodic (ESP 4-5), un-reactive clay fraction (44-48%), that is significantly moderated by sand content (coarse sand/fine sand - 47% combined). Subsoil materials are likely to be subject to slaking, dense packing, severe compaction and elevated erosion risk post disturbance. Laboratory measured dispersion in sandy surface horizons is high (R1 0.87-89) (due to fines associated with the sand fraction), but decreases to low or moderate levels (R1 0.38-63) in the structurally more competent, non-sodic clayey subsoil. Subsoil materials, whilst suitable for salvage, are recommended for subsurface replacement only.

Summary

Coarse sandy surface soil material varies significantly in thickness (0.3-1.1m), has very low fertility, massive structure, very low clay content (<10%), very low salinity (EC <0.1dS/m), low sodicity (ESP 1-2) and a significant coarse sand fraction (60-65%). It is considered benign and relatively stable, but is likely to experience loose/incoherent behaviour and elevated erosion risk following disturbance. Salvaged sandy material is recommended for replacement only on level terrain or low gradients. Potential exists to use coarse sandy material (to depths of 1.1m where present) as surrogate topsoil on steeper slopes, but such a strategy would require adequate mixing with competent sandstone spoil to increase surface roughness, topsoil resilience and slope integrity. **Clayey Subsoil material below 0.3-1.1m** has benign physical and chemical characteristics and represents a useful source of additional root zone media. It is characterized by a moderately structured, non-sodic (ESP 4-5), un-reactive clay fraction (without shrink swell characteristics) that is moderated by significant sand content (47%). Salvaged subsoil materials are likely to lack structural integrity following disturbance, and be subject to dense packing, compaction and elevated erosion risk. Clayey subsoil material below 0.3-1.1m is recommended for stripping, but only as root zone media for sub-surface replacement.

Soil 8b – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.3m	Strip sandy surface soil to 0.3m and segregate as primary topsoil to preserve seed source material. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
	Root zone	0.3-0.8m or deeper	Strip additional sandy or clayey root zone media from 0.3m to depth of weathered rock (0.8->1.5m) for sub-surface replacement only.
Single stage	Combined	0-0.5m	Strip sandy surface soil to 0.5m as primary topsoil. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.

Soil 8b – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	5	Unsuitable due to extreme limitations	e3-5, es1-5, m5, pm1-3, r3, w4	-
Grazing	4	Breeding country – marginal for improved pastures, suitable for grazing native pastures	m4, nd4, e2, v2	C2

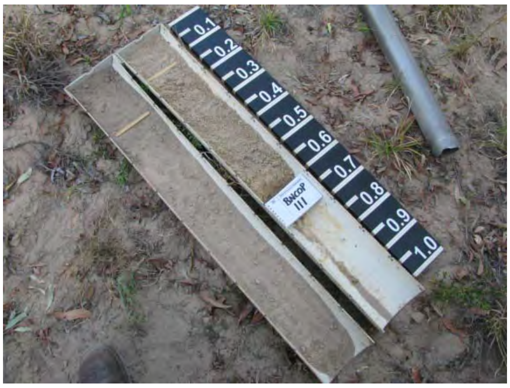
Soil 8c — Loose grey colluvial sand on Tertiary sandstone footslopes + eucalypt

Soil concept:	Loose, massive, bleached, grey coarse sand on steeper colluvial footslopes.
Regional Soil Name:	Wyndham (Wm), affinities with Cherwell (Cw)
Aust. Soil Classification:	Bleached-Orthic Tenosol **Principal Profile Form:** Uc2.12
Landform:	Colluvial footslopes below elevated and moderately dissected, undulating to rolling remnant rises on relatively fresh, coarse grained Tertiary sandstone. Slope range 1-5%.
Geological landscape:	Tertiary – Quaternary colluvium (TQr). Sandy colluvium derived from little weathered, medium to coarse grained Tertiary sandstone (largely unaltered by Tertiary weathering) (Ta, Tm).
Land zone:	Cainozoic to Proterozoic medium to coarse grained sediments (LZ 10).
Vegetation:	Eucalypt.
Runoff, perm., & drainage:	Very slow to slow runoff; high permeability; moderately well drained.
Surface features:	Loose coarse sandy surface; non-cracking; non-gilgaied; no surface gravel or stone.

Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
(relevant data from Soil 8b)	low-mod. (0.06)	very low (2.0)	very low (0.147)	low-moderate (2.3)

Moisture Characteristics:	**ERD:** >1.0m (no salinity or ESP restrictions)	**PAWC:** 40mm/1.0m
Investigation sites:	**Field sites** – 45, 111	**Analysed sites** – see 29, 40

Bloodwood ± blue gum ± -silver-leaved ironbark with a shrubby quinine bush understorey on a sandy colluvial footslope (Site 111).



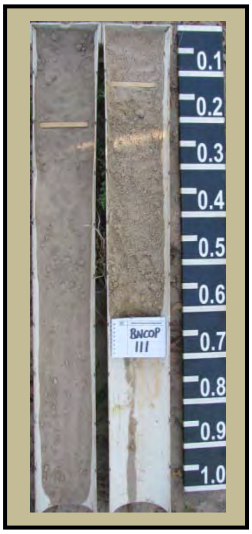
Moderately deep to deep, bleached, grey, loose colluvial coarse sand at Site 111.

Profile description

The **surface soil** (A1) is a brown (10YR 4/3), loamy coarse sand with massive/single grain fabric; field pH 5.5-6.5. Clear change to

The **upper sub-surface layer** (A21e) is a bleached, brown (10YR 5/4-6/3; 7/2-7/3 when dry), coarse sand with massive/single grain fabric; field pH 5.5-6.5. Gradual or diffuse change to

The **lower sub-surface layer** (A22e) is a bleached, grey (10YR 6/3-6/4; 7/2 when dry), coarse sand with massive/single grain fabric ± <10% weak iron/manganese nodules and/or orange mottling above hard quartzose sandstone from 1.2->1.5m; field pH 5.0-6.5.



Subsoil Chemistry – relevant representative data from Soil 8b (colluvial) - BNCOP Site 29

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.9	0.031	<5	3	2.2	0.71	0.374	0.018
0.25 – 0.35	6.9	0.014	<5	2	1.3	0.37	0.233	0.015
0.55 – 0.65	6.6	0.014	<5	2	1.5	0.70	0.151	0.020

pH, EC and Cl analyses (see Appendices 2 and 5) indicate profiles are acidic to neutral, with consistently low salinity throughout (EC <0.1dS/m, Cl <5ppm). CEC levels are also very low throughout (2-3meq/100g) and reflect limited clay content (9-13%) and colluvial origins (Tertiary sandstone). CEC/clay ratios (0.15-0.33) indicate the clay fraction (albeit very small) is predominantly kaolinitic and non-reactive. Profile sodicity is very low (ESP <1), and reflects the absence of an effective clay fraction and the dominance of the sand fraction.

Physical Soil Characteristics – relevant representative data from Soil 8b (colluvial) - BNCOP Site 29

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	41	44	7	9	-	0.33	0.79	3.1	1	very low
0.25 – 0.35	43	42	7	10	-	0.20	0.85	3.5	1	very low
0.55 – 0.65	37	44	7	13	-	0.15	0.83	2.1	1	very low

Clay content is very low (9-13%) throughout, and the profile is dominated by an equivalent mix of coarse (37-43%) and fine sand (42-44%). The soil profile is unstructured (massive or single grain), highly permeable and unlikely to exhibit dispersive tendencies either insitu or after disturbance. Reworked materials will be loose, coarse sandy and incoherent, and not subject to compaction or pulverescent/hardsetting behaviour. Laboratory measured dispersion is relatively high (R1 0.79-85), but relates to elevated levels of fine sand rather than a dispersive clay fraction.

Summary

Sandy surface soil and subsurface material to about 1.2m (or depth to weathered rock where shallower) has very low fertility, massive/single grain structure, very low clay content (<13%), very low salinity EC <0.1dS/m), very low sodicity (ESP 1) and a significant coarse sand fraction (37-43%). It is considered completely benign and relatively stable, but is likely to experience loose/incoherent behaviour and elevated erosion risk following disturbance. Salvaged sandy material is recommended for replacement only on level terrain or low gradients. Potential exists to strip coarse sandy material to 1.2m (or depth to weathered rock where shallower) as surrogate topsoil for use on steeper slopes, but such a strategy would require adequate mixing with competent sandstone spoil to increase surface roughness, topsoil resilience and slope integrity.

Soil 8c – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.3m	Strip sandy surface soil to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.2m	Strip additional sandy root zone media between 0.3-1.2m (or depth to weathered rock where shallower) for sub-surface replacement only.
Single stage	Combined	0-1.2m	Strip sandy surface soil to 1.2m as surrogate topsoil material. Mix preferentially with competent sandstone spoil for use on low to moderate gradients. Where possible, segregate material to 0.3m to preserve seed source material.

Soil 8c – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Summer cropping	5	Unsuitable due to extreme limitations	e3-4, es1-3, m5	-
Grazing	5	Seasonal breeding country – suitable for grazing native pastures, requires dry season destocking	m5, nd4, e2, v2	C2

Soil 8d — Red colluvial sandy soil on Tertiary sandstone pediments + eucalypt

Soil concept: Loose, massive red or brown earthy sand grading to a very thick sandy surfaced (1.0->1.5m), red or brown non-sodic texture contrast soil on gentle colluvial pediments and outwash deposits.

Regional Soil Name: Wyndham (Wm), Bills Hut sandy variant (BhSv)

Aust. Soil Classification: Red/Brown-Orthic Tenosol, Red Chromosol **Principal Profile Form:** Uc5.21, Dr4.12

Landform: Gentle colluvial pediments and outwash deposits flanking less dissected, undulating remnant rises on relatively fresh, coarse grained Tertiary sandstone. Slope range <1-3%.

Geological landscape: Tertiary – Quaternary colluvium (TQr). Sandy colluvium derived from little weathered, medium to coarse grained Tertiary sandstone (largely unaltered by Tertiary weathering) (Ta, Tm).

Land zone: Cainozoic to Proterozoic medium to coarse grained sediments (LZ 10).

Vegetation: Eucalypt.

Runoff, perm., & drainage: Slow runoff; moderate to high permeability; well drained to rapidly drained.

Surface features: Loose coarse sandy surface; non-cracking; non-gilgaied; no surface gravel or stone.

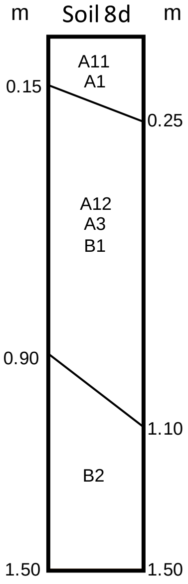
Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
(relevant data from Soil 8b)	low-mod. (0.06)	very low (2.0)	very low (0.374)	low-moderate (2.2)

Moisture Characteristics: **ERD:** >1.0m (no salinity or ESP restrictions) **PAWC:** 40mm/1.0m

Investigation sites: **Field sites** – 35, 42 **Analysed sites** – see 29

Cleared Moreton Bay ash ± bloodwood ± -silver-leaved ironbark woodland on a gently undulating colluvial pediment (Site 35).

Deep, red, coarse sand on outwash colluvium derived from Tertiary sandstones (Site 35).

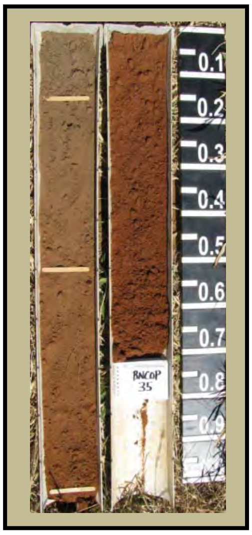


Profile description

The **surface soil** (A11, A1) is a brown (7.5YR 3/3), loamy sand (medium to coarse sand fraction) with massive/single grain fabric; field pH 6.0-6.5. Gradual change to

The **sub-surface layer** (A12, A3, B1) is a reddish brown (5YR, 7.5YR 3/3-4/4), loamy sand (medium to coarse sand fraction) with massive/single grain fabric; field pH 6.0-7.0. Clear change to

The **lower subsoil** (B2) is a red (2.5YR 4/4-4/6), sandy loam to sandy light medium clay (medium to coarse sand fraction) with massive or weak blocky structure; and occasional weak clay nodules in sandy profiles; field pH 6.5-7.5.



Subsoil Chemistry – relevant representative data from Soil 8b (colluvial) - BNCOP Site 29

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.9	0.031	<5	3	2.2	0.71	0.374	0.018
0.25 – 0.35	6.9	0.014	<5	2	1.3	0.37	0.233	0.015
0.55 – 0.65	6.6	0.014	<5	2	1.5	0.70	0.151	0.020
0.85 – 0.95	6.4	0.018	<5	12	8.0	3.6	0.518	0.204
1.15 – 1.25	6.6	0.016	5	-	-	-	-	-

pH, EC and Cl analyses (see Appendices 2 and 5) indicate profiles are slightly acidic to neutral, with consistently low salinity throughout (EC <0.1dS/m, Cl <5ppm). CEC levels are very low (2-3meq/100g) in sandy profiles, but increase marginally (12meq/100g) where clayey subsoils are developed. CEC/clay ratios in the clayey subsoil (where developed 0.29), indicate the clay fraction is non-reactive and of mixed mineralogy (mostly kaolinite and illite). Subsoil materials, whether sandy or clayey are non-sodic (ESP 1-2).

Physical Soil Characteristics – relevant representative data from Soil 8b (colluvial) - BNCOP Site 29

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	41	44	7	9	-	0.33	0.79	3.1	1	very low
0.25 – 0.35	43	42	7	10	-	0.20	0.85	3.5	1	very low
0.55 – 0.65	37	44	7	13	-	0.15	0.83	2.1	1	very low
0.85 – 0.95	26	28	6	41	-	0.29	0.51	2.2	2	very low

Clay content varies, depending whether a clayey subsoil is developed (before 1.5m). Clay content in deep sandy profiles is very low (9-13%); but increases markedly (41%) where gradational or texture contrast clayey subsoils are developed. The soil profile (whether sandy or texture contrast) is unstructured (massive or single grain), highly permeable and unlikely to exhibit dispersive tendencies either insitu or after disturbance. Reworked coarse sandy materials will be loose and incoherent, and not subject to compaction or pulverescent/hardsetting behaviour. In contrast, clayey subsoil materials are characterized by a non-sodic, un-reactive clay fraction (41%), which is significantly moderated by coarse sand/fine sand (54% combined). Clayey materials are likely to experience slaking, compaction and elevated erosion risk post disturbance. Laboratory measured dispersion in sandy material is high (R1 0.79-85) due to fines within the sand fraction, but decreases (R1 0.51) in the non-sodic clayey subsoil. Clayey materials are recommended for subsurface replacement only.

Summary

Sandy soil material varies significantly in thickness (0.9->1.5m), has very low fertility, massive/single grain structure, very low clay content (9-13%), very low salinity (EC <0.1dS/m), very low sodicity (ESP 1) and a significant coarse sand fraction (37-43%). It is considered completely benign and relatively stable, but is likely to experience loose/incoherent behaviour and elevated erosion risk following disturbance. Salvaged sandy material is recommended for replacement only on level terrain or low gradients. Potential exists to use coarse sandy material (down to 0.9->1.5m) as surrogate topsoil on steeper slopes, but such a strategy would require adequate mixing with competent sandstone spoil to increase surface roughness, topsoil resilience and slope integrity. **Clayey subsoil material below 0.9->1.5m** (where present) has benign physical/chemical characteristics and represents a useful source of additional root zone media. It is massive (to weakly structured) and non-sodic (ESP 2), with an un-reactive clay fraction that is moderated by significant sand content (54%). Salvaged subsoil material will lack structural integrity following disturbance, and be subject to compaction and elevated erosion risk. It is recommended for stripping, but only as root zone media for sub-surface replacement.

Soil 8d – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.3m	Strip sandy surface soil to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.5m	Strip additional sandy or clayey root zone media between 0.3-1.5m for sub-surface replacement only.
Single stage	Combined	0-1.0m	Strip sandy surface soil to 1.0m as surrogate topsoil material. Mix preferentially with competent sandstone spoil for use on low to moderate gradients. Where possible segregate material to 0.3m to preserve seed source material.

Soil 8d – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	5	Unsuitable due to extreme limitations	e3, m5	-
Grazing	5	Seasonal breeding country – suitable for grazing native pastures, requires dry season destocking	m5, nd4, v2	C2

Soil 9a — Loamy brown texture contrast soil/clay on calcareous sediments + eucalypt

Soil concept: Hardsetting, loamy to clay loamy surfaced (0.2-0.3m), brown non-sodic texture contrast soil grading to a structured, brown non-cracking clay overlying calcareous sediments from 0.7m->1.5m.

Regional Soil Name: Mayfair (Mf), Kirkcaldy (Kc); affinities with Adeline (Ad) and Carlo (Cc)
Aust. Soil Classification: Brown Chromosol, Brown Dermosol **Principal Profile Form:** Db1.33, Uf6.31

Landform: Level to gently undulating plains and low rises associated with outcropping sub-labile calcareous sediments (either locally developed unconsolidated calcareous substrates; or outcropping calcareous upper Permian strata). Distribution is confined to small areas in the north of the BNCOP Disturbance Footprint. Slope range <1-3%.
Geological landscape: Either unconsolidated calcareous Tertiary–Quaternary sediments (TQr); or outcropping calcareous upper Permian strata (Pwy - Gyranda Subgroup). Surficial lithology presents as sub-labile calcareous fine grained sediments ± marl and secondary carbonate.
Land zone: Cainozoic clay deposits (LZ 4)/Cainozoic to Proterozoic fine grained sedimentary rocks (LZ 9).
Vegetation: Eucalypt.

Runoff, perm., & drainage: Slow runoff; slow permeability; moderately well drained.
Surface features: Hardsetting; non-cracking; non-gilgaied; no surface gravel or stone.

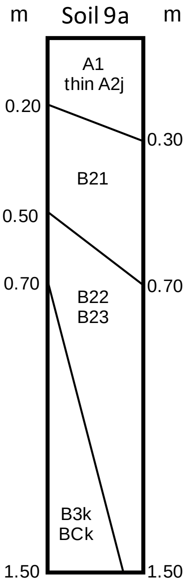
	Total N (%)	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
Surface soil fertility:	mod.-high (0.10)	very low (4.0)	high (0.71)	high (5.7)

Moisture Characteristics: **ERD:** >1.0m (no salinity or ESP restrictions) **PAWC:** 85-100mm/1.0m

Investigation sites: **Field sites** – 25, 28, 30 **Analysed sites** – 30

Cleared silver-leaved ironbark ± bloodwood ± ghost gum (with limebush) on gently undulating insitu calcareous sediments at Site 28.

Loamy surfaced, brown non-sodic texture contrast soil overlying insitu calcareous sediments at depth (Site 28).



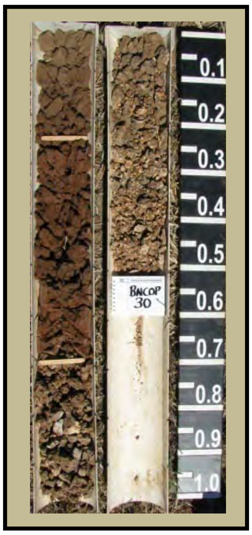
Profile description

The **surface soil** (A1, A2j) is a black or brown (10YR 3/2-3/3), sandy loam to sandy light clay (fine sand fraction) with weak to moderate subangular blocky structure; typically with a thin bleached A2 horizon immediately above the subsoil contact; field pH 6.0-7.0. Clear or abrupt change to

The **upper subsoil** (B21) is a brown or reddish brown (7.5YR, 10YR 4/3-5/3), sometimes mottled (20% faint or distinct orange), light medium clay (fine to medium sand fraction) with moderate blocky structure; field pH 7.0-8.5. Gradual change to

The **lower subsoil** (B22, B23) is a brown (7.5YR, 10YR, 2.5Y 5/3-6/4), sometimes mottled (<20% faint or distinct orange), light medium clay (fine to medium sand fraction) with moderate blocky structure; and 10->20% soft or nodular carbonate; field pH 8.0-8.5. Clear change to

Substrate material (B3k, BCk) where present is a grey or brown (10YR, 2.5Y 5/4-6/2) clayey matrix with >50% soft, very weathered fine grained calcareous marl/soft or nodular carbonate; field pH 8.0-8.5.



Subsoil Chemistry – representative data from BNCOP Site 30

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.7	0.048	5	12	5.7	5.5	0.710	0.071
0.25 – 0.35	7.9	0.041	5	22	9.7	12.6	0.370	0.303
0.55 – 0.65	8.9	0.196	85	25	9.3	16.7	0.255	0.835
0.85 – 0.95	9.1	0.301	215	21	7.5	16.0	0.196	0.865
1.15 – 1.25	9.0	0.355	353	-	-	-	-	-

pH is acidic to neutral in the surface soil and alkaline to strongly alkaline in the subsoil. EC and Cl analyses (see Appendices 2 and 5) indicate profile salinity is low (<0.3dS/m) to about 0.5-0.7m, with moderate levels (0.3-0.5dS/m) below 0.5-0.7m. Non-cracking behaviour, moderate CEC levels (21-25meq/100g) and moderately high CEC/clay ratios (0.54-0.62) in the subsoil suggest the clay fraction is of mixed mineralogy, with limited activity and lacks significant shrink-swell characteristics. Sodicity data indicates profiles are non-sodic throughout (ESP 1-4). Magnesium (Mg) dominates cation chemistry, but is unlikely to have a significant effect because of elevated calcium chemistry and low ESP.

Physical Soil Characteristics – representative data from BNCOP Site 30

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	17	51	11	23	-	0.52	0.58	1.0	1	very low
0.25 – 0.35	11	40	10	41	-	0.54	0.42	0.8	1	very low
0.55 – 0.65	13	34	11	41	-	0.61	0.37	0.6	3	very low
0.85 – 0.95	33	21	15	34	-	0.62	0.77	0.5	4	low

Clay content in texture contrast profiles increases sharply between loamy surface horizons (<25%) and the underlying clay subsoil (35-45%). In heavier profiles (non-cracking clay), surface clay content is higher (30->35%) and the change less abrupt. The surface soil to 0.2-0.3m is hardsetting, non-sodic (ESP 1), relatively non-dispersive (R1 0.42-0.58), only weakly to moderately structured and characterized by high levels of fine sand/silt (50-62% combined). This suggests significant slaking, pulverescent behaviour and compaction is likely post disturbance. Subsoil clay to about 0.7-0.8m is moderately structured, non sodic (ESP 1-3), non dispersive (R1 0.37-0.42) and considered benign. This material has limited reactivity (shrink-swell behaviour), similarly elevated levels of fine sand/silt (45-50 combined) and will be subject to pulverescent behaviour, dense packing and significant compaction after reworking. Calcareous substrate below 0.7-0.8m is typically less clayey (34%) and subject to significantly higher dispersive behaviour (R1 0.77). It is not recommended for salvage.

Summary

Loamy/clayey surface soil material to 0.3m has low fertility, and is non-sodic (ESP 1), relatively non-dispersive (R1 0.42-0.58), weakly to moderately structured, hardsetting and characterized by high levels of fine sand/silt (50-62% combined). It is considered relatively benign, but is likely to be prone to pulverescent behaviour, severe compaction, slaking and high erosion risk following disturbance. Topsoil materials to 0.3m are suitable for replacement only on level terrain or low gradients. **Subsoil material between 0.3-0.8m** is also benign and is characterized by a moderately structured, non-sodic (ESP<3), relatively un-reactive clay fraction (lacking shrink swell characteristics) that is moderated by significant fine sand and silt (45-50% combined). Salvaged subsoil clay will lack structural integrity post disturbance and be subject to dense packing, compaction and elevated erosion risk. This material is recommended for stripping, but only as root zone media for sub-surface replacement. **Calcareous subsoil/substrate material below about 0.8m** is subject to elevated erosion risk because of increased dispersive behaviour (R1 0.77) and is not recommended for salvage.

Soil 9a – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.3m	Strip loamy/clayey surface soil to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-0.8m	Strip additional root zone media between 0.3-0.8m for sub-surface replacement only.
Single stage	Combined	0-0.5m	Strip a mix of surface soil and subsoil clay to 0.5m as primary topsoil.

Soil 9a – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	4	Marginal due to severe limitations	e2, m4, pm2, ps4, w2	B
Grazing	4	Breeding country – marginal for improved pastures, suitable for grazing native pastures	m3, nd4, ps2, v2	-

Soil 9b — Weakly self-mulching black clay on calcareous sediments + open grassland

Soil concept: Hardsetting to moderately self-mulching, black cracking clay with weak normal gilgai (VI <0.1-0.2m, HI 8-15m) overlying calcareous sediments from >1.2m.

Regional Soil Name: Kirkcaldy (Kc); affinities with Carfax (Cx) and Mt Stuart (Ms)
Aust. Soil Classification: Black Vertosol **Principal Profile Form:** Ug5.14

Landform: Level to gently undulating plains associated with outcropping sub-labile calcareous sediments (either locally developed unconsolidated calcareous substrates; or outcropping calcareous upper Permian strata). Distribution is confined to small areas in the north of the BNCOP Disturbance Footprint. Slopes <1%.

Geological landscape: Either unconsolidated calcareous Tertiary–Quaternary sediments (TQr); or outcropping calcareous upper Permian strata (Pwy - Gyranda Subgroup). Surficial lithology presents as sub-labile calcareous fine grained sediments ± marl and secondary carbonate.

Land zone: Cainozoic clay deposits (LZ 4)/Cainozoic to Proterozoic fine grained sedimentary rocks (LZ 9).

Vegetation: Open grassland.

Runoff, perm., & drainage: Slow runoff; slow permeability; moderately well drained.

Surface features: Hardsetting to moderately self-mulching (2-5mm); cracking; weakly gilgaied (VI 0.15m, HI 8-15m); no surface gravel or stone; <2-5% nodular carbonate on surface.

Surface soil fertility:	**Total N (%)**	**Available P (ppm)**	**Ex. K (meq/100g)**	**Ex. Ca (meq/100g)**
	high (0.135)	low-mod. (9.5)	high (0.676)	high (14.2)

Moisture Characteristics: **ERD:** 0.7m (salinity >0.8dS/m or >800ppm Cl) **PAWC:** 85mm/1.0m

Investigation sites: **Field sites** – 43 **Analysed sites** – 43

Open grassland on localised black soils flats associated with insitu calcareous sediments at Site 43.

Hardsetting to moderately self mulching, black cracking clay overlying insitu calcareous sediments below 1.3m (Site 43).

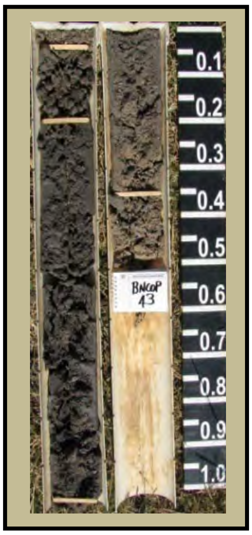
Profile description

The **surface soil** (A11, A12) is a black (2.5Y 3/1-3/2) light medium to medium clay with moderate to strong granular surface structure grading to strong fine blocky subsurface structure; field pH 7.0-8.0. Clear change to

The **upper subsoil** (B21) is a black (2.5Y 2/1-3/1), medium heavy clay with strong lenticular structure and minor (<5%) soft or nodular carbonate; field pH 8.0-8.5. Gradual change to

The **lower subsoil** (B22k) is a grey (10YR 4/1-4/2), medium heavy clay with strong coarse lenticular structure and >20% soft or nodular carbonate; field pH 8.0-8.5. Gradual change to

Substrate material (B3k, Ck) is a pale grey (10YR, 2.5Y 6/2) clayey matrix with >50% soft, very weathered fine grained calcareous sandstone, siltstone or shale ± 10% calcareous marl/soft or nodular carbonate; field pH 8.5-9.0.



Subsoil Chemistry – representative data from BNCOP Site 43

Sample depth (m)	pH (1:5)	EC (dS/m)	Cl (mg/kg)	CEC/ECEC (meq/100g)	Exchangeable cations (meq/100g)			
					Ca	Mg	K	Na
0 – 0.1	6.5	0.060	30	23	14.2	7.0	0.676	0.726
0.25 – 0.35	8.4	0.069	25	28	16.7	10.6	0.290	1.9
0.55 – 0.65	9.0	0.502	475	37	16.4	17.8	0.308	5.5
0.85 – 0.95	8.9	0.760	900	37	16.8	19.3	0.329	5.9
1.15 – 1.25	9.0	0.715	810	-	-	-	-	-

pH is neutral in the immediate surface soil, and alkaline to strongly alkaline throughout the subsoil. EC and Cl analyses (see Appendices 2 and 5) indicate profile salinity is low (<0.3dS/m) to about 0.5m, with moderate levels (0.3-0.6dS/m) between 0.5-0.7m and increasing salinity below 0.7m. High CEC levels (23-37meq/100g), moderately high CEC/clay ratios (0.61-0.73) and the presence of cracking and strong lenticular structure suggest the clay fraction is active, with significant shrink-swell characteristics, and is of mixed mineralogy with a high proportion of smectites. ESP data indicate surface horizons to 0.2m (A11/A12 horizons) are non-sodic (ESP <3), upper subsoil materials to about 0.5m are weakly to moderately sodic (ESP 3-<15), while below 0.5m lower subsoil clay becomes highly sodic (ESP 15-16). Magnesium (Mg) co-dominates cation chemistry below 0.5m and is likely to enhance dispersive behaviour.

Physical Soil Characteristics – representative data from BNCOP Site 43

Sample depth (m)	Particle size analysis				15 Bar	CCR	R1 Disp. Ratio	Ca/Mg ratio	ESP (%)	Sodicity rating
	CS %	FS %	Silt %	Clay %						
0 – 0.1	11	31	21	38	-	0.61	0.47	2.0	3	low
0.25 – 0.35	17	35	10	39	-	0.72	0.52	1.6	7	low-mod.
0.55 – 0.65	14	23	14	51	-	0.73	0.66	0.9	15	mod.-high
0.85 – 0.95	14	19	14	54	-	0.69	0.66	0.9	16	high

Clay content in immediate surface horizons to 0.2m is moderately high (38-39%), with significant levels of fine sand/silt (45-52%), moderate to strong structure, significant clay activity and strong cracking behaviour. The upper subsoil to about 0.5m is characterised by increasing clay content (39-51%), Ca dominant cation chemistry, low to moderate sodicity (ESP 3-<15) and increasing dispersion (R1 0.47-0.66). Below 0.5m, worsening sodicity and dispersion, increasing salinity and coarse macro lenticular structure suggest adverse physical behaviour and poor establishment response are likely post-disturbance.

Summary

Surface soil/upper subsoil material to 0.2m has moderate fertility and is strongly aggregated and finely structured. It is characterised by moderately high clay content (38-39%), active clay behaviour (CEC/Clay ratio 0.61-0.72), low salinity (<0.3dS/m), low sodicity (ESP <3), low dispersion (R1 0.47-0.52) and Ca dominant cation chemistry. These attributes suggest material to 0.2m will be relatively benign and physically stable/resilient post disturbance. It is likely however, to experience shrink-swell behaviour, strong cracking and significant root zone shearing (depending on replacement thickness). Salvaged topsoil materials to 0.2m are suitable for replacement on low to moderate gradients. **Upper subsoil material between 0.2-0.5m** is characterised by increasing clay content and shrink-swell capacity, weak to moderate sodicity (ESP 7-<15) and increasing dispersive behaviour (R1 0.52-0.66). Salvage of this material is recommended, but only as root zone media for sub-surface replacement. **Lower subsoil material below 0.5m** is considered undesirable, with high to very high levels of salinity (0.5->0.7dS/m, Cl >800ppm), and worsening sodicity and dispersive behaviour (ESP 15-16, R1 0.66). It is not recommended for salvage.

Soil 9b – Stripping Recommendations

Method	Material	Depth	Stripping recommendation
Two stage	Topsoil	0-0.2m	Strip structured surface soil/subsoil clay to 0.2m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.2-0.5m	Strip additional root zone media between 0.2-0.5m for sub-surface replacement only. Avoid undesirable subsoil material below 0.5m.
Single stage	Combined	0-0.2m	Strip structured surface soil/subsoil clay to 0.2m as primary topsoil. Avoid increasingly undesirable subsoil material below 0.2m.

Soil 9b – Land Suitability Assessment (DNRM/DSITIA 2013a, 2013b, QDME 1995)

Land use	Suitability class		Limitation subclasses	ALC
Summer cropping	4	Marginal due to severe limitations	e2, es3, m4, ps2, tm2, w2	B
Grazing	3	"Grower" country – suitable for improved pastures, but less productive than Classes 1 & 2	m2, nd3, ps2, sa2, w2, ph2	-

8. Topsoil stripping and management recommendations

Topsoil stripping recommendations are primarily determined by inherent soil characteristics and spatial soil variability within the landscape. However, landform design, rehabilitation technique and in particular, proposed final end use clearly influence the physical conditions that stripped materials will be subjected to following reinstatement, and as such need to be considered whilst formulating stripping recommendations.

Assumptions

Stripping recommendations where post mining commitments undertake to reinstate pre-mining cropping or grazing suitability, will be very different to those where more passive, non agricultural final uses are planned.

- To realistically achieve reinstatement of cropping or grazing land uses requires not only appropriate landform design, but also the sequential removal and replacement of both topsoil and root zone material, in a number of separate layers, to at least the effective rooting depth of the crops/pastures being considered.
- If however, planned post mining commitments aim to achieve sustainable ecosystem uses with a view to achieving biodiversity outcomes and built landscape stability, then final landform design and rehabilitation techniques may differ significantly, and single stage or possibly two stage soil stripping may achieve the desired outcomes.

In effect, the suitability of materials available for stripping depends not only on the presence/absence and severity of inherent soil based limitations (such as salinity or dispersive behaviour) but also on proposed landform design and final desired outcomes to which the materials are likely to be subjected. Differing landform designs and final end uses will change individual stripping depths accordingly.

Stripping recommendations presented in this report have been purposefully designed to maximize the salvage of suitable soil resources (topsoil and root zone materials) for the establishment of a functional native vegetation ecosystem capable of sustainably rehabilitating and stabilizing low to moderate slopes. Soil materials recommended for salvage have been selected only to provide suitable growth media for the establishment and longer term survival of selected/adapted native tree and groundcover species.

It is important to note that stripping recommendations designed for the reinstatement of pre-mining land uses such as dryland cropping or grazing will differ significantly to those presented. To achieve targeted rehabilitation outcomes such as these would require, in addition to the design and reshaping of appropriate landforms, careful salvage and sequential placement of soil material from multi-stage stripping operations. In particular, the sequential placement of far greater quantities of subsoil root zone media would be required to ensure constructed soil profiles were of sufficient depth to support the end use envisaged. The success of any such re-instatement for cropping would require (as a minimum) landforms with gradients less than 3%, shortened slope lengths and controlled capture and disposal of surface flows.

Materials stripped using recommendations presented in this report are incompatible with achieving post mining cropping or grazing end uses. Salvage operations across the Bowen Basin typically employ single stage, non-sequential stripping and stripped volumes in general would be insufficient for such end uses. Poor outcomes in terms of very low productivity and excessive erosion risk could be expected where attempts to implement pre-mining land uses (such as cropping) were undertaken without appropriate and purpose specific stripping and placement recommendations.

Revision of the topsoil stripping recommendations from this investigation would be required where end uses other than the stabilization of low to moderate slopes through the establishment of sustainable native vegetation cover are envisaged.

Topsoil management plan

In any topsoil stripping, stockpiling and replacement operation, planned activities need to carefully follow actions outlined in a detailed topsoil management plan. The aim of any such plan should be to ensure optimal allocation of available topsoil/root zone reserves across all future rehabilitation scenarios proposed for the mine. It is important ongoing topsoil management planning is implemented during the normal operation of the mine to ensure shortfalls in available rehabilitation media are not experienced leading towards mine closure. Topsoil/root zone requirements for planned activities need to take into account proposed landform designs, nature of the waste to be rehabilitated and intended rehabilitation methods to be employed. In addition, the management plan should outline the intended depth and surface treatment of topsoil/root zone media cover to be reinstated, and the intended type/nature of vegetative cover to be established.

In practice, a detailed topsoil management plan should clearly outline:

- delineation of areas to be disturbed;
- volumes/characteristics of topsoil/root zone materials available from identified disturbance;
- methodology for optimal soil management during stockpiling;
- delineation of areas for reinstatement and rehabilitation;
- physical conditions expected at each rehabilitation location (e.g. slope degree/length, spoil characteristics, proposed rehabilitation technique);
- selection methodology to identify the most appropriate materials from available stockpiled resources for different rehabilitation scenarios; and
- volumes/characteristics of topsoil/root zone media (or other cover materials) required for salvage to meet rehabilitation requirements.

General stripping and stockpiling guidelines

The following general recommendations may assist or guide stripping and stockpiling activities planned for disturbance areas within the BNCOP Disturbance Footprint:

- Where stripping depth exceeds 0.3-0.5m two **stage stripping and replacement** is recommended to minimize mixing of surface soil and subsoil materials. Materials stripped using a two stage process are referred to as **topsoil** and **root zone materials** respectively (as defined in the methodology section of this report). Separation of these materials will optimize physical conditions in stockpiled resources and assist in preserving seed source potential.

- Topsoil salvage should be maximized from all disturbed areas and **topsoil materials (optimal depth 0.1-0.3m) should be stockpiled separately** from subsoil based root zone media.

- **Topsoil materials which potentially contain significant native seed** (for example bluegrass downs or eucalypt woodlands where introduced grasses have not invaded) should be **segregated and stockpiled separately** from cropping or pasture improved topsoil resources which are likely to contain heavy loads of introduced pasture or weed seed.

- **Topsoil stockpiles which potentially contain significant native seed should be utilized preferentially** to maximize re-establishment of native species from available seed stores; providing this fits the requirements of the rehabilitation plan in terms of soil and vegetative cover required.
- **Topsoil stockpiles containing predominantly surface soil material** (typically stripped from the upper 0.1-0.3m of the soil profile) should ideally be **formed no more than 1.5m in height** and should be ripped and seeded to native species following stockpile laydown to stabilize and protect the material.
- Stripped materials (whether topsoil or root zone media) should be **segregated into stockpiles which have similar reuse or textural characteristics**. Soils with good surface physical characteristics should not be stockpiled with soils where poorer physical attributes are indicated; clays should not be stockpiled with loams or sands.
- **Root zone media** should be salvaged from all disturbed areas where suitable material has been identified, an**d stockpiled separately from topsoil materials.**
- **Root zone media** (typically stripped from below 0.3m) can be **stockpiled to greater depths than the 1.5m specified for topsoil materials.** Root zone material stockpiles should only be constructed in areas from which topsoil has first been stripped. Stockpiles should be ripped and seeded with native species following lay down to stabilize and protect the resource.

Topsoil stripping recommendations – topsoil/subsoil depths for salvage

Multi-stage stripping and replacement is widely accepted as best management practice for the salvage and reuse of soil/rehabilitation media from areas of mining disturbance. As such, a summary of t**wo stage stripping recommendations** for soil types mapped within the BNCOP Disturbance Footprint is presented in **Table 4** below.

It is recognized however that single stage stripping which involves the salvage of maximum quantities of useable soil material (i.e. combined topsoil and suitable subsoil) is often the preferred stripping methodology for many mines. As such, **recommendations for single stage stripping** outlining one off salvage depths for the retrieval of all useable materials are also presented in **Table 4**. It is important to recognise however that single stage stripping by its very nature will result in greater mixing of discordant materials and a reduction in soil quality, particularly less desirable physical and chemical characteristics and a dilution of surface fertility, topsoil organics and seed source potential. When compared with multi-stage reinstatement, single stage material will be subject to slower infiltration and higher runoff rates, while plant establishment will potentially be slower and less successful.

For most rehabilitation situations, subsoil clays with elevated levels of soluble salts or highly dispersive physical behaviour are not recommended for salvage either as topsoil or root zone media. Reinstatement of such materials, particularly as surface materials, will typically be subject to poor physical behaviour (sodicity, dispersion and coarse/dense structure) and limited plant establishment. Cumulatively, these effects restrict the development of ground and canopy cover and slow water relations and structural recovery in the surface soil. Such effects impact significantly on rehabilitation outcomes at a site and significantly increase erosion risk and the potential for localized rehabilitation failure. Where soil mapping indicates high levels of subsoil salinity may be present or significant spatial variability in salinity levels exists, localized field testing of materials prior to salvage is recommended.

Table 4. **Summary of stripping depth recommendations for soils mapped within the BNCOP Disturbance Footprint.**

Method	Material	Depth	Stripping recommendations
Soil – 2b			
Two stage	Topsoil	0-0.3m	Strip structured surface soil/subsoil clay to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.2m	Strip additional root zone media 0.3-1.2m for sub-surface replacement only.
Single stage	Combined	0-0.8m	Strip structured surface soil/subsoil clay to 0.8m as surrogate topsoil material. Avoid increasingly undesirable grey/brown clay below 0.8m.
Soil –3a			
Two stage	Topsoil	0-0.3m	Strip structured surface soil/subsoil clay to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.0m	Strip additional root zone media 0.3-1.0m for sub-surface replacement only.
Single stage	Combined	0-0.7m	Strip structured surface soil/subsoil clay to 0.7m as surrogate topsoil material. Avoid increasingly undesirable grey or brown clay below 0.7m.
Soil –3b			
Two stage	Topsoil	0-0.35m	Strip loamy surface soil to 0.35m and segregate as primary topsoil to preserve topsoil/seed source material. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
	Root zone	nil	Subsoil clay below 0.35m is dispersive and should be avoided.
Single stage	Combined	0-0.35m	Strip loamy surface soil to 0.35m (maximum) as topsoil/seed source material. Avoid dispersive subsoil clay below 0.35m. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
Soil – 4c			
Two stage	Topsoil	0-0.3m	Strip structured surface soil/subsoil clay to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-0.8m	Strip additional root zone media between 0.3-0.8m for sub-surface replacement only. Avoid grey or brown clay below about 0.7-0.9m.
Single stage	Combined	0-0.4m	Strip structured surface soil/subsoil clay to 0.4m as primary topsoil. Avoid increasingly undesirable subsoil material below 0.4m.
Soil – 4d			
Two stage	Topsoil	0-0.4m	Strip structured surface soil/subsoil clay to 0.4m and segregate as primary topsoil to preserve seed source material.
	Root zone	nil	Subsoil clay below 0.4m is undesirable and should be avoided.
Single stage	Combined	0-0.4m	Strip structured surface soil/subsoil clay to 0.4m as primary topsoil. Avoid undesirable subsoil clay below 0.4m. Melonhole gilgai (where present) require topsoil be stripped with an excavator and batter bucket; stripping depth should follow surface contours.
Soil –5			
Two stage	Topsoil	0-0.2m	Strip structured surface soil/subsoil clay to 0.2m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.2-0.4m	Strip additional root zone media between 0.2-0.4m for sub-surface replacement only. Avoid undesirable subsoil material below 0.4m.
Single stage	Combined	0-0.2m	Strip surface soil/subsoil clay to 0.2m as primary topsoil. Avoid increasingly undesirable subsoil material below 0.2m.
Soil – 7a			
Two stage	Topsoil	0-0.1m	Strip structured surface soil/subsoil clay to 0.1m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.1-0.4m	Strip additional root zone media between 0.1-0.4m for sub-surface replacement only. Avoid undesirable subsoil clay below 0.4m.
Single stage	Combined	0-0.1m	Strip surface soil/subsoil clay to 0.1m as primary topsoil. Avoid increasingly undesirable subsoil clay below 0.1m. Stripping with an excavator and batter bucket is recommended; stripping depth to follow surface contours.

Method	Material	Depth	Stripping recommendations
Soil – 7b			
Two stage	Topsoil	0-0.15m	Strip surface soil/upper subsoil clay to 0.15m and segregate as primary topsoil to preserve seed source material.
	Root zone	nil	Subsoil clay below 0.15m is undesirable and should be avoided.
Single stage	Combined	0-0.15m	Strip structured surface soil/subsoil clay to 0.15m. Avoid undesirable subsoil clay below this depth.
Soil – 7c			
Two stage	Topsoil	0-0.5m	Strip sandy surface soil to 0.5m and segregate as primary topsoil to preserve seed source material. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
	Root zone	0.5-1.2m	Strip additional clayey root zone media between 0.5-1.2m for sub-surface replacement only.
Single stage	Combined	0-0.5m	Strip sandy surface soil to 0.5m as primary topsoil. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
Soil – 7d			
Two stage	Topsoil	0-0.1/0.2m	Strip loamy surface soil to between 0.1-0.2m (maximum) and segregate as primary topsoil to preserve seed source material. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
	Root zone	nil	Subsoil clay below 0.1-0.2m is dispersive and should be avoided.
Single stage	Combined	0-0.1/0.2m	Strip loamy surface soil to between 0.1-0.2m (maximum) as topsoil/seed source material. Avoid dispersive subsoil clay below 0.1-0.2m. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
Soil – swp/7a			
Two stage	Topsoil	0-0.1m	Strip structured surface soil/subsoil clay to 0.1m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.1-0.4m	Strip additional root zone media between 0.1-0.4m for sub-surface replacement only. Avoid undesirable subsoil clay below 0.4m.
Single stage	Combined	0-0.1m	Strip surface soil/subsoil clay to 0.1m as primary topsoil. Avoid increasingly undesirable subsoil clay below 0.1m. Stripping with an excavator and batter bucket is recommended; stripping depth to follow surface contours.
Soil – 8a			
Two stage	Topsoil	0-0.3m	Strip sandy/loamy surface soil to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.2m	Strip additional loamy/clayey root zone media between 0.3-1.2m for sub-surface replacement only.
Single stage	Combined	0-0.5m	Strip sandy/loamy surface soil to 0.5m as primary topsoil. Avoid clayey subsoil materials below this depth because of undesirable physical attributes and poor establishment response post disturbance.
Soil – 8b			
Two stage	Topsoil	0-0.3m	Strip sandy surface soil to 0.3m and segregate as primary topsoil to preserve seed source material. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
	Root zone	0.3-0.8m or deeper	Strip additional sandy or clayey root zone media from 0.3m to depth of weathered rock (0.8->1.5m) for sub-surface replacement only.
Single stage	Combined	0-0.5m	Strip sandy surface soil to 0.5m as primary topsoil. Use bleaching ± the presence of dense subsoil clay to guide stripping limit.
Soil – 8c			
Two stage	Topsoil	0-0.3m	Strip sandy surface soil to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.2m	Strip additional sandy root zone media between 0.3-1.2m (or depth to weathered rock where shallower) for sub-surface replacement only.
Single stage	Combined	0-1.2m	Strip sandy surface soil to 1.2m as surrogate topsoil material. Mix preferentially with competent sandstone spoil for use on low to moderate gradients. Where possible, segregate material to 0.3m to preserve seed source material.

Method	Material	Depth	Stripping recommendations
Soil – 8d			
Two stage	Topsoil	0-0.3m	Strip sandy surface soil to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-1.5m	Strip additional sandy or clayey root zone media between 0.3-1.5m for sub-surface replacement only.
Single stage	Combined	0-1.0m	Strip sandy surface soil to 1.0m as surrogate topsoil material. Mix preferentially with competent sandstone spoil for use on low to moderate gradients. Where possible segregate material to 0.3m to preserve seed source material.
Soil – 9a			
Two stage	Topsoil	0-0.3m	Strip loamy/clayey surface soil to 0.3m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.3-0.8m	Strip additional root zone media between 0.3-0.8m for sub-surface replacement only.
Single stage	Combined	0-0.5m	Strip a mix of surface soil and subsoil clay to 0.5m as primary topsoil.
Soil – 9b			
Two stage	Topsoil	0-0.2m	Strip structured surface soil/subsoil clay to 0.2m and segregate as primary topsoil to preserve seed source material.
	Root zone	0.2-0.5m	Strip additional root zone media between 0.2-0.5m for sub-surface replacement only. Avoid undesirable subsoil material below 0.5m.
Single stage	Combined	0-0.2m	Strip structured surface soil/subsoil clay to 0.2m as primary topsoil. Avoid increasingly undesirable subsoil material below 0.2m.

Topsoil stripping recommendations – topsoil/subsoil volumes for salvage

Assessment of topsoil resources for stripping and salvage within the BNCOP Disturbance Footprint (external to ML80169 and ML80170) provides the necessary framework to plan and secure sufficient volumes for prescribed future rehabilitation objectives, while guaranteeing only the most appropriate material is salvaged. The stripping recommendations and underlying soil data presented, both in **Table 4** and also the earlier Soil Characterization Section of this report, ensures appropriate data is available (ahead of mining) to quantify resources, optimize and balance selection decisions and inform future stockpile planning requirements. Topsoil (± benign subsoil) volumes (m^3) available for stripping and salvage from the 16 soils mapped within the BNCOP Disturbance Footprint are presented in **Table 5**. Final volumes have been calculated using recommended single stage stripping depths (m) combined with the spatial extent (m^2) each soil occupies.

Minimal single stage stripping depths (<0.2m) are available from Soils 5, 7a, 7b, 7d, swp/7a and 9b, moderate depths (0.2-0.5m) from Soils 3b, 4c, 4d, 7c, 8a, 8b, and 9a and significant depths (>0.5m) from Soils 2b, 3a, 8c and 8d. The largest volumes (>500,000m^3) are available from Soils 7c, 8a, 8b and 8d through a combination of greater depth and wider spatial extent. The combined volume of suitable topsoil/root zone media potentially available for salvage and stockpiling from within the BNCOP Disturbance Footprint is estimated at **5,825,600 m^3.**

Salvage volumes within already approved sections of the BNCOP EIS Operational Area (namely ML80169 and ML80170) have been presented previously and are available from the soil investigation report *Pre-mining Agricultural Land Suitability and Soil Reuse Recommendations - Wonbindi North area, Baralaba, Queensland* by NQSA (2011a), and also in *Appendix A – Topsoil Inventory* in the *Baralaba Central and Baralaba North Plan of Operations* released in 2013 (Cockatoo Coal Limited 2013). Data for areas external to the BNCOP Disturbance Footprint are not presented in this report.

Table 5. **Summary of stripping volumes for soils mapped within the BNCOP Disturbance Footprint.**

Soil	BNCOP Disturbance Footprint		
	Single stage stripping depth (m)	Spatial area (ha)	Salvage volume (m^3)
Soil – 2b	0.80	4.8	38,400
Soil –3a	0.70	13.5	94,500
Soil –3b	0.35	6.2	21,700
Soil – 4c	0.40	69.6	278,400
Soil – 4d	0.40	7.7	30,800
Soil –5	0.20	28.7	57,400
Soil – 7a	0.10	240.6	240,600
Soil – 7b	0.15	201.6	302,400
Soil – 7c	0.50	174.5	872,500
Soil – 7d	0.15	82.2	123,300
swp/7a	0.10	14.9	14,900
Soil – 8a	0.50	283.0	1,415,000
Soil – 8b	0.50	222.1	1,110,500
Soil – 8c	1.20	34.5	414,000
Soil – 8d	1.00	63.2	632,000
Soil – 9a	0.50	33.8	169,000
Soil – 9b	0.20	5.1	10,200
Total	**na**	**1486.0**	**5,825,600**

9. Pre-mining land suitability – dryland cropping and grazing

Pre-mining land suitability within the BNCOP Disturbance Footprint has been assessed for dryland cropping and grazing (the dominant existing land uses in the local area) and provides an important record of the agricultural potential of the land prior to disturbance or development. The assessment has utilised spatially accurate mapping (1:25000) and detailed soil attribute data, and follows the suitability methodology defined by the Queensland Government (DNRM/DSITIA 2013a, 2013b), in accordance with the requirements of the BNCOP Terms of Reference. Land suitability methodology and findings for the previously approved Baralaba/Wonbindi North Mine Lease (ML80169 and ML80170) have been presented in an earlier report by NQSA (2011a) and are not re-presented or discussed in this report.

Dryland cropping assessment

Land suitability assessment for summer and winter dryland cropping within the BNCOP Disturbance Footprint follows the methodology, criteria and decision rules defined by DNRM/DSITIA (2013a, 2013b). The study area lies within the boundaries of the Inland Fitzroy – South Burdekin Region (DNRM/DSITIA 2013b) and the classification rules for this area have been adopted in full (without change or addition) and applied as defined. The dryland cropping suitability data presented in **Tables 6 and 7** provides a clear record of the limitations, attributes and subclass rules used in the assessment.

The Inland Fitzroy – South Burdekin Region suitability framework (DNRM/DSITIA 2013b) evaluates the broadacre potential of land to grow a range of summer and winter crops (12 in total) under rainfed conditions within inland Central Queensland. Cropping systems in this region are largely opportunistic and are dependent upon the timing and variability of rainfall, previous cropping history and fallow management. The dominant crops grown are sorghum and wheat, and summer cropping is the dominant land use.

Similarity between the agronomic/crop management requirements (and associated subclass rule sets) listed for the 12 individual crops have been simplified in accordance with the DNRM/DSITIA (2013b) scheme to just summer and winter cropping classifications for the purposes of this investigation. As such, suitability findings presented below are on a summer and winter cropping basis only, and individual assessments on a crop by crop basis (whilst available) have not been reported.

Further to this, any realistic (yet robust) assessment of dryland cropping suitability in the Baralaba area is preferentially based on summer cropping suitability outcomes because of the greater likelihood and reliability of summer rainfall compared with winter rainfall across the region. Seasonal rainfall patterns strongly influence dryland cropping success in Central Queensland, and cropping cycles and planting opportunities are determined year to year by preceding rainfall history (Burgess 2003a). Summer cropping dominates long term cropping success (both spatially and temporally), and suitability criteria for winter cropping have been set at more conservative levels to reflect this. In response, all further discussion relating to suitable, marginal and unsuitable cropping land within the BNCOP Disturbance Footprint will primarily reference dryland summer cropping findings in the first instance.

Extreme climatic variability and the opportunistic nature of cropping in inland Central Queensland mean soil moisture is the primary determinant of cropping success. **Classes 1, 2 and 3** for dryland cropping (based on summer cropping criteria) have only been assigned to soils with the capacity to store enough plant available moisture to effectively complete a crop cycle from planting to harvest with minimal in-crop rainfall. Soils in this category are largely restricted to self-mulching cracking clays that are at least 0.8m deep and have PAWC values >100mm/1.0m (Class 3 or better according to DNRM/DSITIA 2013b cropping suitability criteria).

Class 4 lands, which are considered marginal for dryland cropping (based on summer cropping criteria), include a range of clay soils that have adequate depth characteristics to store sufficient PAWC but have undesirable infiltration characteristics (i.e. clays that are hardsetting to only weakly self-mulching); or are constrained by limited effective rooting depth and marginal PAWC values (75-100 mm). Class 4 soils have difficulties growing a crop without significant additions of in-crop rainfall, and crop success is unreliable and directly dependent on seasonal conditions.

All other soils are considered **Class 5** and are unsuitable for dryland cropping (based on summer cropping criteria) because PAWC levels are <75 mm and/or one or more other extreme limitations preclude their use. Moisture availability is typically limited by unfavourable surface condition, reduced infiltration, excessive runoff, continued deep drainage, low clay content or shallow effective rooting depth (due to subsoil salinity, sodicity or rock).

Suitability findings for dryland cropping

Assessment of dryland cropping suitability for both summer and winter crops (determined in accordance with DNRM/DSITIA 2013b) provides a structured and robust scientific evaluation of pre-mining cropping potential for lands potentially affected by the BNCOP Disturbance Footprint. A summary of the spatial extent (ha) of cropping suitability classes (summer and winter) and contributing soils is presented below. Further detail including summer cropping suitability statements, final suitability classes and contributing limitation subclasses for all soils within the footprint is presented in **Tables 6 and 7** and displayed in **Figure 5**. Winter cropping findings are presented for comparison purposes only, and displayed in **Figure 6**. These findings are also summarized individually for each soil type in the **Soil Characterization Section** presented earlier in this report.

Closer analysis of the suitability findings below indicates land suitable for broadacre summer cropping (Classes 2 and 3) occupies only 96ha or 6.5% of the total Disturbance Footprint. No Class 1 land was identified. The remaining 93.5% is either marginal (Class 4 – 4.5%) or unsuitable (Class 5 – 89%) for summer cropping due to inherent soil and landscape constraints that directly limit cropping success. Marginal and unsuitable areas comprise a mix of soils, all of which are better suited to grazing uses, ranging from fattening through to breeding. Analysis of winter cropping findings suggests even less land is suitable for winter crops (i.e. a total of 5 ha of Class 3).

Suitability Class		Soils	Area (ha)
Summer cropping	Class 1 - suitable	none recorded	-
	Class 2 - suitable	2b	5
	Class 3 - suitable	3a, 4c, 4d	91
	Class 4 - marginal	5, 9a, 9b	68
	Class 5 - unsuitable	3b, 7a, 7b, 7c, 7d, 8a, 8b, 8c, 8d, swp/7a	1322
Winter cropping	Class 1/2 - suitable	none recorded	-
	Class 3 - suitable	2b	5
	Class 4 - marginal	3a, 4c, 4d	91
	Class 5 - unsuitable	3b, 5, 7a, 7b, 7c, 7d, 8a, 8b, 8c, 8d 9a, 9b, swp/7a	1390

Suitable cropping land (Classes 2 and 3) within the BNCOP Disturbance Footprint (based on summer cropping criteria), is restricted to just 4 of the 16 soils mapped, namely Soils 2b, 3a, 4c and 4d. Apart from a small occurrence of Soil 4d in the north, all are associated with a long term cropping paddock at the southern end of the Disturbance Footprint. This area has also been identified by the SCL trigger mapping (DNRM 2011a) and assessed accordingly for SCL status as part of this investigation. Three of the suitable soils (namely Soils 3a, 4c and 4d) are marginal for winter cropping however, because of limited plant available water capacity (PAWC) and more conservative moisture availability criteria during the winter dry season.

The **suitable summer cropping soils 2b, 3a, 4c and 4d (Classes 2 and 3)** are deep, relatively young, alluvial self mulching cracking clays that have effective rooting depths (ERD) ranging from 0.7->1.0m. Estimated equivalent PAWC values range from 85->120mm/1.0m and suggest stored moisture availability under normal seasonal conditions is sufficient to complete a crop cycle. Slopes are mostly <3% and the soils are moderately well drained, have acceptable surface conditions for germination and establishment, are easily cultivated, non-gilgaied and lack gravel or rock in the plough zone. Limitation subclasses recorded for these soils are only negligible (sub-class 1), minor (sub-class 2) or moderate (sub-class 3) at worst.

Soils 5, 9a and 9b are considered marginal for summer cropping (Class 4). Soils 5 and 9b are weakly self-mulching clays with restricted ERD and constrained PAWC values due to subsoil salinity (Cl >800ppm) below about 0.6-0.7m. Soil 9a is a sandy to loamy surfaced non-sodic texture contrast soil/non-cracking clay that has sufficient ERD (>1.0m), but limited water holding capacity. Estimated PAWC values for all 3 soils are only 70-100mm/1.0m indicating stored moisture availability under normal seasonal conditions may be insufficient to complete a crop cycle without significant in crop rainfall. Slopes are mostly <3% and all 3 soils are moderately well drained, have acceptable surface conditions for germination and establishment, are easily cultivated, non-gilgaied and lack gravel or rock in the plough zone. Limitations recorded for these soils range from negligible (sub-class 1) to severe (sub-class 4).

The remainder of soils mapped within the BNCOP Disturbance Footprint are considered **unsuitable for summer cropping** (Class 5). Soils include **3b, 7a, 7b, 7c, 7d, 8a, 8b, 8c, 8d and swp/7a**, and collectively these soils occupy the majority of the land surface within the footprint. Soil characteristics include hardsetting sodic texture contrast soils (3b, 7b, 7d), hardsetting sodic non-cracking clays (7b), melonholed sodic grey cracking clays (7a, swp/7a), sandy surfaced non-sodic to weakly sodic texture contrast soils (7c, 8b), deep loamy red earths (8a) and deep loose colluvial sands (8c, 8d).

ERD constraints and water holding characteristics vary enormously across this group. All soils however, have estimated PAWC values between 30-85 mm/1.0m, and in all cases stored moisture availability under normal seasonal conditions is considered grossly inadequate to complete a crop cycle. Other limitations vary across the group (depending on soil and landscape characteristics) and limitations recorded range from negligible (sub-class 1) to extreme (sub-class 5).

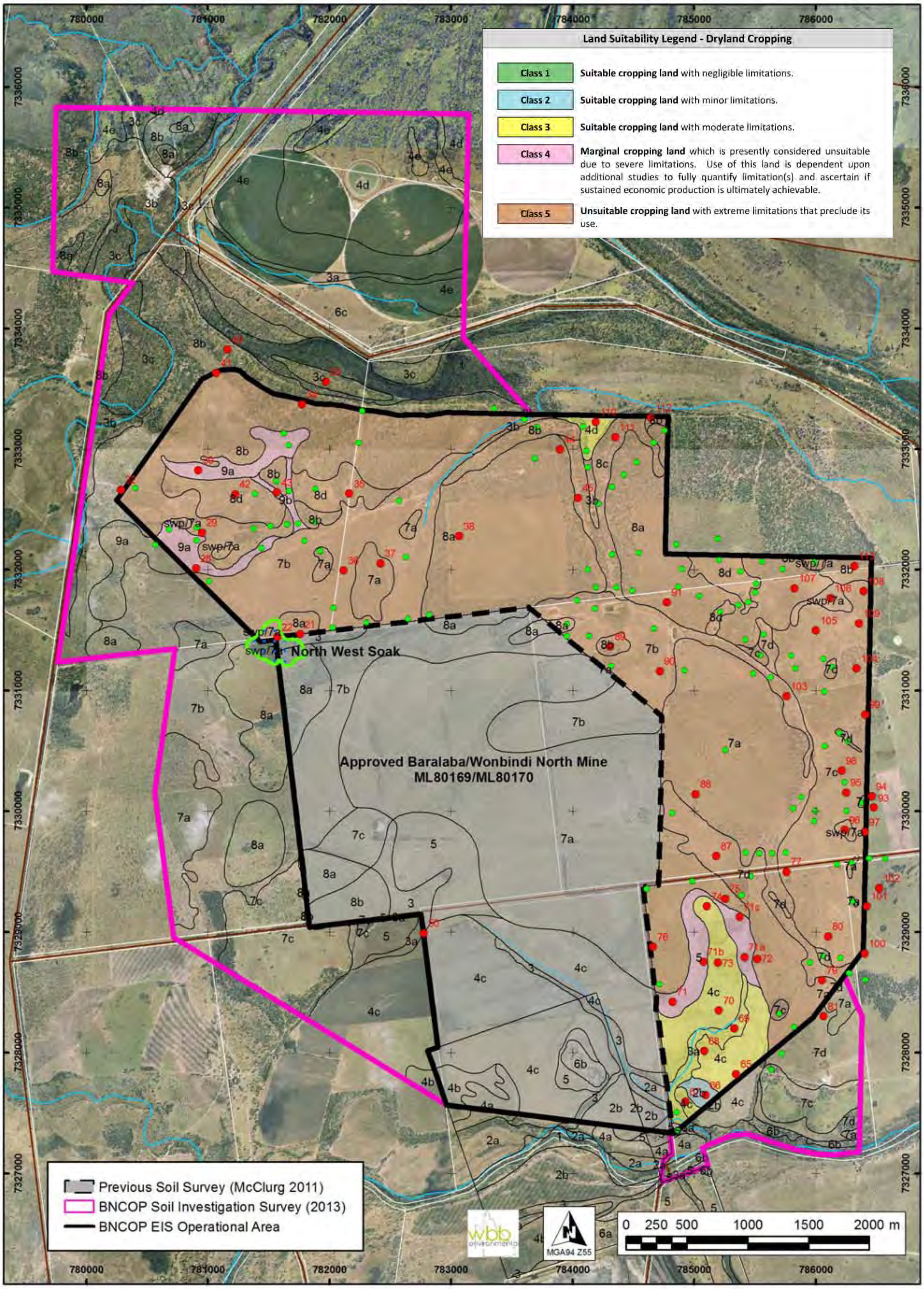


Figure 5. Dryland cropping suitability – summer crops within the BNCOP Disturbance Footprint.

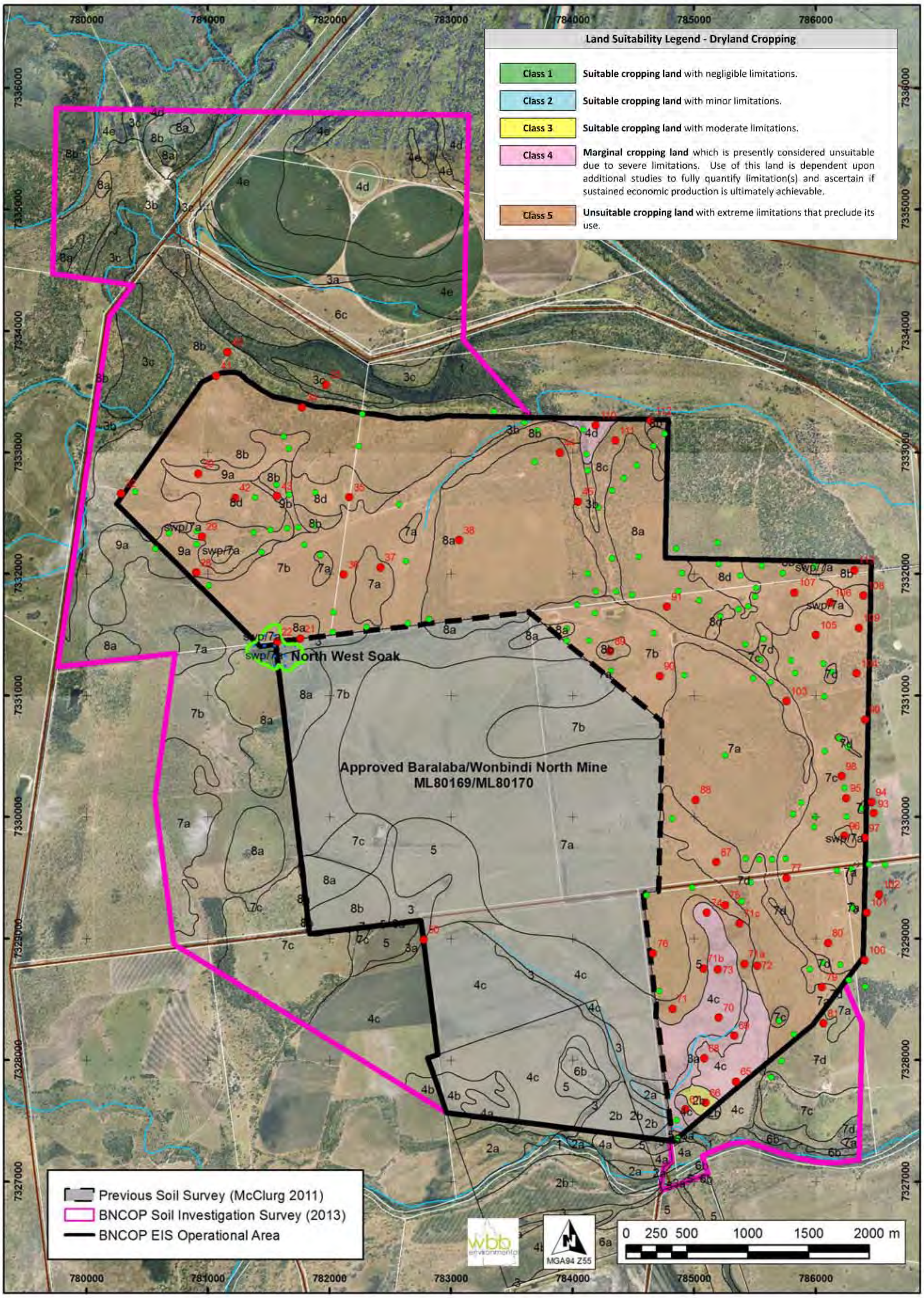


Figure 6. Dryland cropping suitability – winter crops within the BNCOP Disturbance Footprint.

Grazing assessment

Land suitability assessment for grazing within the BNCOP Disturbance Footprint follows the methodology, criteria and decision rules defined by QDME (1995). This scheme is relevant to the Central Queensland region and evaluates soils in terms of the potential to graze and finish cattle on improved pastures. The classification rules defined in the scheme are reproduced in **Appendix 8** and have been adopted in full (without change or addition) and applied as defined. The grazing suitability data presented in **Tables 8 and 9** provides a clear record of the limitations, attributes and subclass rules used in the assessment.

Typically, grazing systems in inland Central Queensland aim to produce young, finished, grassfed, export quality cattle without inputs other than pasture development. Most production is focused on improved pasture grass - legume pastures. Improved pasture development in many areas is dominated by buffel grass, although Rhodes grass and other introduced grasses (Indian bluegrass, creeping bluegrass, purple pigeon grass and panic species) play a role. Legume establishment and species vary significantly depending on soil characteristics and climate. Commonly used legumes include shrubby stylos species, Desmanthus species, Wynn cassia (sandy), butterfly pea (clay), siratro and leucaena (cropping soils).

Land that qualifies as **Classes 1 and 2** is considered suitable for grazing improved pastures and capable of attaining maximum grazing productivity (QDME 1995) in most seasons. In inland Central Queensland this can be defined as the production of young, finished, grassfed, export quality cattle in most seasons, and such country is termed ‘fattening country’. **Class 3** land is suitable for grazing improved pastures but is generally less productive than Classes 1 and 2 and encompasses a range in productivity. Land in this class is often termed ‘growing country’ and is defined as country on which younger cattle perform well but may be difficult to finish at a young age, depending on seasonal conditions (i.e. cattle on Class 3 land may take longer to achieve the desired weight class or finished grade than equivalent cattle on Classes 1 and 2).

Class 4 land is considered marginal for grazing improved pastures, but is generally considered suitable for grazing native pastures of varying quality all year round, depending on soil characteristics (QDME 1995). In inland Central Queensland such country is typically termed ‘breeding country’. It encompasses a range in productivity from the lower end of Class 3 ‘growing country’ through to the poorer end of Class 4 ‘breeding country’. Shields and Williams (1991) suggest 3 possible subclasses exist within Class 4:

- land with native pasture of low productivity, which while physically capable of being developed to improved pasture, is subject to low soil fertility and doubtful long term productivity;
- land with high quality native pasture (typically black soil downs) on which improved pasture establishment is largely unsuccessful because of unfavourable soil characteristics and limited species; and
- land with native pasture of low productivity, which has physical limitations that preclude full improved pasture development, but allow oversowing of legumes such as shrubby stylo.

Class 5 land is unsuitable for any form of pasture improvement, and land use is limited to extensive grazing of native pastures of low productivity. In many cases, lands are of such poor quality they are considered marginal as ‘breeding country’ and may require destocking in the winter/dry season, unless grazed in conjunction with better quality country. Land in this class is mostly used as ‘seasonal breeding country’ during the summer/wet season when planes of nutrition are higher.

Suitability findings for grazing

Assessment of grazing suitability (determined in accordance with QDME 1995) is important as it provides a structured and robust scientific evaluation of pre-mining grazing potential for lands potentially affected by the BNCOP Disturbance Footprint. A summary of the spatial extent (ha) of grazing suitability classes and contributing soils is presented below. Further detail including grazing suitability statements, final suitability classes and contributing limitation subclasses are listed for all soils within the BNCOP Disturbance Footprint in **Tables 8 and 9** and displayed in **Figure 7**. These findings are also summarized individually for each soil type in the **Soil Characterization Section** presented earlier in this report.

Grazing Suitability Class	Soils	Area (ha)
Class 1 - suitable (fattening country)	none recorded	-
Class 2 - suitable (fattening country)	2b, 3a, 4c, 4d, 5, 7a	365
Class 3 - suitable (growing country)	3b, 7b, 7d, 9b, swp/7a	310
Class 4 - marginal (breeding country)	7c, 8a, 8b, 9a	713
Class 5 - unsuitable (seasonal breeding country)	8c, 8d	98

Closer analysis of the assessment findings indicates land suitable for improved pasture development and also capable of reliably fattening cattle in most seasons (Class 2) occupies about 365ha or 24.5% of the total Disturbance Footprint. Land suitable for improved pasture development but limited to “growing out” younger cattle in most seasons (Class 3) occupies a further 310ha or 21%. No Class 1 improved pasture fattening country was identified. Of the remaining area, 713ha or 48% is lower fertility country that is marginal for improved pasture development, but suited to year round breeding herd utilisation (Class 4), while the final 98 ha or 6.5% comprises sandy, infertile soils unsuitable for improved pasture development and limited to wet season breeding use only (Class 5 – requiring dry season destocking or co-access to better country).

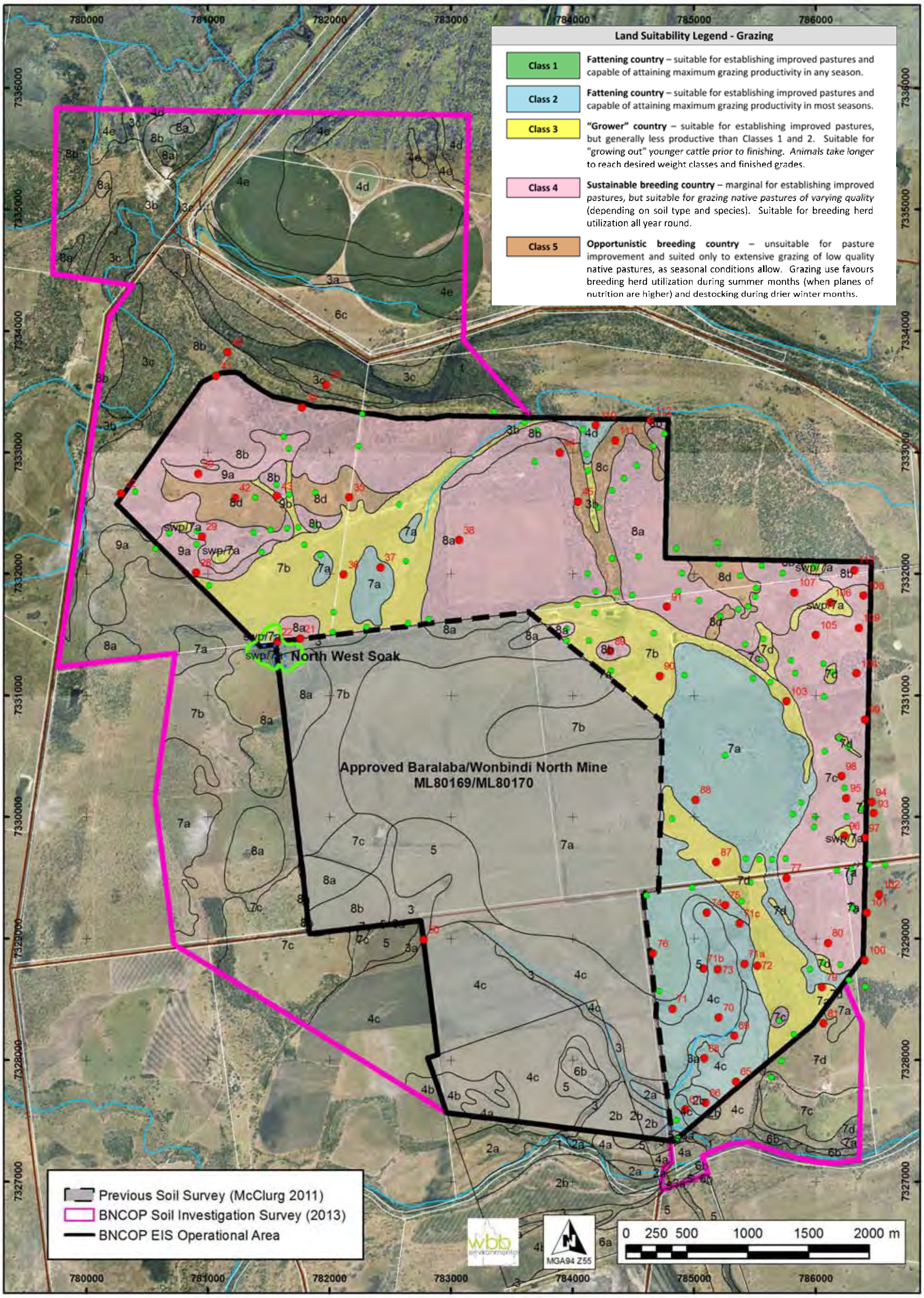
All soils within the BNCOP Disturbance Footprint are suited to grazing of some form (fattening growing or breeding) and non-agricultural land that cannot be grazed at all is absent. **Soils suitable for grazing improved pastures and capable of fattening cattle** (**Classes 1-2** – production of young, finished, grassfed, export quality cattle in most seasons) include **Soils 2b, 3a, 4c, 4d, 5 and 7a**. These soils are deep, firm pedal to self mulching cracking clays on level to gently undulating landscapes with adequate PAWC characteristics (mostly 60-75mm/0.6m) and high to very high fertility status. Slopes for all soil landscapes listed are <3% and the soils are moderately well drained, have acceptable surface conditions for germination and establishment, are capable of being cultivated for pasture development and lack significant rock or coarse fragments. Limitation subclasses recorded for these soils are only negligible (sub-class 1) or minor (sub-class 2) at worst and final grazing suitability is Class 2.

Soils 3b, 7b, 7d, 9b and swp/7a are considered suitable for grazing improved pastures, but are less productive than soils in Classes 1 and 2. Typically, these soils are more suited for use as **‘grower country’ (Class 3)** on which younger cattle perform well but may be difficult to finish (at a young age) in most seasons (i.e. cattle exclusively grazed on Class 3 soils may take longer to achieve the desired weight class or finished grade than equivalent cattle on Class 1 and 2 soils). Soil 9b has similar PAWC levels to Class 1 and 2 soils (>60mm/0.6m), while soils 3b, 7b, 7d and swp/7a have significantly lower moisture availability characteristics (30-60mm/0.6m) due to restricted ERD associated with relatively shallow saline and/or sodic subsoil constraints. In addition, Soils 7b and 9b have significantly lower fertility status (<10ppm P) than soils in Classes 1 and 2. Slopes are typically <3% and all 4 soils are moderately well drained, have acceptable surface conditions for germination and establishment, are capable of being cultivated for pasture development and lack significant rock or coarse fragments. Limitation subclasses recorded for these soils are either negligible (sub-class 1), minor (sub-class 2) or moderate (sub-class 3) at worst, and final grazing suitability is Class 3.

The remainder of soils mapped within the BNCOP Disturbance Footprint (with the exception of Soils 8c and 8d), are considered **marginal for improved pasture development, but suitable for grazing native pastures of varying quality all year round (Class 4)**. Soils in this category are considered typical of year round breeding country in Central Queensland and include **Soils 7c, 8a, 8b and 9a.** These soils are associated either with older relict alluvial sediments or outcropping insitu Tertiary sandstones, and dominate the landscape within the northern and eastern parts of the BNCOP Disturbance Footprint.

Soil characteristics are varied, and include sandy surfaced texture contrast soils (Soils 7c, 8b), sandy/loamy red earths (Soil 8a) and loamy surfaced non-sodic texture contrast soils/non-cracking clays (Soil 9a). PAWC values range from 30-60mm/0.6m, while fertility is consistently low or very low as a result of soil age, parent material characteristics and leaching status. Slopes associated with Soils 7c, 8a and 9a are mostly 1-<5%, but get as steep as 12% on more dissected insitu Tertiary sandstone rises associated with Soil 8b. All soils are imperfectly drained to moderately well drained or better, have acceptable surface conditions for germination and establishment, are capable of being cultivated for pasture development and lack significant rock or coarse fragments. Limitation subclasses recorded for these soils range from negligible (sub-class 1) to severe (sub-class 4) and final grazing suitability (for fattening cattle) is Class 4.

Soils 8c and 8d are deep sands that have very low fertility status and severely restricted moisture availability characteristics (PAWC <25mm). They are considered **unsuitable for improved pasture development, and are useful only for seasonal breeding herd utilisation (Class 5).** Native pasture species are low quality and pasture performance and grazing response is limited. Grazing (in isolation) is restricted to wet season utilisation (when planes of nutrition are higher) and would require destocking during the winter dry season. Limitation subclasses recorded range from negligible (sub-class 1) to extreme (sub-class 5) and final grazing suitability (for fattening cattle) is Class 5.



Land Suitability Legend - Grazing

Class 1	**Fattening country** – suitable for establishing improved pastures and capable of attaining maximum grazing productivity in any season.
Class 2	**Fattening country** – suitable for establishing improved pastures and capable of attaining maximum grazing productivity in most seasons.
Class 3	**"Grower" country** – suitable for establishing improved pastures, but generally less productive than Classes 1 and 2. Suitable for "growing out" younger cattle prior to finishing. Animals take longer to reach desired weight classes and finished grades.
Class 4	**Sustainable breeding country** – marginal for establishing improved pastures, but suitable for grazing native pastures of varying quality (depending on soil type and species). Suitable for breeding herd utilization all year round.
Class 5	**Opportunistic breeding country** – unsuitable for pasture improvement and suited only to extensive grazing of low quality native pastures, as seasonal conditions allow. Grazing use favours breeding herd utilization during summer months (when planes of nutrition are higher) and destocking during drier winter months.

Figure 7. Grazing suitability within the BNCOP Disturbance Footprint.

Table 6. **Dryland cropping limitation subclass ratings and final suitability classes (DNRM/DSITIA 2013b) for soils in the BNCOP Disturbance Footprint.**

Unit	Soil landscape description	Limitation subclasses	Class	Suitability for dryland cropping
Soils derived from Quaternary alluvium (Qa)				
Active, channelled lower floodplain of the Dawson River and associated anabranches; relatively low lying, undulating unit adjacent to the main channel and subject to regular flooding				
2b	Moderately self-mulching, often silty, black cracking clay on level backplains within the lower floodplain.	**summer**: e2, es2, m2, ps2, w2 **winter**: e2, es2, m3, ps2, w2	**S: 2** **W: 3**	**Suitable** with minor limitations **Suitable** with moderate limitations
Active levees and alluvial plains of tributary drainage lines and floodplain drainage features within or at the margins of elevated terraces and backplains; subject to both local and wider flooding				
3a	Hardsetting to coarsely self-mulching, (poached), black cracking clay in narrow terrace drainage lines of the upper floodplain.	**summer**: e2, es2, m3, ps3, w2 **winter**: e2, es2, m4, ps3, w2	**S: 3** **W: 4**	**Suitable** with moderate limitations **Marginal** due to severe limitations
3b	Hardsetting, clay loamy surfaced (0.2-0.4m), bleached, brown sodic texture contrast soil on level alluvial plains of Saline Creek and associated tributaries.	**summer**: es3, m5, pm3, ps4, w2 **winter**: es3, m5, pm3, ps4, w2	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations
Elevated, backplains, terraces and indistinct levees of the upper floodplain of the Dawson River and associated anabranches; typically level and extensive; commonly flooded				
4c	Moderately to strongly self-mulching, black cracking clay on elevated level backplains.	**summer**: e2, es2, m3, ps2, w2 **winter**: e2, es2, m4, ps2, w2	**S: 3** **W: 4**	**Suitable** with moderate limitations **Marginal** due to severe limitations
4d	Weakly to moderately self-mulching, grey cracking clay with weak to moderate melonhole gilgai (VI <0.3-0.6m, HI 10-25m) on level backplains of the Dawson River.	**summer**: e2, es3, m3, ps2, tm3, w2 **winter**: e2, es3, m4, ps2, tm3, w2	**S: 3** **W: 4**	**Suitable** with moderate limitations **Marginal** due to severe limitations
Gently undulating side slopes and dissected margins transitional between recent alluvium of the upper floodplain and older more elevated landscapes adjacent; rarely flooded				
5	Firm pedal or weakly to moderately self-mulching, black cracking clay on gently undulating sideslopes/plains that mark the transition from recent alluvium to older elevated plains.	**summer**: e3, es4, m4, ps2, w2 **winter**: e3, es4, m5, ps2, w2	**S: 4** **W: 5**	**Marginal** due to severe limitations **Unsuitable** due to extreme limitations
Soils derived from older unconsolidated Tertiary–Quaternary sediments (Cz/TQr – elevated Cainozoic clay sheets and relict sandy alluvial deposits)				
Older, elevated, level to gently undulating plains and low rises ; not flooded				
7a	Hardsetting or firm pedal to weakly self mulching, grey cracking clay with strongly developed melon-hole gilgai (VI 0.3-0.8m, HI 12-20m) on older clay sheets; saline, sodic and acidic at depth.	**summer**: e4, es3, m5, pm3, ps3, tm4, w2-4 **winter**: e4, es3, m5, pm3, ps3, tm4, w2-4	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations
7b	Hardsetting, thin clay loamy surfaced (<0.05-0.2m), bleached, grey or brown sodic texture contrast soil grading to a grey or brown non-cracking/cracking clay ± occasional weak gilgai (VI 0.1m, HI 10m) on older unconsolidated sediments and clay sheets.	**summer**: e4, es3, m5, pm3-4, ps4, tm2, w2 **winter**: e4, es3, m5, pm3-4, ps4, tm2, w2	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations
7c	Hardsetting, thick sandy surfaced (0.4-0.7m), bleached, often mottled, brown non-sodic to weakly sodic texture contrast soil on elevated relict alluvial deposits.	**summer**: e2, es3, m5, pm3, ps4, w2-4 **winter**: e2, es3, m5, pm3, ps4, w2-4	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations
7d	Hardsetting, clay loamy surfaced (0.10-0.2m), bleached, black sodic texture contrast soil on older unconsolidated sediments and clay sheets.	**summer**: e2, es4, m5, pm3, ps4, w2 **winter**: e2, es4, m5, pm3, ps4, w2	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations
Local seasonal swamps and closed depressions – occasional landscape features sitting between elevated sandstone units (Landscape 8) and lower lying clay sheets (Landscape 7)				
SWP (7a)	Hardsetting, silty surfaced, mottled, grey non-cracking/cracking clay ± weak gilgai (VI <0.1-0.3m, HI 8-12m) etched within the Cainozoic clay sheets and subject to localized alluvial deposition.	**summer**: es3, m5, pm3, ps3, tm2, w4 **winter**: es3, m5, pm3, ps3, tm2, w4	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations

Unit	Soil landscape description	Limitation subclasses	Class	Suitability for dryland cropping
Soils derived from older consolidated Tertiary sandstone (Ta/Tm)				
Elevated and only weakly dissected, level to gently undulating plateau surface				
8a	Hardsetting, massive, gradational loamy red earth overlying weathered Tertiary sandstone (>1.5m).	**summer**: e2-3, es1-3, m5, pm2, ps4 **winter**: e2-3, es1-3, m5, pm2, ps4	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations
Elevated and strongly dissected, undulating to rolling remnant rises				
8b	Soft to loose, thick sandy surfaced (0.3-1.0m), bleached, strongly mottled, non-sodic grey texture contrast soil overlying insitu Tertiary sandstone from 0.8->1.5m.	**summer**: e3-5, es1-5, m5, pm1-3, r3, w4 **winter**: e3-5, es1-5, m5, pm1-3, r3, w4	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations
Colluvial footslopes and pediments				
8c	Loose, massive, bleached, grey coarse sand on steeper colluvial footslopes.	**summer**: e3-4, es1-3, m5 **winter**: e3-4, es1-3, m5	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations
8d	Loose, massive red or brown earthy sand grading to a very thick sandy surfaced (1.0->1.5m), red or brown non-sodic texture contrast soil on gentle colluvial pediments and outwash deposits.	**summer**: e3, m5 **winter**: e3, m5	**S: 5** **W: 5**	**Unsuitable** due to extreme limitations **Unsuitable** due to extreme limitations
Soils derived from older calcareous sediments (possibly Pwy)				
Level to gently undulating plains and low rises				
9a	Hardsetting, loamy to clay loamy surfaced (0.2-0.3m), brown non-sodic texture contrast soil grading to a structured, brown non-cracking clay overlying calcareous sediments from 0.7m->1.5m.	**summer**: e2, m4, pm2, ps4, w2 **winter**: e2, m5, pm2, ps4, w2	**S: 4** **W: 5**	**Marginal** due to severe limitations **Unsuitable** due to extreme limitations
9b	Hardsetting to moderately self-mulching, black cracking clay with weak normal gilgai (VI <0.1-0.2m, HI 8-15m) overlying calcareous sediments from >1.2m.	**summer**: e2, es3, m4, ps2, tm2, w2 **winter**: e2, es3, m5, ps2, tm2, w2	**S: 4** **W: 5**	**Marginal** due to severe limitations **Unsuitable** due to extreme limitations

Table 7. Cropping suitability – soil attributes contributing to limitation subclasses (DNRM/DSITIA 2013b) for soils in the BNCOP Disturbance Footprint.

Limitation	Attributes	2b		3a		3b		4c		4d		5		7a		7b		7c	
water erosion (E)	**slope &disp.**	<1% mod. SM + ESP 1	**2**	<1% mod. SM - HS + ESP 1	**2**	<1% HS +ESP 2	**1**	<1% mod.-str. SM + ESP 3	**2**	<1% weak-mod SM +ESP1	**2**	1-3% firm-mod SM + ESP 4	**3**	<1% HS-weak SM + ESP >4	**4**	<1% very HS + ESP 4-7	**4**	0.5-2% HS + ESP 1	**2**
erosion hazard (Es)	**slope &disp.**	subsoil ESP 2-9	**2**	subsoil ESP 3-13	**2**	subsoil ESP 6-19 (2tests >15)	**3**	subsoil ESP 8-18 (1 test >15)	**2**	subsoil ESP 6-21 (2 tests>15)	**3**	subsoil ESP 14-20 (2 tests>15)	**4**	subsoil ESP 14-28 (2 tests>15)	**3**	subsoil ESP 13-35 (2 tests>15)	**3**	subsoil ESP 1-7	**3**
soil water availability (M)	**PAWC (1.0m)**	S - >120mm W - >120mm	**2** **3**	S - 95-120mm W - 95-120mm	**3** **4**	S - 45-55mm W - 45-55mm	**5** **5**	S - 90-120mm W - 90-120mm	**3** **4**	S - 85-120mm W - 85-120mm	**3** **4**	S - 70-85mm W - 70-85mm	**4** **5**	S - 50-70mm W - 50-70mm	**5** **5**	S - 30-60mm W - 30-60mm	**5** **5**	S - 70-75mm W - 70-75mm	**5** **5**
narrow moist range (Pm)	**drainage and surface cond.**	DC 4 mod. SM	**1**	DC 4 HS - mod. SM	**1**	DC 4 sodic TC <0.4m	**3**	DC 4 mod.-str. SM	**1**	DC 4 weak-mod. SM	**1**	DC 4 firm-mod. SM	**1**	DC 3-4 HS-weak SM	**3**	DC 4 HS sodic TC/NCC<0.4m	**3** **4**	DC 3-4 ns TC 0.4-0.7m	**3**
surface condition (Ps)	**surface cond.**	mod. SM 2-5mm	**2**	HS - mod. SM 5-10mm	**3**	HS FS/Z >60%	**4**	mod.-str. SM 2-5mm	**2**	weak-mod. SM 2-5mm	**2**	firm-mod. SM 2-5mm	**2**	HS-weak SM 2-5mm	**3**	very HS FS/Z >60%	**4**	HS FS/Z >60%	**4**
rockiness (R)	**abund.& size**	no rock	**1**	no rock	**1**	no rock	**1**	no rock	**1**	no rock	**1**	no rock	**1**	no rock	**1**	no rock	**1**	no rock	**1**
microrelief (Tm)	**size & % land**	non-gilgaied	**1**	non-gilgaied	**1**	non-gilgaied	**1**	non-gilgaied	**1**	VI <0.6m 30-70%	**3**	non-gilgaied	**1**	VI 0.3-0.8m >70%	**4**	VI <0.1m 30-70%	**2**	non-gilgaied	**1**
wetness (W)	**drain./perm.**	DC 4 slow	**2**	DC 4 slow	**2**	DC 4 slow	**2**	DC 4 slow	**2**	DC 4 slow	**2**	DC 4 slow	**2**	DC 4 slow DC 3 slow	**2** **4**	DC 4 slow	**2**	DC 4 slow DC 3 slow	**2** **4**
Suitability Class		**Summer** **Winter**	**2** **3**	**Summer** **Winter**	**3** **4**	**Summer** **Winter**	**5** **5**	**Summer** **Winter**	**3** **4**	**Summer** **Winter**	**3** **4**	**Summer** **Winter**	**4** **5**	**Summer** **Winter**	**5** **5**	**Summer** **Winter**	**5** **5**	**Summer** **Winter**	**5** **5**

Limitation	Attributes	7d		SWP/7a		8a		8b		8c		8d		9a		9b			
water erosion (E)	**slope &disp.**	<1-2% HS + ESP 3	**2**	<1% HS-weak SM + ESP <4	**1**	<1-5% massive HS + ESP 1	**2** **3**	<1-12% loose or soft + ESP 1	**3** **5**	1-5% loose + ESP 1	**3** **4**	<1-3% loose + ESP 1	**3**	<1-3% HS + ESP 1	**2**	<1% HS - mod. SM + ESP 3	**2**		
erosion hazard (Es)	**slope &disp.**	subsoil ESP 12-36 (2 tests>15)	**4**	subsoil ESP 14-28 (2 tests>15)	**3**	subsoil ESP 1	**1** **3**	subsoil ESP 2-5	**1** **5**	subsoil ESP 1 (<20% clay)	**1** **3**	subsoil ESP 1-2 (<20% clay)	**1**	subsoil ESP 1-4	**1**	subsoil ESP 7-16 (2 tests>15)	**3**		
soil water availability (M)	**PAWC (0.1m)**	S - 50mm W - 50mm	**5** **5**	S - 50-70mm W - 50-70mm	**5** **5**	S - 70-85mm W - 70-85mm	**5** **5**	S - 50-80mm W - 50-80mm	**5** **5**	S - 40mm W - 40mm	**5** **5**	S - 40mm W - 40mm	**5** **5**	S - 85-100mm W - 85-100mm	**4** **5**	S - 85mm W - 85mm	**4** **5**	S - summer W - winter	
narrow moist range (Pm)	**drainage and surface cond.**	DC 4 sodic TC<0.4m	**3**	DC 3 HS-weak SM	**3**	DC 5 HS, massive RE	**2**	DC 3 ns TC 0.3-1.1m	**1** **3**	DC 4 deep sand	**1**	DC 5-6 deep sand	**1**	DC 4 HS loamy TC	**2**	DC 4 HS - mod. SM	**1**		
surface condition (Ps)	**surface cond.**	HS FS/Z >50%	**4**	HS-weak SM 2-5mm	**3**	HS FS/Z >60%	**4**	loose-soft sandy	**1**	loose sandy	**1**	loose sandy	**1**	HS FS/Z >60%	**4**	HS - mod. SM 2-5mm	**2**		
rockiness (R)	**abund.& size**	no rock	**1**	no rock	**1**	no rock	**1**	<2% outcrop	**3**	no rock	**1**	no rock	**1**	no rock	**1**	no rock	**1**		
microrelief (Tm)	**size & % land**	non-gilgaied	**1**	VI <0.3m 30-70%	**2**	non-gilgaied	**1**	non-gilgaied	**1**	non-gilgaied	**1**	non-gilgaied	**1**	non-gilgaied	**1**	VI 0.1-0.2m 30-70%	**2**		
wetness (W)	**drain./perm.**	DC 4 slow	**2**	DC 3 slow	**4**	DC 5 moderate	**1**	DC 3 slow	**4**	DC 4 high	**1**	DC 5-6 high	**1**	DC 4 slow	**2**	DC 4 slow	**2**		
Suitability Class		**Summer** **Winter**	**5** **5**	**Summer** **Winter**	**5** **5**	**Summer** **Winter**	**5** **5**	**Summer** **Winter**	**5** **5**	**Summer** **Winter**	**5** **5**	**Summer** **Winter**	**5** **5**	**Summer** **Winter**	**4** **5**	**Summer** **Winter**	**4** **5**		

Table 8. Grazing limitation subclass ratings and final suitability classes (QDME 1995) for soils in the BNCOP Disturbance Footprint.

Unit	Soil landscape description	Limitation subclasses	Class	Suitability for grazing
Soils derived from Quaternary alluvium (Qa)				
Active, channelled lower floodplain of the Dawson River and associated anabranches; relatively low lying, undulating unit adjacent to the main channel and subject to regular flooding				
2b	Moderately self-mulching, often silty, black cracking clay on level backplains within the lower floodplain.	m2, nd2, ps2, w2, f2, v2, ph2	**2**	**Fattening country** – suitable for improved pastures, attains max grazing productivity in most seasons
Active levees and alluvial plains of tributary drainage lines and floodplain drainage features within or at the margins of elevated terraces and backplains; subject to both local and wider flooding				
3a	Hardsetting to coarsely self-mulching, (poached), black cracking clay in narrow terrace drainage lines of the upper floodplain.	m2, nd2, ps2, w2, f2, v2, ph2	**2**	**Fattening country** – suitable for improved pastures, attains max grazing productivity in most seasons
3b	Hardsetting, clay loamy surfaced (0.2-0.4m), bleached, brown sodic texture contrast soil on level alluvial plains of Saline Creek and associated tributaries.	m3, nd2, ps2, w2, f2, v2	**3**	**Grower" country** – suitable for improved pastures, but less productive than Classes 1 and 2
Elevated, backplains, terraces and indistinct levees of the upper floodplain of the Dawson River and associated anabranches; typically level and extensive; commonly flooded				
4c	Moderately to strongly self-mulching, black cracking clay on elevated level backplains.	m2, ps2, sa2, f2, ph2	**2**	**Fattening country** – suitable for improved pastures, attains max grazing productivity in most seasons
4d	Weakly to moderately self-mulching, grey cracking clay with weak to moderate melonhole gilgai (VI <0.3-0.6m, HI 10-25m) on level backplains of the Dawson River.	m2, ps2, sa2, tm2, w2, f2, v2, ph2	**2**	**Fattening country** – suitable for improved pastures, attains max grazing productivity in most seasons
Gently undulating side slopes and dissected margins transitional between recent alluvium of the upper floodplain and older more elevated landscapes adjacent; rarely flooded				
5	Firm pedal or weakly to moderately self-mulching, black cracking clay on gently undulating sideslopes/plains that mark the transition from recent alluvium to older elevated plains.	m2, ps2, sa2, f2, ph2	**2**	**Fattening country** – suitable for improved pastures, attains max grazing productivity in most seasons
Soils derived from older unconsolidated Tertiary–Quaternary sediments (Cz/TQr – elevated Cainozoic clay sheets and relict sandy alluvial deposits)				
Older, elevated, level to gently undulating plains and low rises ; not flooded				
7a	Hardsetting or firm pedal to weakly self mulching, grey cracking clay with strongly developed melon-hole gilgai (VI 0.3-0.8m, HI 12-20m) on older clay sheets; saline, sodic and acidic at depth.	m2, ps2, sa2, tm2, w2, v2, ph2	**2**	**Fattening country** – suitable for improved pastures, attains max grazing productivity in most seasons
7b	Hardsetting, thin clay loamy surfaced (<0.05-0.2m), bleached, grey or brown sodic texture contrast soil grading to a grey or brown non-cracking/cracking clay ± occasional weak gilgai (VI 0.1m, HI 10m) on older unconsolidated sediments and clay sheets.	m3, nd3, ps2, sa2, w2, v2, ph2, esp2	**3**	**Grower" country** – suitable for improved pastures, but less productive than Classes 1 and 2
7c	Hardsetting, thick sandy surfaced (0.4-0.7m), bleached, often mottled, brown non-sodic to weakly sodic texture contrast soil on elevated relict alluvial deposits.	m4, nd3, ps2	**4**	**Breeding country** – marginal for improved pastures, suitable for grazing native pastures
7d	Hardsetting, clay loamy surfaced (0.10-0.2m), bleached, black sodic texture contrast soil on older unconsolidated sediments and clay sheets.	m3, ps2, w2, e2	**3**	**"Grower" country** – suitable for improved pastures, but less productive than Classes 1 and 2
Local seasonal swamps and closed depressions – occasional landscape features sitting between elevated sandstone units (Landscape 8) and lower lying clay sheets (Landscape 7)				
SWP (7a)	Hardsetting, silty surfaced, mottled, grey non-cracking/cracking clay ± weak gilgai (VI <0.1-0.3m, HI 8-12m) etched within the Cainozoic clay sheets and subject to localized alluvial deposition.	m2, nd2, ps2, sa2, w3, f2	**3**	**"Grower" country** – suitable for improved pastures, but less productive than Classes 1 and 2

Unit	Soil landscape description	Limitation subclasses	Class	Suitability for grazing
Soils derived from older consolidated Tertiary sandstone (Ta/Tm)				
Elevated and only weakly dissected, level to gently undulating plateau surface				
8a	Hardsetting, massive, gradational loamy red earth overlying weathered Tertiary sandstone (>1.5m).	m4, nd4, ps2, e2, v2	**4**	**Breeding country** – marginal for improved pastures, suitable for grazing native pastures
Elevated and strongly dissected, undulating to rolling remnant rises				
8b	Soft to loose, thick sandy surfaced (0.3-1.0m), bleached, strongly mottled, non-sodic grey texture contrast soil overlying insitu Tertiary sandstone from 0.8->1.5m.	m4, nd4, e2, v2	**4**	**Breeding country** – marginal for improved pastures, suitable for grazing native pastures
Colluvial footslopes and pediments				
8c	Loose, massive, bleached, grey coarse sand on steeper colluvial footslopes.	m5, nd4, e2, v2	**5**	**Seasonal breeding country** – suitable for grazing native pastures, requires dry season destocking
8d	Loose, massive red or brown earthy sand grading to a very thick sandy surfaced (1.0->1.5m), red or brown non-sodic texture contrast soil on gentle colluvial pediments and outwash deposits.	m5, nd4, v2	**5**	**Seasonal breeding country** – suitable for grazing native pastures, requires dry season destocking
Soils derived from older calcareous sediments (possibly Pwy)				
Level to gently undulating plains and low rises				
9a	Hardsetting, loamy to clay loamy surfaced (0.2-0.3m), brown non-sodic texture contrast soil grading to a structured, brown non-cracking clay overlying calcareous sediments from 0.7m->1.5m.	m3, nd4, ps2, v2	**4**	**Breeding country** – marginal for improved pastures, suitable for grazing native pastures
9b	Hardsetting to moderately self-mulching, black cracking clay with weak normal gilgai (VI <0.1-0.2m, HI 8-15m) overlying calcareous sediments from >1.2m.	m2, nd3, ps2, sa2, w2, ph2	**3**	**"Grower" country** – suitable for improved pastures, but less productive than Classes 1 and 2

Table 9. Grazing suitability – soil attributes contributing to relevant limitation subclasses (QDME 1995) for soils in the BNCOP Disturbance Footprint.

Limitation	Attributes	2b		3a		3b		4c		4d		5		7a		7b		7c	
water availability (M)	PAWC (0.6m)	70-75mm	2	70-75mm	2	45-55m	3	70-75mm	2	70-75mm	2	70-75mm	2	50-70mm	2	30-60mm	3	30-35mm	4
nutrient deficiency (Nd)	fertility (P)	P - 73ppm N - high	2	P - 83ppm N - high	2	P -28ppm N - high	2	P - 56ppm N - very high	1	P - 36ppm N - very high	1	P - 32ppm N - high	1	P - 20ppm N - high	1	P - 6-8ppm N - moderate	3	P - <11ppm N - moderate	3
soil physical factors (Ps)	surface cond.	mod. SM 2-5mm	2	HS - mod. SM 5-10mm	2	HS FS/Z >60%	2	mod.-str. SM 2-5mm	2	weak-mod. SM 2-5mm	2	firm-mod. SM 2-5mm	2	HS-weak SM 2-5mm	2	very HS FS/Z >60%	2	HS FS/Z >60%	2
root zone salinity (Sa)	mean EC (dS/m)	0.08	1	0.13	1	0.05	1	0.19	2	0.18	2	0.27	2	0.31	2	0.15-0.27	2	0.04	1
rockiness (R)	abund.& size	no rock	1	no rock	1	no rock	1	no rock	1	no rock	1	no rock	1	no rock	1	no rock	1	no rock	1
microrelief (Tm)	size & % land	non-gilgaied	1	non-gilgaied	1	non-gilgaied	1	non-gilgaied	1	VI <0.6m 30-70%	2	non-gilgaied	1	VI 0.3-0.8m >70%	2	VI <0.1m 30-70%	1	non-gilgaied	1
wetness (W)	soil/landscape	low lying	2	low lying	2	level - sodic TC	2	elevated	1	level plain	2	undulating	1	level plain	2	level plain	2	undulating	1
water erosion (E)	slope &disp.	<1% cracking clay	1	<1% cracking clay	1	<1% sodic rigid TC	1	<1% cracking clay	1	<1% cracking clay	1	1-3% cracking clay	1	<1% cracking clay	1	<1% sodic TC/NCC	1	0.5-2% non-sodic rigid	1
flooding (F)	occurrence	reg. flooding	2	reg. flooding	2	occ. flooding	2	occ. flooding	2	occ. flooding	2	occ. flooding	2	flood free	1	flood free	1	flood free	1
vegetation (V)	veg. type	coolibah	2	coolibah	2	poplar box	2	brigalow	1	brigalow gilgai	2	brigalow	1	brigalow gilgai	2	shrubby box	2	Euc - softwood	2
surface pH (pH)	pH (0-0.1m)	7.5	2	6.7-7.7	2	5.9	1	7.4-8.7	2	7.8-8.5	2	7.8-8.7	2	7.0-8.0	2	6.4-7.4	2	6.0-6.7	1
surface ESP (ESP)	ESP (0-0.1m)	ESP 1	1	ESP 1	1	ESP 2	1	ESP 3	1	ESP 1	1	ESP 4	1	ESP 4	1	ESP 4-7	2	ESP 1	1
Final suitability Class			2		2		3		2		2		2		2		3		4

Limitation	Attributes	7d		SWP/7a		8a		8b		8c		8d		9a		9b			
water availability (M)	PAWC (0.6m)	50mm	3	50-70mm	2	35-45mm	4	30-35mm	4	25mm	5	25mm	5	50-60mm	3	70mm	2		
nutrient deficiency (Nd)	fertility (P)	P - 28ppm N - high	1	P - 20ppm N - high	2	P - 1ppm N - moderate	4	P - 2ppm N - low-mod.	4	P - 1-2ppm N - low-mod.	4	P - 1-2ppm N - low-mod	4	P - 4ppm N - mod-high	4	P - <10ppm N - high	3		
soil physical factors (Ps)	surface cond.	HS FS/Z >50%	2	HS-weak SM 2-5mm	2	HS FS/Z >60%	2	loose-soft sandy	1	loose sandy	1	loose sandy	1	HS FS/Z >60%	2	HS - mod. SM 2-5mm	2		
root zone salinity (Sa)	mean EC (dS/m)	0.13	1	0.16	2	0.04	1	0.04	1	<0.03	1	0.03	1	0.08	1	0.19	2		
rockiness (R)	abund.& size	no rock	1	no rock	1	no rock	1	<2% outcrop	1	no rock	1	no rock	1	no rock	1	no rock	1		
microrelief (Tm)	size & % land	non-gilgaied	1	VI <0.3m 30-70%	1	non-gilgaied	1	non-gilgaied	1	non-gilgaied	1	non-gilgaied	1	non-gilgaied	1	VI 0.1-0.2m 30-70%	1		
wetness (W)	soil/landscape	level - sodic TC	2	seasonal swp.	3	elevated plain	1	undulating	1	undulating	1	undulating	1	undulating	1	level plain	2		
water erosion (E)	slope &disp.	<1-2% sodic rigid TC	2	<1% cracking clay	1	<1-5% non-sodic rigid	1 2	<1-12% non-sodic rigid	1 2	1-5% non-sodic rigid	1 2	<1-3% non-sodic rigid	1	<1-3% non-sodic rigid	1	<1% cracking clay	1		
flooding (F)	occurrence	flood free	1	reg. inundation	2	flood free	1	flood free	1	flood free	1	flood free	1	flood free	1	flood free	1		
vegetation (V)	veg. type	brigalow - euc	1	forest red gum	1	eucalypt - no wattle	2	eucalypt - no wattle	2	eucalypt - no wattle	2	eucalypt - no wattle	2	eucalypt - no wattle	2	open grassland	1		
surface pH (pH)	pH (0-0.1m)	6.0-7.2	1	5.5-6.9	1	5.5-6.3	1	5.2-6.4	1	5.5-6.5	1	5.5-6.5	1	5.9-6.4	1	7.1	2	SC = median value of range	
surface ESP (ESP)	ESP (0-0.1m)	ESP 3	1	ESP <4	1	ESP 1	1	ESP 1	1	ESP 1	1	ESP 1	1	ESP 1	1	ESP 3	1		
Final suitability Class			3		3		4		4		5		5		4		3		

10. Agricultural Land Class (ALC) assessment

Agricultural Land Class (ALC) assessment

Agricultural Land Classification (ALC) in Queensland has recently been revised (DNRM/DSITIA 2013a) and now follows a simple, consistent hierarchical scheme that is applicable across the State. Three classes of agricultural land (Class A – Crop land; Class B – Limited crop land; Class C – Pasture land) and one class of non-agricultural land (Class D) are defined (DNRM/DSITIA 2013a). Further definition and description of these classes is available in the methodology section of this report and from DNRM/DSITIA (2013a). ALC assessment has used detailed land suitability outcomes for broadacre dryland cropping and grazing (see **Tables 6 and 7** and **Tables 8 and 9** respectively), and follows the latest methodology and conventions prescribed by DNRM/DSITIA (2013a).

Agricultural Land Class (ALC) findings

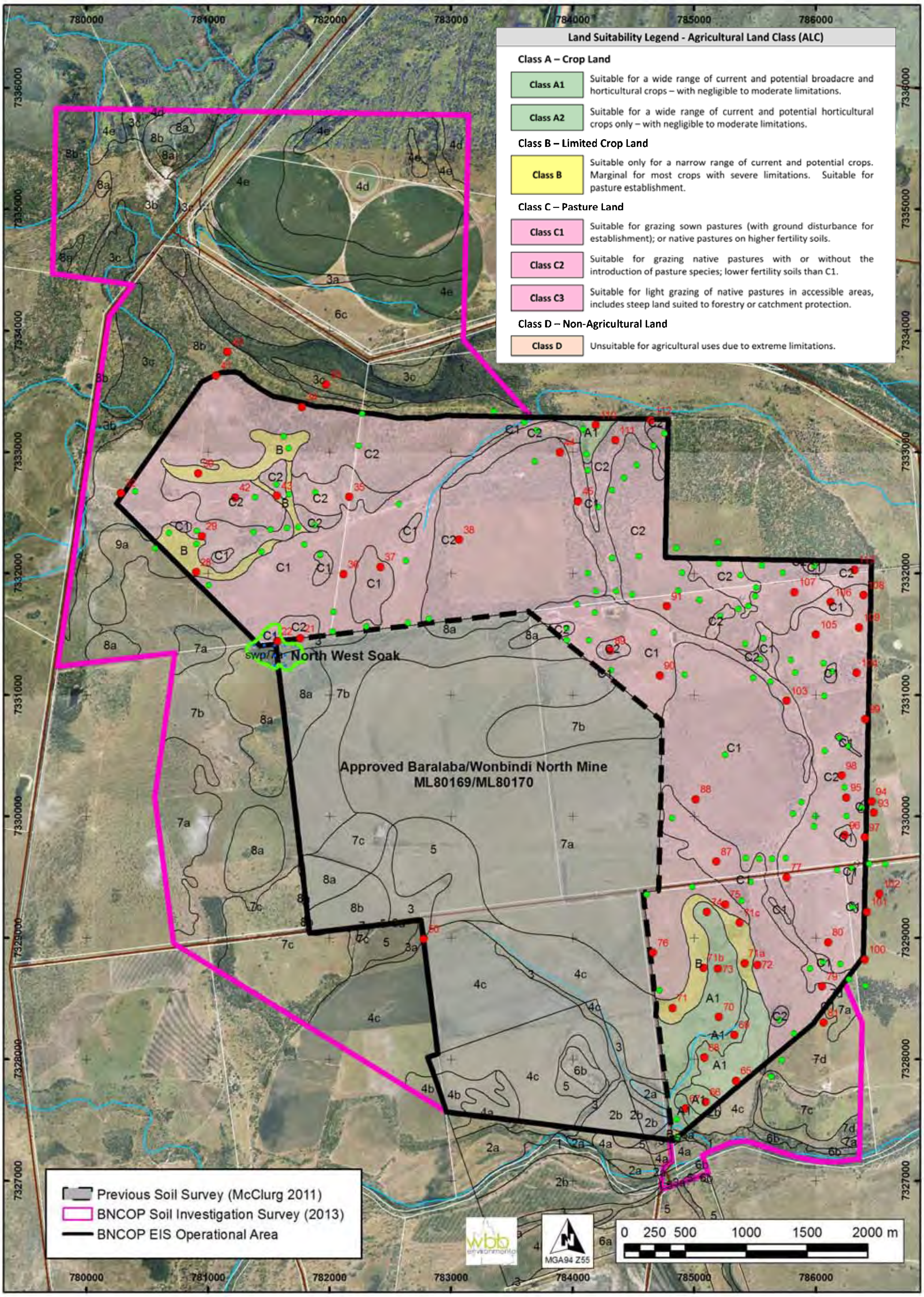
Agricultural Land Classes (ALC) simplify the detail and complexity typically associated with land suitability data, and provide a meaningful and concise summary as to the status of pre-mining agricultural potential within the BNCOP Disturbance Footprint. ALC findings are summarized in **Table 10** and displayed in **Figure 8**.

Table 10. Summary of ALC findings for soils within the BNCOP Disturbance Footprint.

ALC	Soils	Area (ha)
Class A1 Crop Land	Soils 2b, 3a, 4c, 4d	96
Class B Limited Crop Land	Soils 5, 9a, 9b	68
Class C1 Pasture Land	Soils 3b, 7a, 7b, 7d, swp/7a	546
Class C2 Pasture Land	Soils 7c, 8a, 8b, 8c, 8d	776

Class A1 – Crop Land occupies only 96ha or 6.5% of the BNCOP Disturbance footprint and is associated with **Soils 2b, 3a, 4c and 4d**. These soils are deep, self-mulching alluvial clays with adequate moisture holding capacity and high to very high inherent fertility (cropping suitability – Classes 1-3). Class A2 – Horticultural Crop Land is not relevant to the Baralaba region and was not recorded. **Class B – Crop Land** is relatively minor and occupies only 68ha or 4.5%. It is restricted to **Soils 5, 9a and 9b,** all of which are marginal for dryland cropping (cropping suitability – Class 4). These soils have limited effective rooting depth and restricted moisture holding capacity.

Class C1 – Pasture Land is significant within the BNCOP Disturbance Footprint and occupies 546ha or 37% of the total area. It is associated with **Soils 3b, 7a, 7b, 7d and swp/7a**, which include loamy surfaced texture contrast soils, brigalow clays and local seasonal swamps. These soils are unsuitable for dryland cropping, but have desirable fertility and moisture characteristics for pasture development and are suited to fattening or growing out younger cattle (Grazing suitability – Classes 2 and 3). **Class C2 – Pasture Land** is the dominant ALC unit (largest spatial extent) within the BNCOP Disturbance Footprint and occupies 776ha or 52% of the total area. It is associated with **Soils 7c, 8a, 8b, 8c and 8d,** all of which are sandy soils with low to very low inherent fertility and limited moisture holding characteristics. These soils occupy relatively gentle eucalypt landscapes that are unsuitable for fattening cattle (Grazing suitability – Class 4/5), but are accessible, easily managed and typically used as breeding country. Class C3 Pasture Land and Class D Non-agricultural Land do not occur within the BNCOP Disturbance Footprint.



Land Suitability Legend - Agricultural Land Class (ALC)

Class A – Crop Land

Class A1	Suitable for a wide range of current and potential broadacre and horticultural crops – with negligible to moderate limitations.
Class A2	Suitable for a wide range of current and potential horticultural crops only – with negligible to moderate limitations.

Class B – Limited Crop Land

Class B	Suitable only for a narrow range of current and potential crops. Marginal for most crops with severe limitations. Suitable for pasture establishment.

Class C – Pasture Land

Class C1	Suitable for grazing sown pastures (with ground disturbance for establishment); or native pastures on higher fertility soils.
Class C2	Suitable for grazing native pastures with or without the introduction of pasture species; lower fertility soils than C1.
Class C3	Suitable for light grazing of native pastures in accessible areas, includes steep land suited to forestry or catchment protection.

Class D – Non-Agricultural Land

Class D	Unsuitable for agricultural uses due to extreme limitations.

Figure 8. Agricultural Land Classes (ALC) (DNRM/DSITIA 2013a) within the BNCOP Disturbance Footprint.

11. Strategic Cropping Land (SCL) assessment

Within the wider 2013 BNCOP Soil Investigation survey area only those parts intersected by both the:

- BNCOP EIS Operational Area boundary; and
- the state wide Strategic Cropping Land (SCL) trigger mapping (DNRM 2011a);

are triggered for SCL assessment. Triggered areas that lie within the western section of the BNCOP EIS Operational Area (ML80169 and ML80170) have been previously mapped and assessed for SCL status and are subject to existing SCL mitigation determinations.

As such, the current investigation (as a contributing baseline study to the BNCOP Operational Area EIS) is concerned only with newly triggered areas external to ML80169 and ML80170. This effectively limits the current SCL assessment to lands within the BNCOP Disturbance Footprint (as defined in Figure 2). SCL findings for the already approved Baralaba/Wonbindi North Mine Lease (ML80169 and ML80170) have been reported previously by NQSA (2011a, 2011b) and are not re-presented or discussed in this report.

Strategic Cropping Land (SCL) assessment methodology

The SCL assessment has used detailed soil profile data, representative analytical data and large scale soil mapping (1:25000 scale) collected in accordance with recognized standard land resource survey methodologies and analytical procedures (Isbell 1996; McKenzie *et al* 2002; McKenzie *et al* 2008; National Committee on Soil and Terrain 2009 and Rayment and Lyons 2011). Relevant morphological and analytical soil profile data used in the required SCL calculations and criteria compliance assessments are presented in full in **Appendices 2-7,** and summarised in the **Soil Characterization Section** of this report. All recorded field data, measured analytical data and calculated parameters for detailed sites within the triggered area meet the necessary data requirements and follow the procedures and criteria prescribed by DNRM for SCL assessment as at December 2013 (DNRM 2011b, DNRM 2011d, Queensland Government 2011).

Strategic Cropping Land (SCL) zone and trigger mapping status

The BNCOP Disturbance Footprint (excluding ML80169 and ML80170) lies within the **Western Cropping Zone (WCZ)** of the **Strategic Cropping Management Area** (DNRM 2011a, DNRM 2011c). SCL trigger mapping from the DNRM website 2013 (DNRM 2011a) indicates 'likely' (or potential) SCL triggered by the footprint is restricted to an area of 118ha. The triggered land is confined to the southern end of the BNCOP Disturbance Footprint, and is wholly contained within one property (Lot 7, Plan KM44, Central Highlands RC), as defined in Sections 45 and 46 of the *Strategic Cropping Land Act 2011* (Queensland Government 2011). The spatial extent of all triggered land in relation to the wider BNCOP Soil Investigation Survey Area is presented in **Figure 9**, while the location and extent of triggered land specific to the BNCOP Disturbance Footprint is presented in **Figure 10**.

Location of the triggered land within a Strategic Cropping Management Area, has required assessment against both relevant Cropping History criteria (Queensland Government 2011, DNRM 2012) and WCZ SCL Zonal Criteria 1-8 (DNRM 2011d, Queensland Government 2011) before SCL status can be decided.

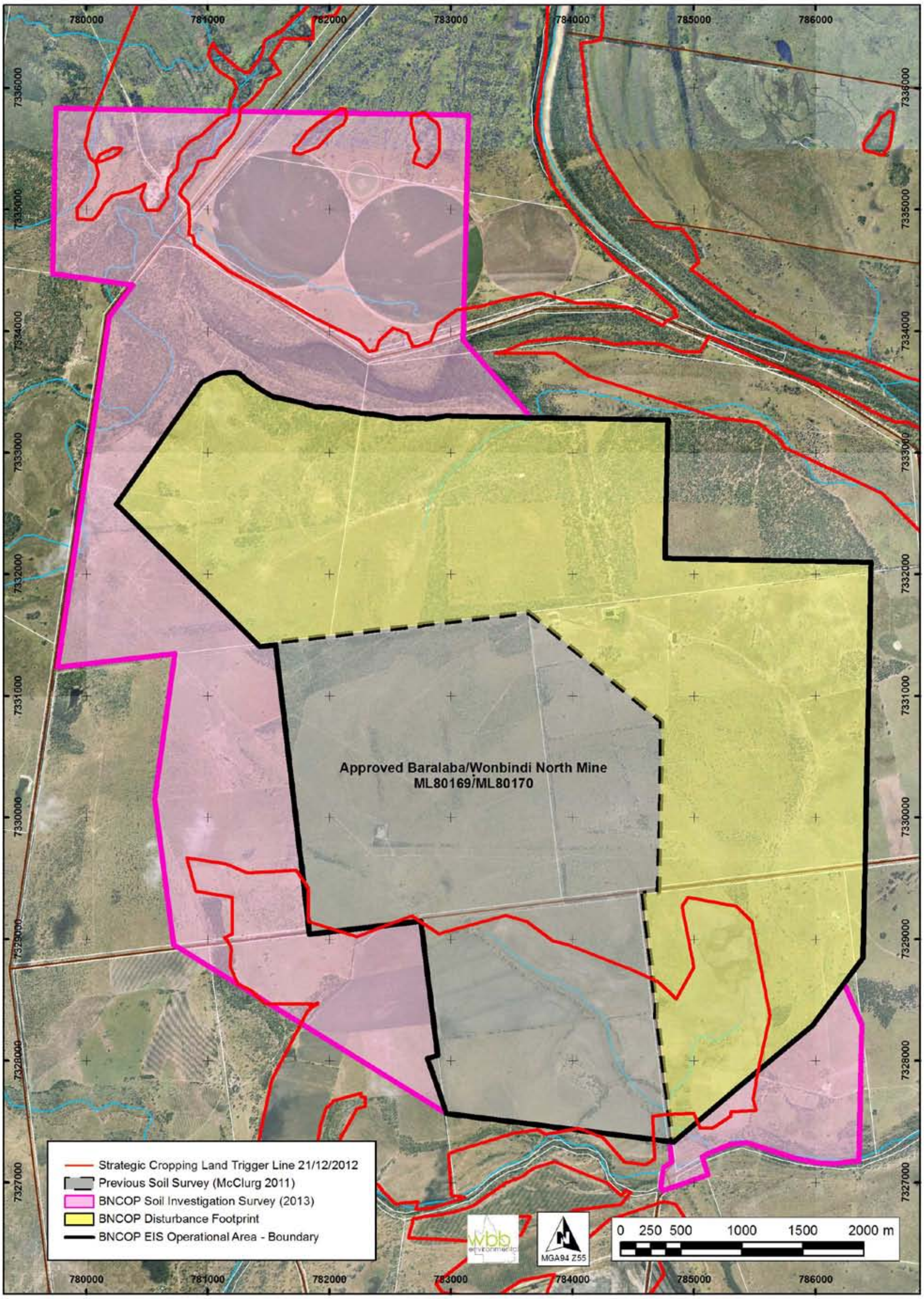


Figure 9. Location and extent of SCL trigger mapping as at 21/12/2012 (DNRM 2011a) in relation to the wider BNCOP Soil Investigation Survey Area.

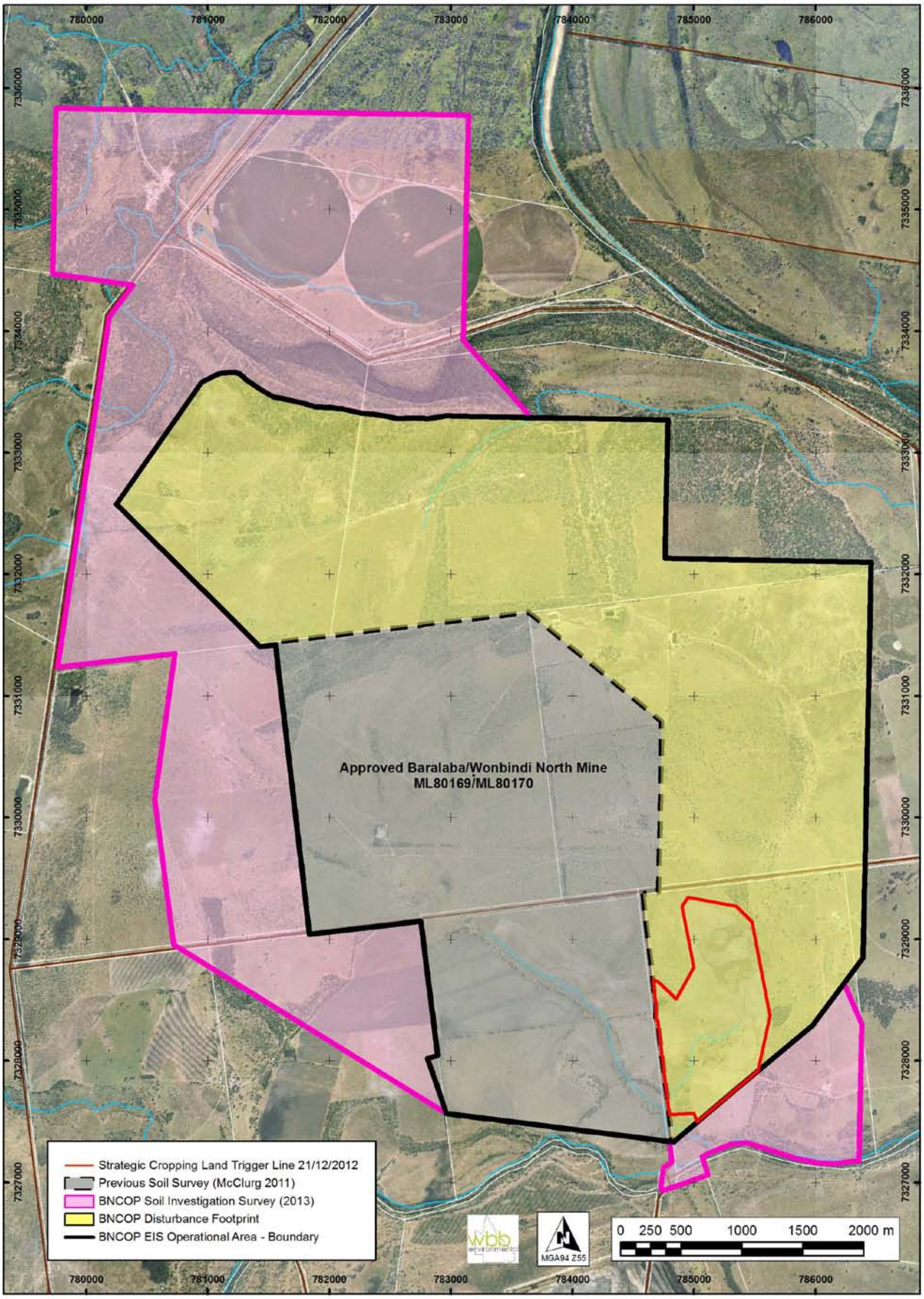


Figure 10. Location and extent of 'likely' (or potential) Strategic Cropping Land specifically triggered for assessment within the BNCOP Disturbance Footprint.

Cropping history assessment

Spatial examination of natural colour Landsat imagery covering the triggered property between the years 1999 and 2010 clearly indicates at least 8 autumn cropping events took place on the property. The extent of the cropping activity appears largely restricted to the triggered land. Autumn was selected as the most appropriate time of year to assess cropping history because of the traditional overlap between summer crop finishing and winter crop preparation during this period. The location and spatial extent of autumn cropping activity within the triggered property is presented for 4 typical years (1999, 2003, 2008 and 2010) in **Figures 11, 12, 13 and 14.**

As such, and in accordance with Section 49 of the *Strategic Cropping Land Act 2011* (Queensland Government 2011) the property was deemed to have the required cropping history (3 or more cropping events between 1 January 1999 and 31 December 2010), and as a consequence has required further assessment against WCZ SCL Zonal Criteria 1-8 to fully determine SCL status.

Assessment against Strategic Cropping Land (SCL) WCZ Zonal Criteria 1-8

The SCL Zonal Criteria considered in the following assessment are those defined for the **Western Cropping Zone** of the **Strategic Cropping Management Area** (DNRM 2011d, Queensland Government 2011). The exact location and extent of detailed field sites within the triggered land are highlighted in **Figure 15.** Similarly, the spatial extent and distribution of soils triggered for SCL Zonal Criteria assessment within the triggered land are displayed in **Figure 16**.

Analytical data from analysed representative sites that occur within (or are relevant to) the triggered portion of the BNCOP Disturbance Footprint can be found in **Appendix 5**. The analytical data is also summarized and discussed in the **Soil Characterization Section** of this report. Morphological descriptions that accompany the analysed representative sites (a number of which occur within or are directly relevant to the triggered land) are presented in **Appendix 6**. Morphological descriptions for all detailed field sites within the triggered boundary (whether analysed or not) are presented in **Appendix 7.**

Relevant morphological and analytical soil data, calculations and identified constraints used in the determination of Effective Rooting Depth (ERD) and Soil Water Status (SWS), for assessment against Zonal Criteria 8, are presented in **Tables 13 and 14** respectively. ERD and SWS determinations are in accordance with defined soil depth criteria, physico-chemical limitation criteria and SWS calculations in the *Strategic Cropping Land Act 2011* (Queensland Government 2011). ERD determinations follow the procedure outlined in Section 4.8.2 of the SCL Guidelines (DNRM 2011d), while SWS calculations follow the procedure outlined in Section 4.8.3 of the SCL Guidelines (DNRM 2011d).

Final SCL Zonal Criteria compliance outcomes are presented in **Table 12**. These outcomes are also displayed spatially in **Figures 18-20.** These maps present a sequential series of images that visually display progressive compliance/non-compliance outcomes as each Zonal Criteria is addressed, for all land mapped within the triggered portion of the BNCOP Disturbance Footprint.

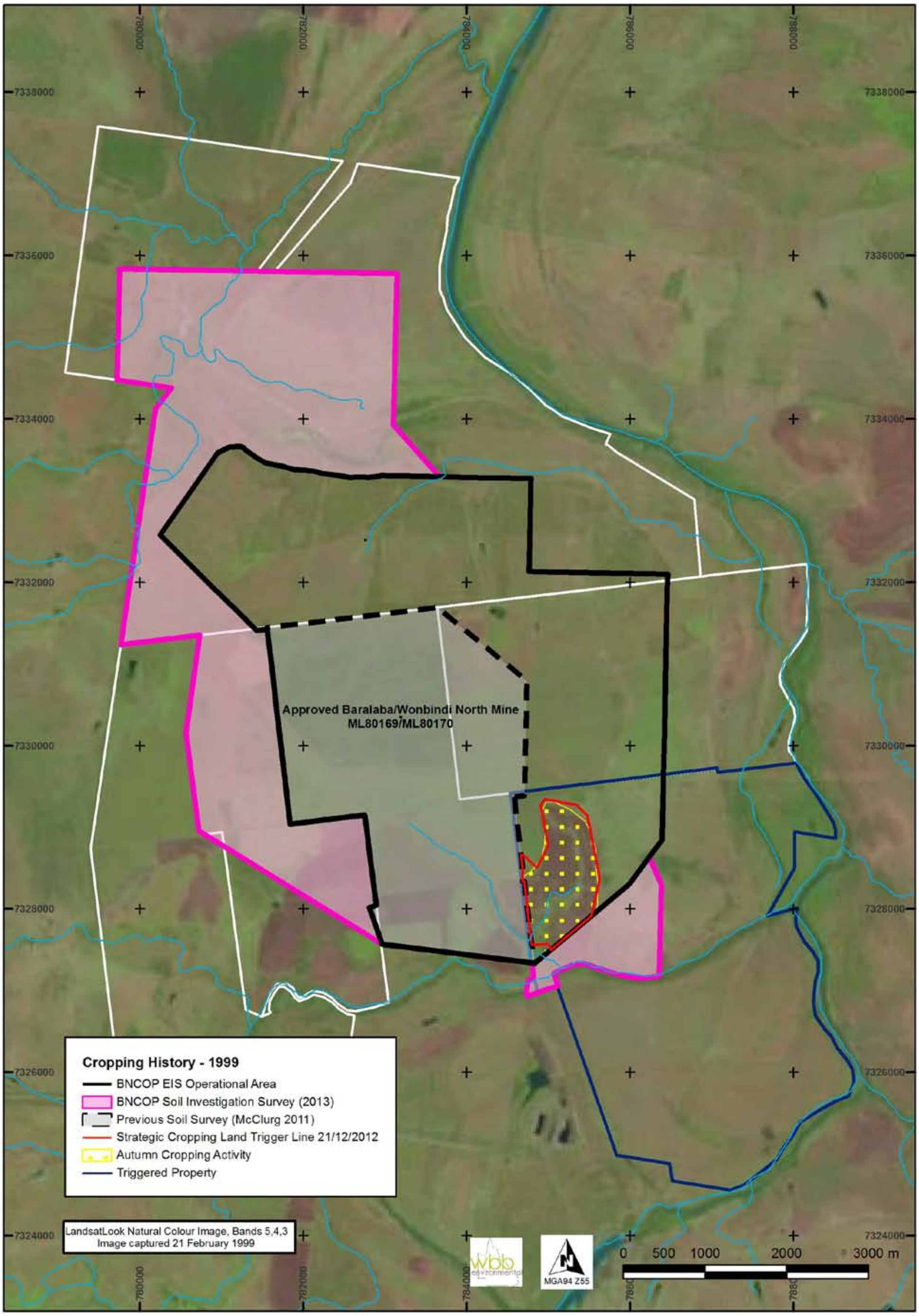


Figure 11. Landsat imagery from 1999 showing active autumn cropping activity within the triggered property. Cropping activity is closely associated with the triggered land.

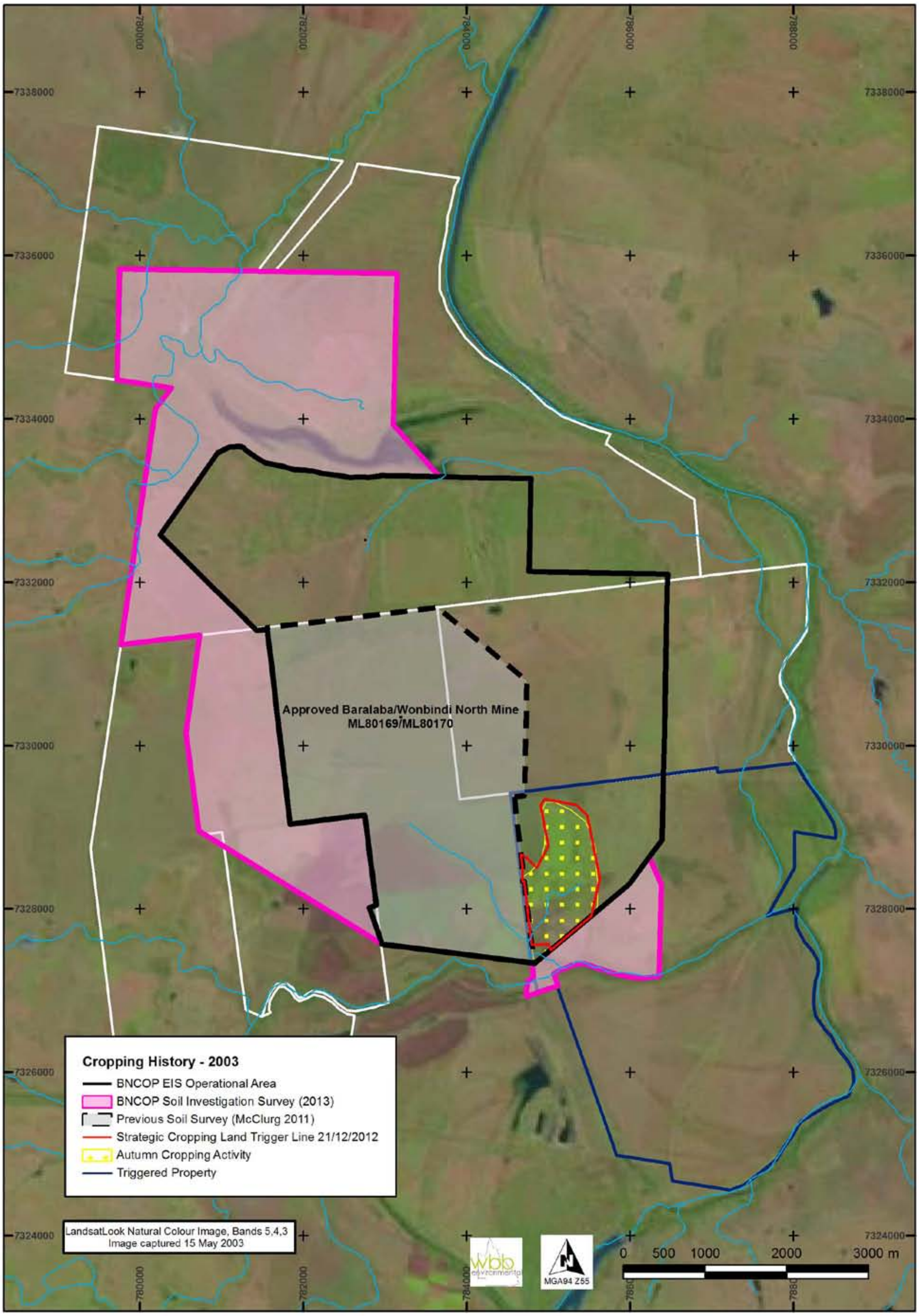


Figure 12. Landsat imagery from 2003 showing active autumn cropping activity within the triggered property. Cropping activity is closely associated with the triggered land.

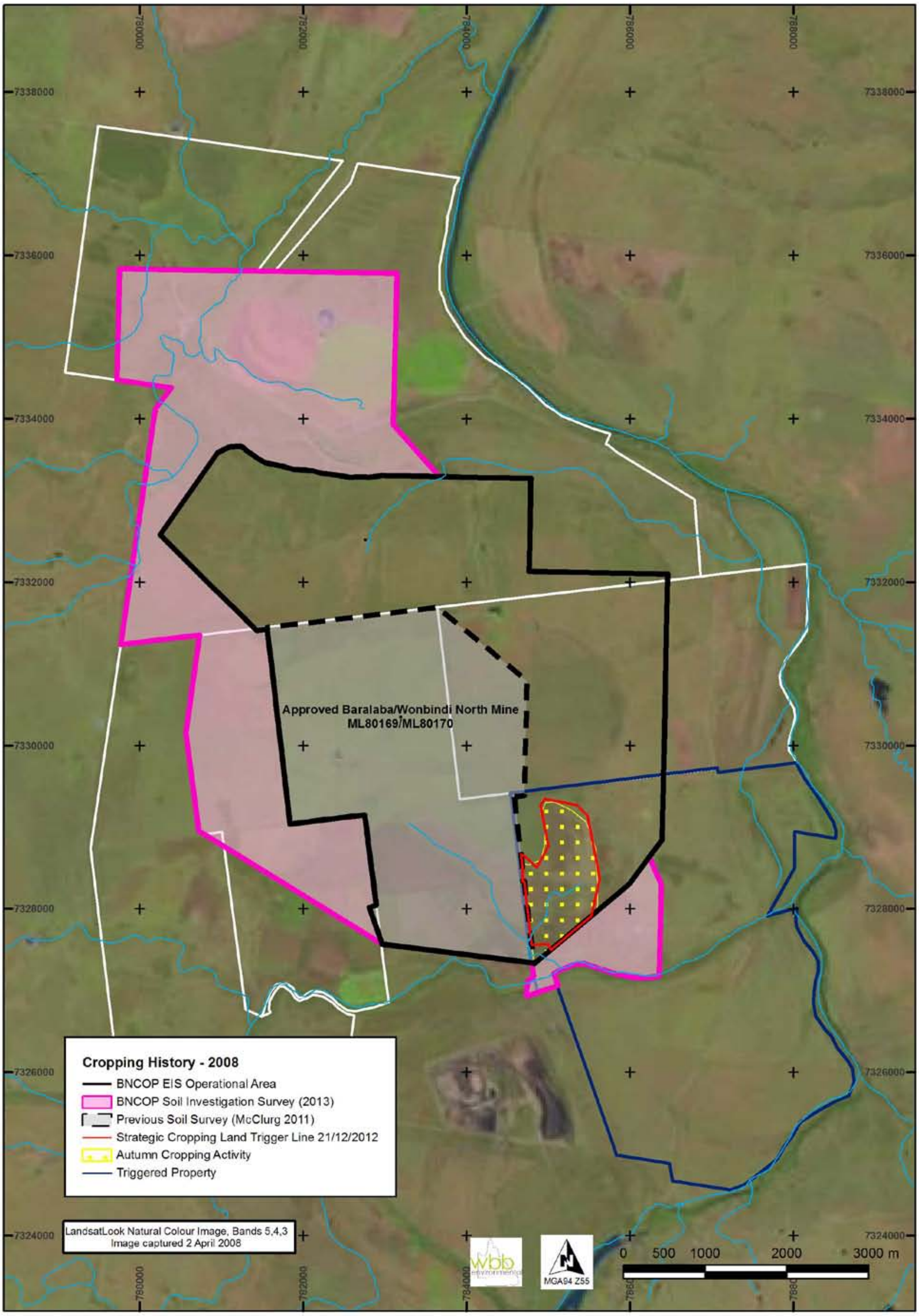


Figure 13. Landsat imagery from 2008 showing active autumn cropping activity within the triggered property. Cropping activity is closely associated with the triggered land.

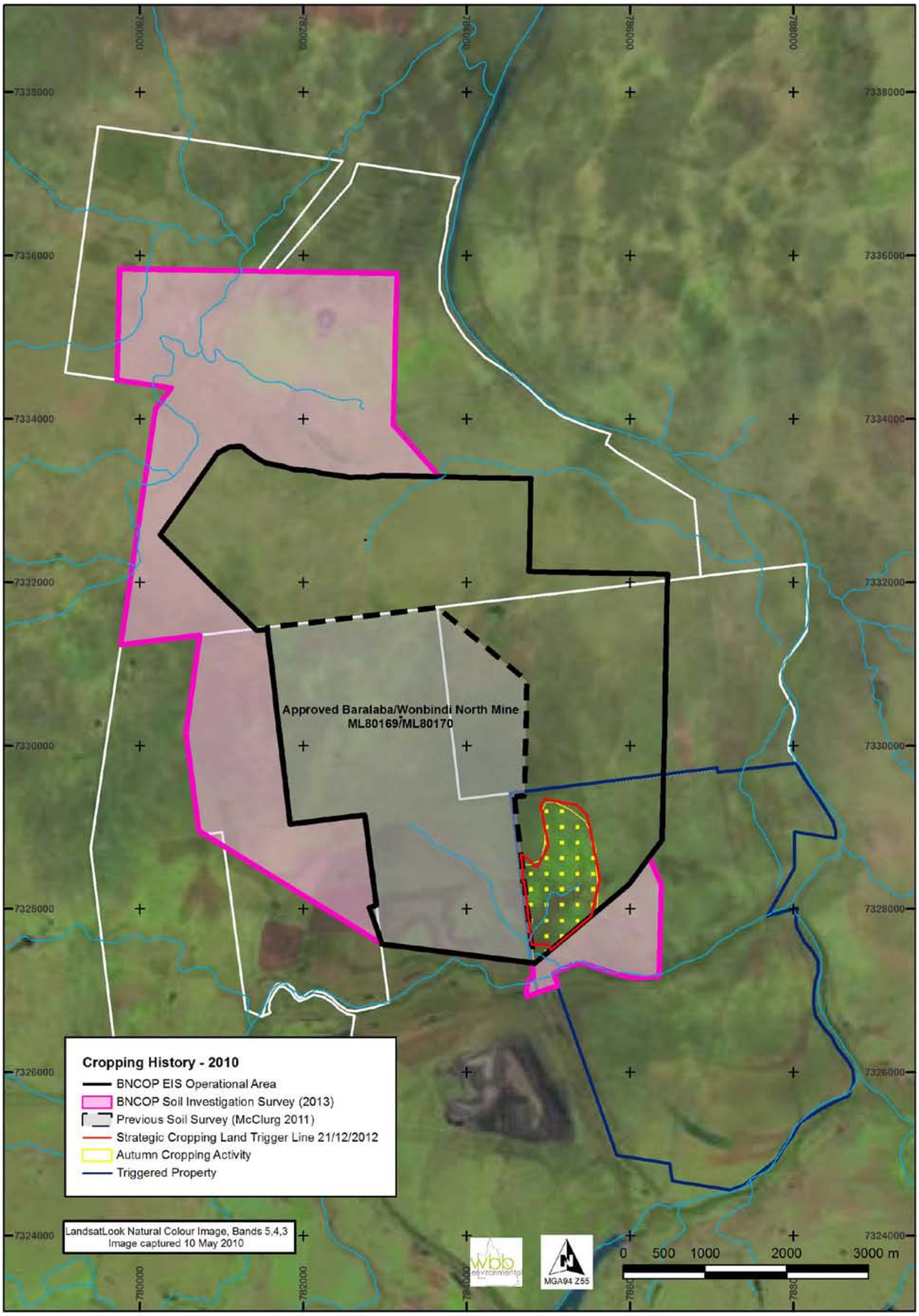


Figure 14. Landsat imagery from 2010 showing active autumn cropping activity within the triggered property. Cropping activity is closely associated with the triggered land.

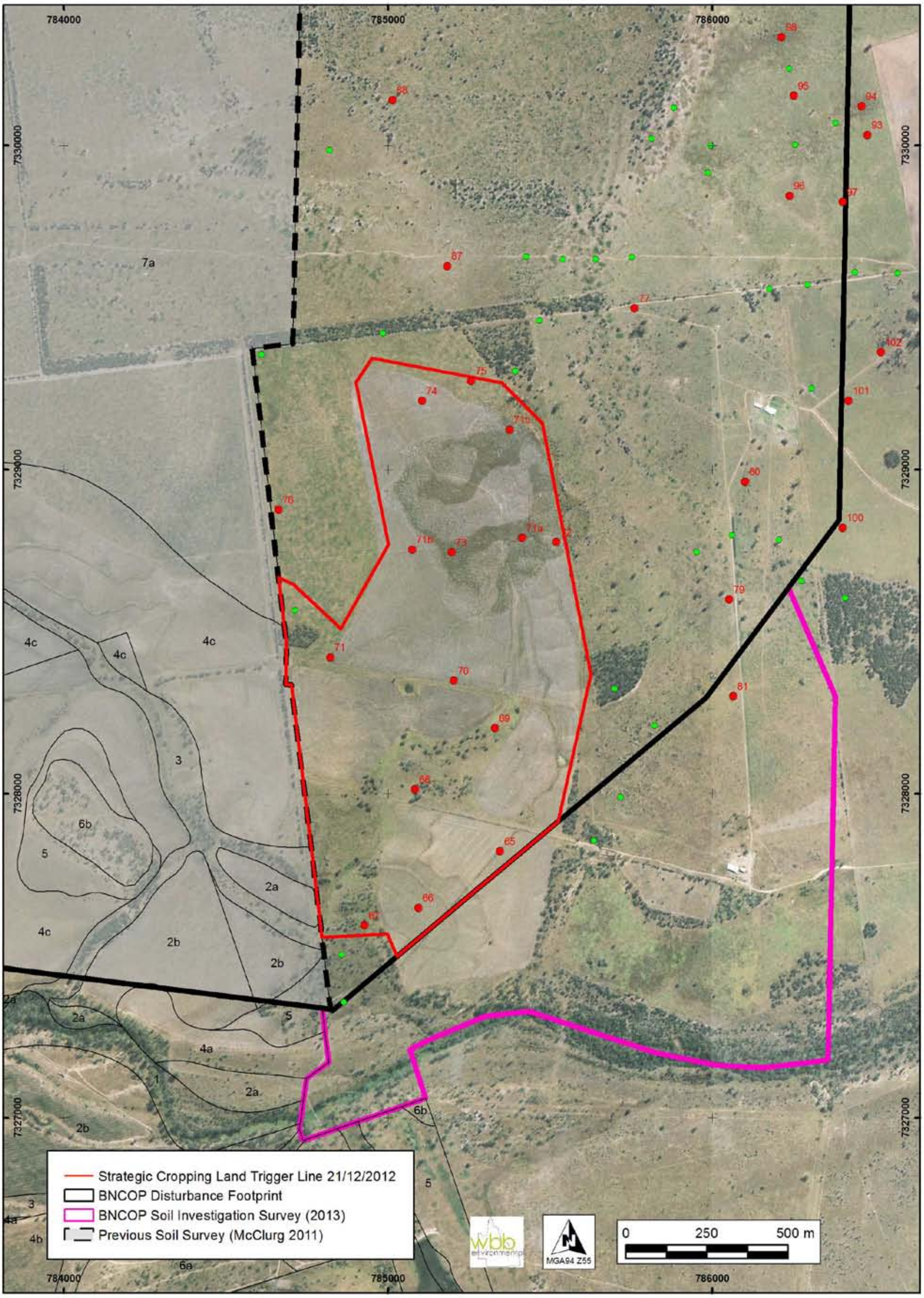


Figure 15. The exact location and extent of land triggered for SCL Zonal Criteria assessment within the BNCOP Disturbance Footprint.

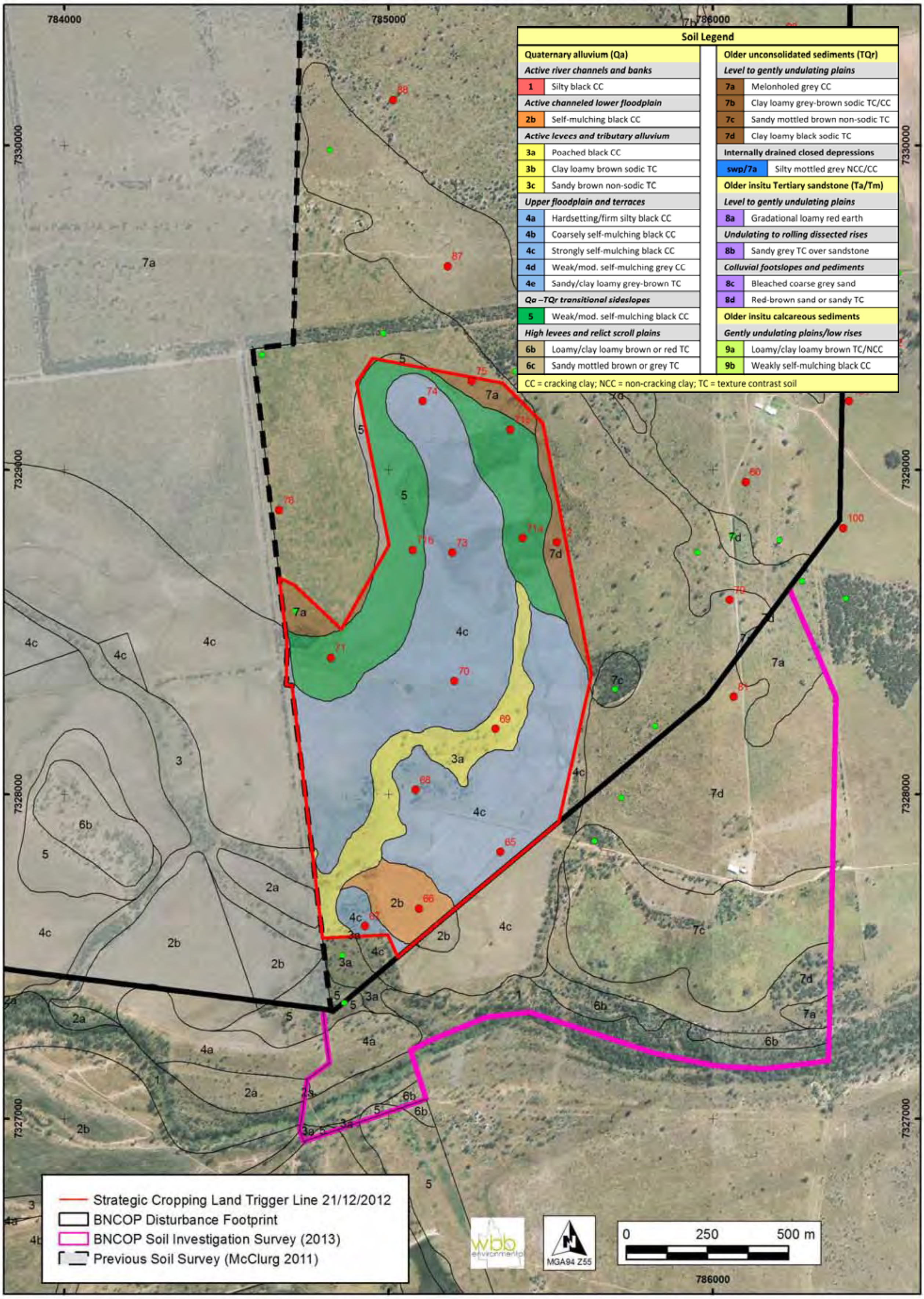


Figure 16. The spatial extent and distribution of soils triggered for SCL Zonal Criteria assessment within the BNCOP Disturbance Footprint.

SCL Zonal Criteria 1 – slope

SCL Zonal Criteria compliance in the Western Cropping Zone requires potential cropping land have gradients of 3% or less, as defined in the *Strategic Cropping Land Act* (Queensland Government 2011) and SCL guidelines (DNRM 2011d). Field data collection and reporting for SCL Zonal Criteria 1 are in line with specifications set out in the SCL Guidelines (DNRM 2011d), and accurate on-ground slope values (recorded by an experienced operator using a hand held Clinometer) are available for all detailed field sites within the trigger area.

However, in an effort to ensure uniform and accurate spatial assessment of Criteria 1 across the entire extent of the triggered land, DEM analysis has been used to better identify and screen areas with slopes >3%, from those with slopes ≤3%. The availability of an accurate and detailed DEM has meant a more complete and definitive spatial analysis has been possible, especially when compared with the potential inaccuracy/inconsistency likely with manual slope interpolation. The use of DEM based slope analysis is well established and is commonly used in government digital mapping programs in Queensland and elsewhere (for example Burgess and Ellis 2007).

Whilst on-ground slope measurements are available for all field sites, they have not been used in the spatial assessment of Criteria 1, other than as point source verification data. Manual slope assessments rely too heavily on the spatial interpolation skills of the assessor, and have the potential to produce skewed or inaccurate spatial estimates, as a result of operator inconsistency in the field or from unrepresentative on-ground locations.

The DEM used in the current assessment is purpose built, and was derived from a spline interpolation of over 2,000,000 LIDAR generated elevation points from across the greater study area. Source elevation points were modelled independently to derive DEMs of 5m and 20m pixel size for differing assessment purposes. The derived DEMs do not represent re-sampled data sets. The accuracy and reliability of the LIDAR generated DEM, in conjunction with the gentle topography common within the triggered area, suggest digital slope analysis is appropriate in this particular case. The interpreted hillshade DEM surface shown in **Figure 17** (interpreted for slopes >3%) clearly demonstrates the subtle elevation and related slope variability requiring clarification for any reasonable assessment of Criteria 1.

The trigger area essentially comprises a north-south trending weakly incised, flooded backplain that forms part of the upper floodplain surface of the Dawson River anabranch system (Soils 2b and 4c). Floodplain dissection has occurred along its central axis and resulted in the formation of a narrow depositional drainage line sourcing local alluvium (Soil 3a). Surrounding sideslopes (Soil 5) are transitional between the younger flood alluvium and the more elevated, level to gently undulating TQr landscapes that are widespread north of the anabranch. Landscape change is subtle at this boundary and the sideslopes which still occasionally flood, merge gradually at upper slope positions with the much older, relatively elevated, level TQr plains that surround (Soils 7a and 7d).

Slopes within the trigger area are mostly ≤3%, except at the lower end of the central floodplain towards the confluence with the main channel of the Dawson River anabranch. Flooding is typically deeper, more erosive and higher frequency in this area and has lead to greater incision and dissection. The severity and intensity of channel and bank/sideslope features increases significantly in this area, and spatial assessment of areas ≤ 3% and > 3% is more complex.

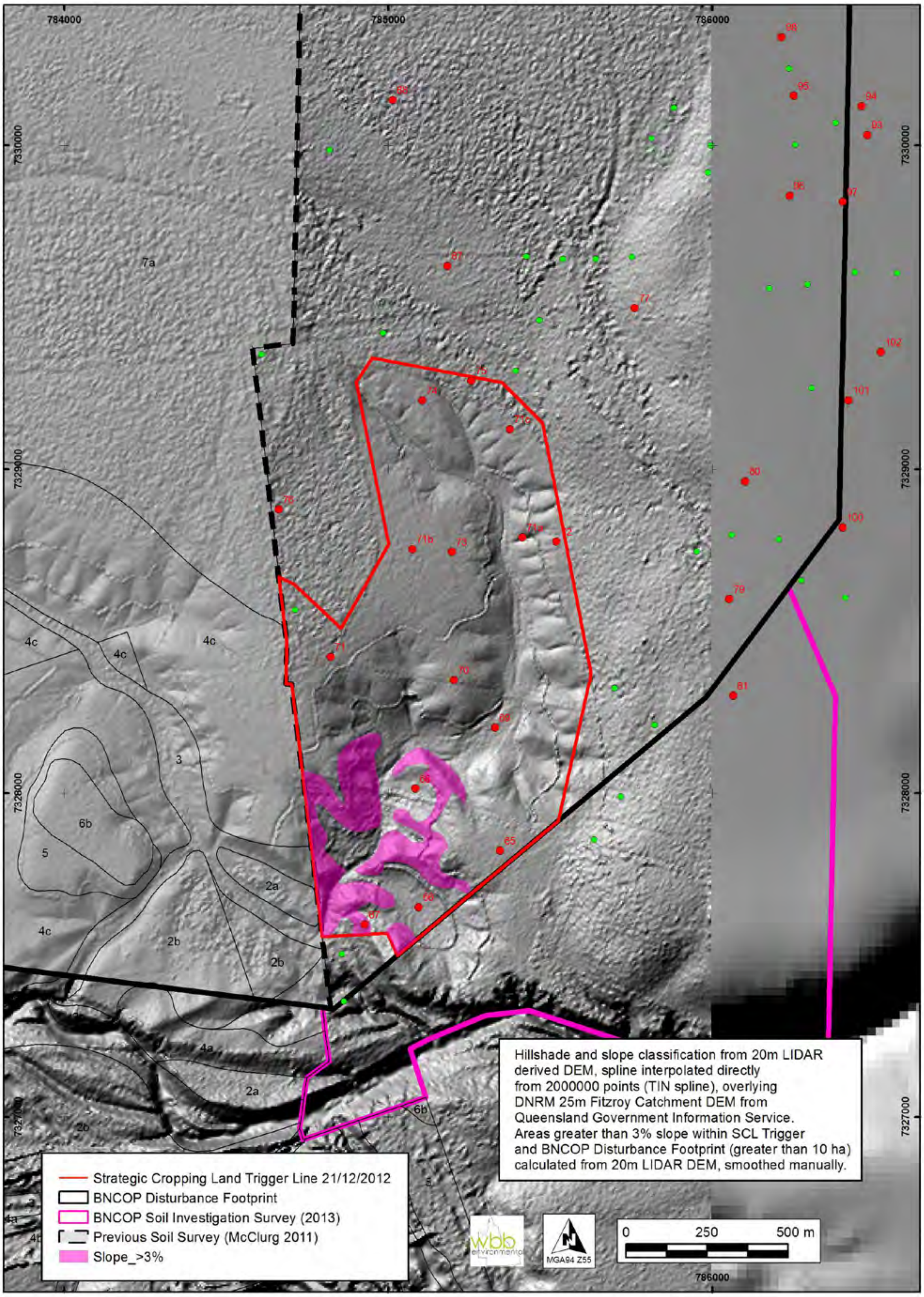


Figure 17. Lidar generated DEM analysis of sloping areas >3%, within lands intersected by the SCL trigger area and the BNCOP Disturbance Footprint.

The DEM analysis presented in **Figure 17** clearly identifies a convoluted land pattern in this area, where flatter areas ≤3% are mixed intimately with steeper dissected sideslopes >3%. Slope features delineated within the DEM surface match landscape features (and point source data) observed in the field. Clinometer measured slope values from field investigations verify the predicted slope ranges and confirm the accuracy of the DEM analysis (see detailed field site data in Appendix 7 for relevant sites – for example Site 67). The DEM surface and slope analysis displayed in Figure 17 (depicting areas >3%) has not been re-interpreted in any way, other than careful digitising to remove noise and edge effects associated with isolated pixel groups and splinters.

The spatial extent of soils mapped within the triggered area that have slopes ≤3% (and therefore comply with Criteria 1 requirements) is presented in **Figure 18**. Areas affected by slopes >3% occur exclusively in the south-west corner. They are limited to small portions of Soils 2b, 3a and 4c, and these portions are deemed non-compliant for Criteria 1. The remaining extent of Soils 2b, 3a and 4c however, have slopes that are ≤3% and these areas are deemed to comply with Criteria 1. The other soils within the trigger area, namely Soils 5, 7a and 7b have slopes ≤3% throughout their entirety and fully comply with Criteria 1.

SCL Zonal Criteria compliance outcomes for each soil following assessment against Zonal Criteria 1 are presented in **Table 12,** and are incorporated spatially in **Figure 18.** The mapped areas displayed in **Figure 18** represent those soil areas that are deemed to comply with Zonal Criteria 1. All 6 soils (2b, 3a, 4c, 5, 7a and 7b) remain compliant to this point (comply with Zonal Criteria 1) but require further assessment against Zonal Criteria 2-8. Any further assessment of Soils 2b, 3a and 4c is restricted to areas of ≤3% slope.

SCL Zonal Criteria 2 – rockiness

SCL Zonal Criteria compliance in the Western Cropping Zone requires potential cropping areas with surface rocks >60mm diameter have an average surface rock density of ≤ 20%, as defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL guidelines (DNRM 2011d). Surface rock was not observed (and is unlikely) within the triggered portion of the BNCOP Disturbance Footprint. Soils are either young alluvial clays (Qa) or are developed from clayey unconsolidated sediments (TQr) that consistently lack coarse fragments, and as such are compliant with SCL Criteria 2 requirements.

SCL Zonal Criteria compliance outcomes for each soil following assessment against Zonal Criteria 2 are presented in **Table 12** and are incorporated spatially in **Figure 18.** The mapped areas displayed in **Figure 18** represent those soil areas that are deemed to comply with Zonal Criteria 1 and 2. All 6 soils (2b, 3a, 4c, 5, 7a and 7d) remain compliant to this point (comply with Zonal Criteria 1 and 2) but require further assessment against Zonal Criteria 3-8. Any further assessment of Soils 2b, 3a and 4c is restricted to areas of ≤3% slope.

SCL Zonal Criteria 3 – gilgai microrelief

SCL Zonal Criteria compliance in the Western Cropping Zone requires potential cropping areas with gilgai microrelief >500mm depth have an average gilgai density of < 50% of the land surface, as defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL guidelines (DNRM 2011d). Gilgai microrelief was only observed in Soil 7a, and occurrence within the trigger area was restricted to 2 locations towards the northern end:

- in a narrow polygon mapped just inside the trigger line boundary in the north-east; and
- in a small triangular area adjacent to the trigger line boundary in the north-west.

Detailed field site data from Site 75 within the north-eastern polygon indicates small to moderate melonhole gilgai are well developed and likely in both areas. Field records indicate measured vertical intervals were consistently 0.5-0.6m, while horizontal intervals ranged from 12-20m (average = 15m). Density estimates recorded in the field indicate mounds/shelves are the dominant feature and occupy approximately 70% of the land surface, while depressions occupy only 30%. As such, the gilgai are within the specifications required for Criteria 3 compliance, and all soils mapped within the triggered portion of the BNCOP Disturbance Footprint are deemed to comply with Zonal Criteria 3.

SCL Zonal Criteria compliance outcomes for each soil following assessment against Zonal Criteria 3 are presented in **Table 12** and are incorporated spatially in **Figure 18.** The mapped areas displayed in **Figure 18** represent those soil areas that are deemed to comply with Zonal Criteria 1-3. All 6 soils (2b, 3a, 4c, 5, 7a and 7d) remain compliant to this point (comply with Zonal Criteria 1-3) but require further assessment against Zonal Criteria 4-8. Any further assessment of Soils 2b, 3a and 4c is restricted to areas of ≤3% slope.

SCL Zonal Criteria 4 – soil depth

SCL Zonal Criteria compliance in the Western Cropping Zone requires potential cropping areas have a soil depth ≥600mm. Soil depth is defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL guidelines (DNRM 2011d) as the depth to bedrock, hard pan, weathered rock (including partially weathered rock, saprolite and decomposed rock) or a continuous gravel layer. Soil depth findings used in the analysis of this criteria use the modal range and midpoint values for relevant horizon boundary depths and designations defined in the detailed soil profile class (SPC) descriptions presented in the **Soil Characterization Section** of this report. The modal range and midpoint values for soil depth to a defined substrate or other physical barrier for each soil are presented in **Table 12.**

Bedrock, hard pans, weathered rock (including partially weathered rock, saprolite and decomposed rock) or continuous gravel layers were not observed (and are unlikely) within the triggered portion of the BNCOP Disturbance Footprint. All soils are of transported origins, either young alluvial clays (Qa) or soils developed from clayey unconsolidated sediments (TQr), and are not developed insitu from (or underlain by) hardened substrates. As such, all soils are compliant with SCL Criteria 4 requirements.

SCL Zonal Criteria compliance outcomes for each soil following assessment against Zonal Criteria 4 are presented in **Table 12** and are incorporated spatially in **Figure 18.** The mapped areas displayed in **Figure 18** represent those soil areas that are deemed to comply with Zonal Criteria 1-4. All 6 soils (2b, 3a, 4c, 5, 7a and 7d) remain compliant to this point (comply with Zonal Criteria 1-4) but require further assessment against Zonal Criteria 5-8. Any further assessment of Soils 2b, 3a and 4c is restricted to areas of ≤3% slope.

SCL Zonal Criteria 5 – soil wetness

SCL Zonal Criteria compliance in the Western Cropping Zone requires potential cropping areas have favourable drainage. This is defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL guidelines (DNRM 2011d) as the absence of any waterlogged layers within the soil profile, assessed either to a defined natural soil depth or to a depth of 1000mm (whichever is shallowest).

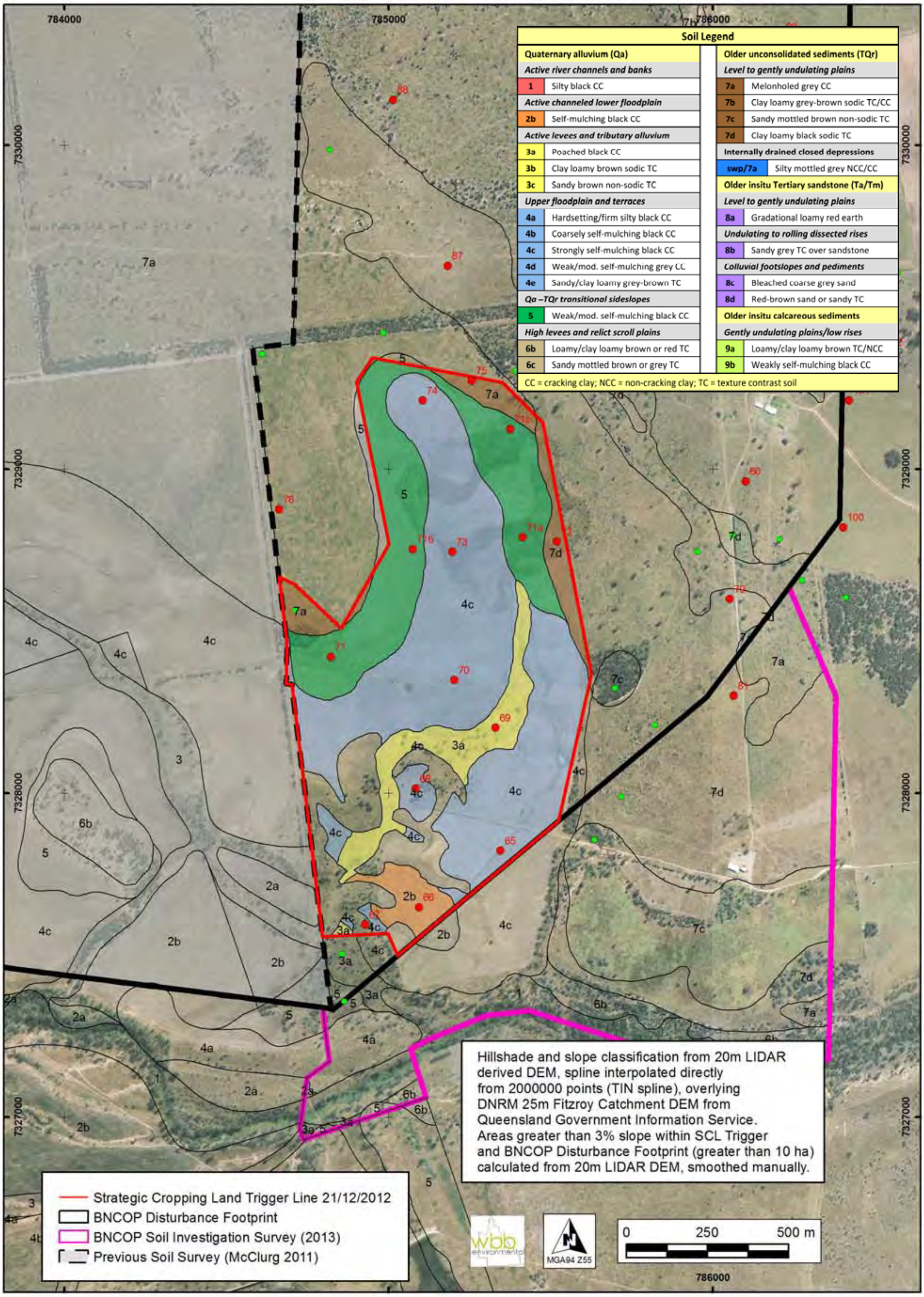


Figure 18. Remaining spatial extent of compliant soils following assessment against WCZ Zonal Criteria 1-5, within lands intersected by the SCL trigger area and the BNCOP Disturbance Footprint. All soils are compliant for Criteria 2-5.

A waterlogged layer is further defined as any layer or horizon within the soil profile that has a dominant soil colour that is gleyed; or has a dominant grey colour with at least 10% distinct or prominent orange or rusty mottling; or any other dominant colour with at least 10% distinct or prominent gley mottling; or has a conspicuous bleach >100mm thick that does not directly overlie bedrock or weathered rock.

Waterlogged layers as defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL guidelines (DNRM 2011d) were not recorded in any of the profile descriptions from the 13 detailed field sites recorded within the triggered land. As such, all soils mapped within the triggered portion of the BNCOP Disturbance Footprint are considered to comply with Zonal Criteria 5.

SCL Zonal Criteria compliance outcomes for each soil following assessment against Zonal Criteria 5 are presented in **Table 12** and are incorporated spatially in **Figure 18.** The mapped areas displayed in **Figure 18** represent those soil areas that are deemed to comply with Zonal Criteria 1-5. All 6 soils (2b, 3a, 4c, 5, 7a and 7d) remain compliant to this point (comply with Zonal Criteria 1-5) but require further assessment against Zonal Criteria 6-8. Any further assessment of Soils 2b, 3a and 4c is restricted to areas of ≤3% slope.

SCL Zonal Criteria 6 – soil pH

SCL Zonal Criteria compliance in the Western Cropping Zone requires potential cropping areas have an acceptable soil pH for plant growth, at two specified depths (namely 300mm and 600mm) within immediate subsurface horizons. The acceptable pH range defined by the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL guidelines (DNRM 2011d) for compliance with Zonal Criteria 6 varies according to whether soils exhibit rigid or non-rigid behaviour (pH 5.1-8.9 for rigid soils, pH >5.0 for non-rigid soils). Laboratory measured pH data at 300mm and 600mm for all detailed field sites recorded within the triggered portion of the BNCOP Disturbance Footprint is presented in **Table 11** and is also available in **Appendix 5**.

The majority of soils within the triggered portion of the BNCOP Disturbance Footprint are active cracking clays (Soils 2b, 3a, 4c, 5 and 7a) with pH levels >5.0 to depths >600mm. These soils clearly meet the pH requirements for **non-rigid soils** as defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and are deemed to comply with Criteria 6. **Rigid soils** are restricted to a small area of Soil 7d located along the north-eastern boundary of the trigger area. Soil 7d is a thin clay loamy surfaced sodic texture contrast soil, and measured and observed subsoil characteristics confirm its rigid status as defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011). Site 72, which is located within and is representative of the 7d polygon, has a laboratory measured pH value of 9.1 at 600mm, and as such fails to meet the requirements for Zonal Criteria 6. On this basis, Soil 7d is deemed non-compliant for Zonal Criteria 6 as defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011), and it is the recommendation of this report that its spatial extent within the triggered land be recorded as decided non-SCL.

SCL Zonal Criteria compliance outcomes for each soil following assessment against Zonal Criteria 6 are presented in **Table 12** and are incorporated spatially in **Figure 19.** The mapped areas displayed in **Figure 19** represent those soil areas that are deemed to comply with Zonal Criteria 1-6. Soils 2b, 3a, 4c, 5 and 7a remain compliant to this point (comply with Zonal Criteria 1-6) but require further assessment against Zonal Criteria 7-8. Any further assessment of Soils 2b, 3a and 4c is restricted to areas of ≤3% slope.

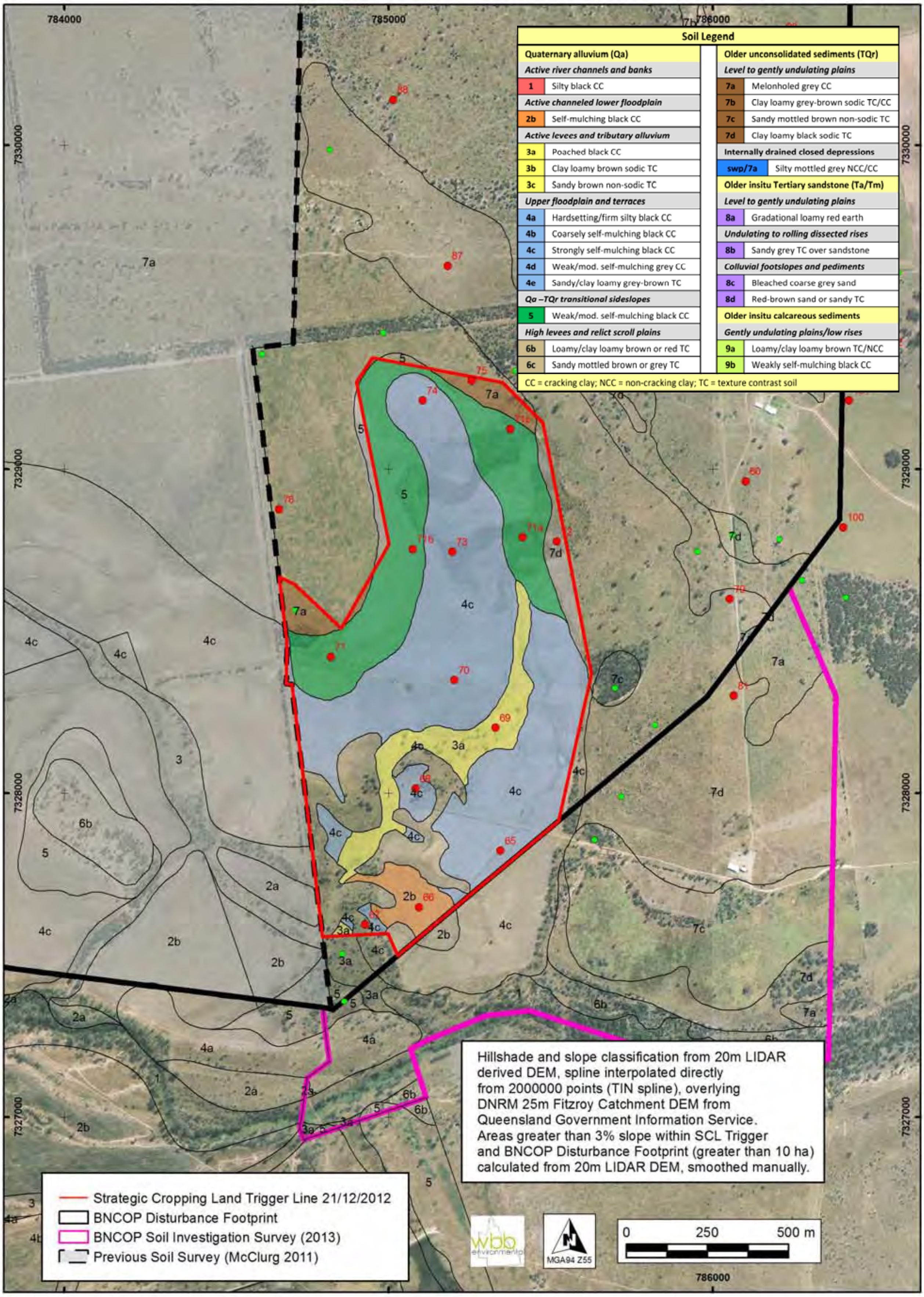


Figure 19. Remaining spatial extent of compliant soils following assessment against WCZ Zonal Criteria 1-6, within lands intersected by the SCL trigger area and the BNCOP Disturbance Footprint. Soil 7d is non-compliant for Criteria 6.

SCL Zonal Criteria 7 – salinity

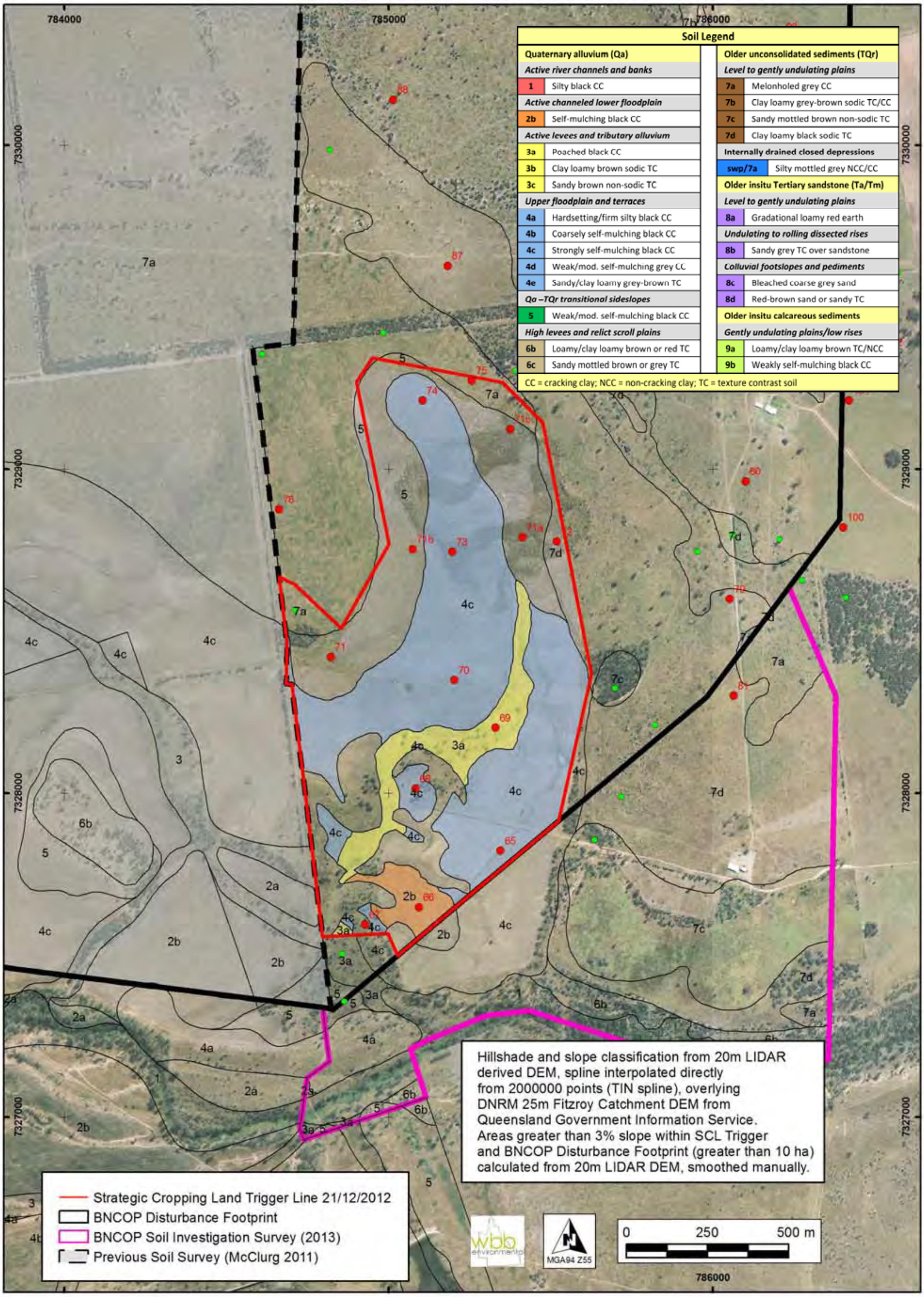
SCL Zonal Criteria compliance in the Western Cropping Zone requires potential cropping areas have an acceptable level of sub-surface/subsoil salinity to allow satisfactory plant growth. This is further defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL guidelines (DNRM 2011d) as a soluble Chloride content of <800 mg/kg Cl from the soil surface to at least a depth of 600mm. Laboratory measured chloride data (mg/kg) at 300mm and 600mm for all detailed field sites recorded within the triggered portion of the BNCOP Disturbance Footprint is presented in **Table 11** and is also available in **Appendix 5**.

Soils 2b, 3a and 4c are young flood-prone, relatively permeable alluvial clays that are well structured, with helpful chemistry and leaching profiles that lack significant subsoil salinity. Chloride levels across all detailed field sites associated with these soils are typically <150mg/kg at 300mm and increase only marginally to levels between 5-438mg/kg by 600mm. Soil 7d (as mapped within the triggered land) also has low Chloride levels (38mg/kg at 600mm at Site 72). As such, Soils 2b, 3a, 4c and 7d are deemed to comply fully with Criteria 7. Soils 5 and 7a however, have salinity levels ≥800mg/kg Cl at or before a depth of 600mm (Soil 5 - 820mg/kg Cl @ 600mm, Soil 7a - 1500mg/kg Cl @ 600mm). As such, both soils fail to meet the requirements defined within the *Strategic Cropping Land Act 2011* (Queensland Government 2011) for Zonal Criteria 7 and are deemed non-compliant. It is the recommendation of this report that the spatial extent of Soils 5 and 7a within the triggered land be recorded as decided non-SCL.

SCL Zonal Criteria compliance outcomes for each soil following assessment against Zonal Criteria 7 are presented in **Table 12** and are incorporated spatially in **Figure 20.** The mapped areas displayed in **Figure 20** represent those soil areas that are deemed to comply with Zonal Criteria 1-7. Soils 2b, 3a and 4c remain compliant to this point (comply with Zonal Criteria 1-7), but require further assessment against Zonal Criteria 8. Any further assessment of Soils 2b, 3a and 4c is restricted to areas of ≤3% slope.

Table 11. pH and Cl data (@ 300mm/600mm) used in the assessment of Zonal Criteria 6 and 7.

Site No.	pH @ 300mm >5 (NR) or 5.1-8.9 (R)	pH @ 600mm >5 (NR) or 5.1-8.9 (R)	Cl (mg/kg) @ 300mm Cl <800mg/kg	Cl (mg/kg) @ 600mm Cl <800mg/kg
Soil – 2b (non-rigid)				
66	8.0	8.5	<5	<5
Soil –3a (non-rigid)				
69	7.7	8.8	<5	25
Soil – 4c (non-rigid)				
65	8.8	8.9	38	85
67	8.6	8.7	5	155
68	8.4	8.8	133	130
70	8.8	8.7	10	245
73	8.7	8.4	15	215
74	8.9	8.7	28	438
Soil –5 (non-rigid)				
71	8.9	8.7	30	820
Soil – 7a (non-rigid)				
75	8.6	7.4	465	1500
Soil – 7d (rigid)				
72	8.8	9.1	<5	38



Hillshade and slope classification from 20m LIDAR derived DEM, spline interpolated directly from 2000000 points (TIN spline), overlying DNRM 25m Fitzroy Catchment DEM from Queensland Government Information Service. Areas greater than 3% slope within SCL Trigger and BNCOP Disturbance Footprint (greater than 10 ha) calculated from 20m LIDAR DEM, smoothed manually.

Figure 20. Remaining spatial extent of compliant soils following assessment against WCZ Zonal Criteria 1-7 and 1-8, within lands intersected by the SCL trigger area and the BNCOP Disturbance Footprint. Soils 5 and 7a are non-compliant for Criteria 7 and 8. Soil 7d is also non-compliant for Criteria 8.

SCL Zonal Criteria 8 – soil water storage

SCL Zonal Criteria compliance in the Western Cropping Zone requires potential cropping areas have an acceptable soil water storage of 100mm or greater, measured over a maximum depth of 1000mm or to a natural soil depth or a soil physico-chemical limitation where shallower, as defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL guidelines (DNRM 2011d).

Representative field and analytical data appropriate to the assessment requirements for Zonal Criteria 8 are presented in the **Soil Characterization Section** of this report and also in **Appendices 5 and 7**. Relevant data and calculations used to determine **Effective Rooting Depth (ERD)** are presented in **Table 13**. ERD determinations are based on the soil depth and physico-chemical limitation criteria specified in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and Section 4.8.2 of the SCL guidelines (DNRM 2011d). Relevant data and calculations used to determine **Soil Water Status (SWS)** are presented in **Table 14.** SWS determinations have followed the requirements and procedures prescribed by the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and Section 4.8.3 of the SCL guidelines (DNRM 2011d) for estimating soil water storage using the soil texture look-up table.

ERD determinations vary significantly between the different soils mapped within the triggered land. Final ERD depends on the type, severity and depth of subsoil constraint (where present) identified in each soil (see Table 13). All 6 soils within the triggered area are developed either on deep alluvium or unconsolidated clayey sediments, and are not constrained by underlying hardened substrates. Absolute soil depths are consistently >1.0m. Soils 2b, 3a, 4c, 5, and 7a are non-rigid cracking clays, and ERD (as defined in the *Strategic Cropping Land Act 2011* Queensland Government 2011) is only limited where extreme acidity (pH ≤ 5) or excessive subsoil salinity (Chloride >800mg/kg) is developed. Soil 7d, in contrast, is a sodic rigid soil, and ERD may be further constrained (in addition to pH and salinity) where Exchangeable Sodium Percentage (ESP) values are >15 and/or Calcium/Magnesium ratios are <0.1 (Queensland Government 2011).

pH and Chloride data presented in **Table 13** and also **Appendix 5** indicates ERD for Soils 2b (Site 66) and 3a (Site 69) are consistently >1.0m. Soil 4c (Sites 65, 67, 68, 70, 73 and 74) is more variable and Chloride levels >800mg/kg in the lower subsoil of some profiles limit ERD to between 0.75->1.0m. Variability in Soil 4c is clearly related to position within the floodplain and proximity to surrounding TQr landscapes. Soil 5 which is transitional between the alluvium and surrounding TQR clay sheets is similarly constrained (Chloride >800mg/kg) but at shallower depths. ERD for Soil 5 is consistently between 0.6-0.7m (Site 71). Soil 7a which is developed on older elevated Cainozoic clay sheets is severely constrained by subsoil salinity (Chloride >800mg/kg), and ERD is limited to only 0.4-0.5mm (Site 75).

Soil 7d, in contrast, is a thin clay loamy surfaced, sodic texture contrast soil developed on elevated TQr sediments above floodplain alluvium. Field and laboratory data confirm it has soil characteristics consistent with those of a rigid soil, as defined in the *Strategic Cropping Land Act 2011* (Queensland Government 2011). Site 72, which is central to and representative of the triggered polygon, has a ph of 9.1 and an ESP value of 14% by 0.6m. Representative data for Soil 7d (from Site 87 located just north of the trigger area) indicates ESP values >30% can occur at relatively shallow depths within this soil. Detailed horizon data from both Site 72 (located within the trigger area) and Site 87 (just outside the trigger area) suggest strongly alkaline pH >8.9 and ESP levels >15% coincide with the start of the lower subsoil (B22 horizon). Estimated ERD for Soil 7d is 0.4-0.5m.

The necessary data and sequence of calculations required to generate **SWS estimates** for each soil (as per the procedure in Section 4.8.3 of the SCL Guidelines DNRM (2011d)) are set out clearly and logically in **Table 14** to ensure findings are transparent and easy to follow. The younger alluvial clays, namely **Soils 2a and 3b**, have ERD values >1.0m and medium clay to heavy clay textures throughout their profiles. Estimated SWS status with these soils is 120mm and they are **deemed to comply with Zonal Criteria 8.**

Soil 4c is marginally older and more affected by subsoil salinity, with an ERD that varies between 0.75 to >1.0m. Clay textures are medium clay or heavier throughout, and SWS status ranges from 90-120mm. Values <100mm are spatially restricted and occur only in the most northerly mapped extent (Site 74) of the unit. Because the majority of sites (and associated mapped extent) are consistently >100mm, more detailed SWS measurements and calculations in line with the procedure outlined in Section 4.8.4 of the SCL Guidelines (DNRM 2011d) were not considered warranted. As such, Soil 4c, as mapped within the triggered portion of the BNCOP Disturbance Footprint, is **deemed to comply with Zonal Criteria 8.**

Soil 5 which is transitional between the alluvium and surrounding TQR clay sheets, has an ERD between 0.6-0.7m, medium clay to medium heavy clay textures throughout, and a SWS status of 80mm. **Soil 7a** which is widespread on the older, slightly elevated Cainozoic clay sheets sitting above the floodplain alluvium is subject to significant subsoil salinity and ERD is limited to 0.4-0.5m. Textures are medium clay or heavier throughout and SWS is estimated at 55mm. SWS estimates for Soil 7a are based preferentially on soil characteristics within mound profiles, because subsoil constraints are shallower, more severe and most limiting (in terms of soil water storage) in mound profiles (Burgess 2003a). **Soil 7d** is a thin clay loamy surfaced, sodic texture contrast soil that occurs adjacent to Soil 7a, and has a similar ERD between 0.4-0.5m. Surface textures (to 0.15m) are sandy clay loam to clay loam sandy and overlie sandy light medium to sandy medium clay textures in the upper subsoil. SWS is estimated at 50mm.

Estimated SWS status for Soils 5, 7a and 7d is collectively between 50-80mm. As such, all three soils are consistently below the 100mm threshold set for the Western Cropping Zone and also clearly below the 15% buffer requiring more detailed assessment (Section 4.8.4 of the SCL Guidelines DNRM 2011d). As such, **Soils 5, 7a and 7d** fail to meet the requirements defined within the *Strategic Cropping Land Act 2011* (Queensland Government 2011) for Zonal Criteria 8 and **are deemed non-compliant**. It is the recommendation of this report that the spatial extent of Soils 5, 7a and 7d within the triggered land be recorded as decided non-SCL.

SCL Zonal Criteria compliance outcomes for each soil following **assessment against Zonal Criteria 8** are presented in **Table 12** and are incorporated spatially in **Figure 20**. The mapped areas displayed in **Figure 20** represent those soil areas that are deemed to comply with Zonal Criteria 1-8. Only Soils 2b, 3a and 4c (in areas where slope is ≤3%) remain compliant after final assessment against Zonal Criteria 8.

SCL Zonal Criteria compliance outcomes

Findings from the SCL Zonal Criteria assessment presented in **Table 12** and **Figure 20** indicate **Soils 2b, 3a and 4c**, within the triggered portion of the BNCOP Disturbance Footprint, are compliant for all 8 Zonal Criteria defined for the Western Cropping Zone, and as such **meet the Zonal Criteria requirements of Schedule 1** of the *Strategic Cropping Land Act 2011* (Queensland Government 2011).

Soils 5, 7a and 7d however, failed at least one or more of Zonal Criteria 6, 7 and 8. In summary:

- Soils 5 was non-compliant for Zonal Criteria 7 and 8 due to excessive subsoil salinity, limited ERD and inadequate soil water storage;

- Soil 7a was non-compliant for Zonal Criteria 7 and 8 due to excessive subsoil salinity, limited ERD and inadequate soil water storage; and
- Soil 7d was non-compliant for Zonal Criteria 6 and 8 because of unfavourable subsoil pH and inadequate soil water storage.

As such, **Soils 5, 7a and 7d** are non-compliant for one or more Zonal Criteria defined for the Western Cropping Zone, and **do not meet the Zonal Criteria requirements of Schedule 1** of the *Strategic Cropping Land Act 2011* (Queensland Government 2011). Final Zonal Criteria compliance outcomes are presented in **Figure 20**.

SCL minimum size requirements

The *Strategic Cropping Land Act 2011* (Queensland Government 2011) requires SCL Zonal Criteria compliant land within the Western Cropping Zone meet minimum size requirements before SCL status can be decided. Prior to any decision, the Act requires criteria compliant polygons be >100ha in extent, at least 80m wide, and where <100ha be contiguous with decided SCL or potential SCL (either internal to or external to the triggered area) to ensure a collective SCL extent >100ha (DNRM 2011d, Queensland Government 2011).

In addition, the SCL Guidelines (Table 6, page 13 of the SCL Guidelines - DNRM (2011d)) require that the minimum map unit area within the Western Cropping Zone be at least 10ha or larger. Further to this requirement Figure 6, on page 18 of the SCL Guidelines (DNRM 2011d), indicates that narrow natural linear features (defined as <80m), such as local depositional drainage lines, should not fragment a larger surrounding compliant SCL polygon. The question of whether such narrow features (<80m wide) should be mapped or not depends entirely on project size and mapping scale. The intent of the SCL Guidelines is clear however, in that the presence of such narrow linear features (whether mapped or not) should be considered effectively invisible and should not fragment surrounding compliant SCL units (see Figure 6, pp 18 of the SCL Guidelines - DNRM (2011d)).

Application of the **minimum size requirements** specified within the *Strategic Cropping Land Act 2011* (Queensland Government 2011) is illustrated in **Figure 21**. Coloured soil polygons that are not hatched demonstrate the spatial extent of soil entities that are criteria compliant and satisfy minimum size requirements (>100ha contiguous area and >80m wide), as specified in Sections 62 and 68 of the *Strategic Cropping Land Act 2011* (Queensland Government 2011). The remaining undersized coloured soil entities within the hatched area shown in Figure 21 demonstrate the extent of fragmented polygons that are recommended for excision. While floodplain dissection and slopes >3% are ultimately responsible for the fragmentation, it was the removal of sloping areas as part of the Criteria 1 assessment, that further isolated a small number of undersized (but otherwise criteria compliant) polygons making them no longer contiguous with nearby larger units. Undersized polygons to be excised total an area of just 3.5ha and include only those coloured soil entities that lie inside the hatched area shown in Figure 21. It is the recommendation of this report that the criteria compliant, but undersized and non-contiguous, soil polygons identified within the hatched area be deemed decided non-SCL.

The only other exception to minimum size requirements is the criteria compliant central 3a soil unit. This unit comprises a linear drainage feature (mostly >80m wide, but less than 80m in its most northern extent) that divides and is contiguous with larger compliant 4c units east and west. The SCL Guideline (2011d) states a narrow linear feature (such as the northern extent of unit 3a), "*cannot fragment an adjacent compliant soil area,*" and infers that the adjacent compliant land either side should remain contiguous, irrespective of whether the linear feature is mapped or not. As such, the central 3a polygon is considered contiguous and deemed to be decided SCL.

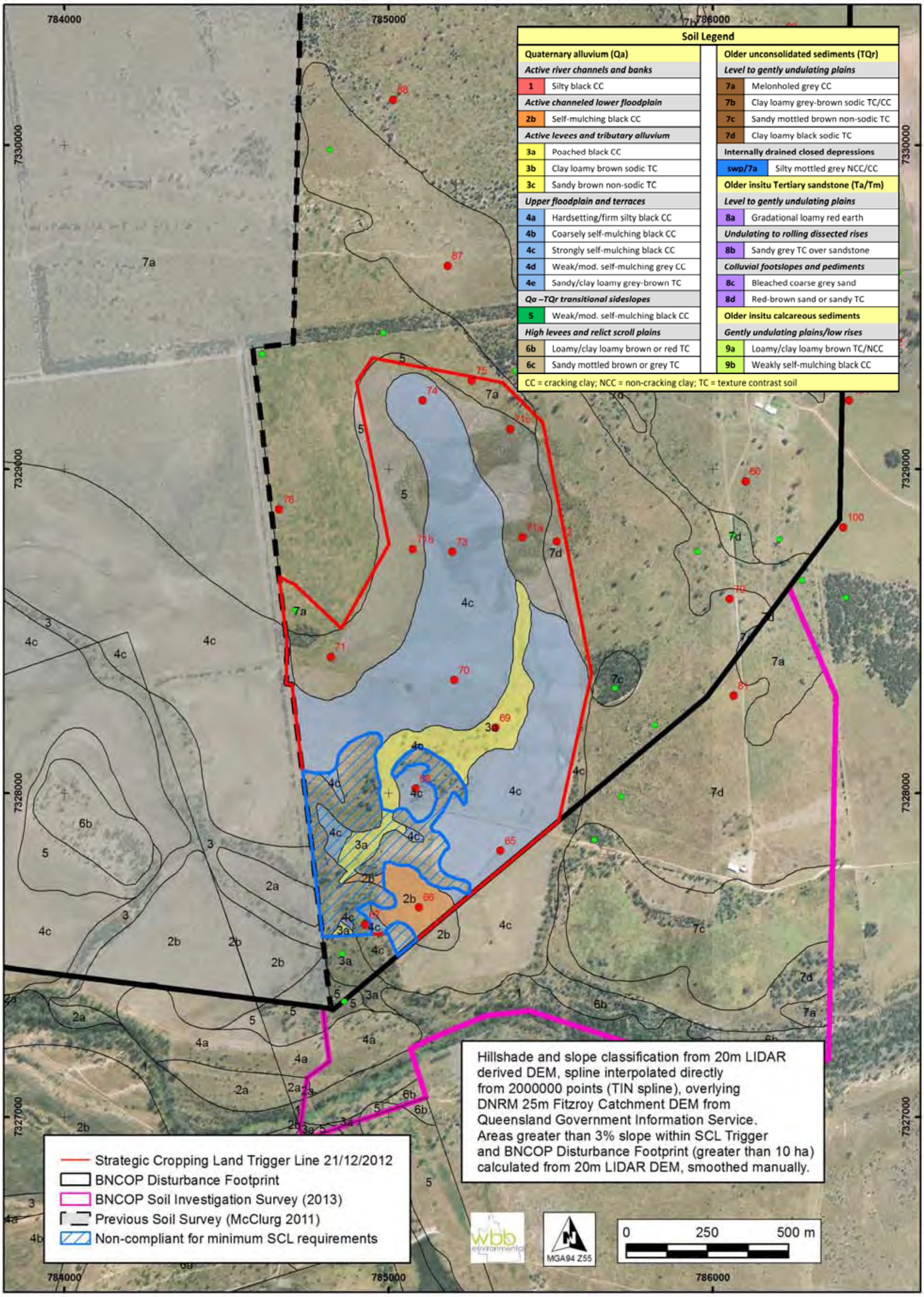


Figure 21. Hatching indicates the spatial extent of dissected, criteria compliant soil fragments that fail WCZ minimum size requirements (Queensland Government 2011), for lands intersected by the SCL trigger area and the BNCOP Disturbance Footprint.

The final spatial extent of the remaining SCL compliant soil polygons (Soils 2b, 3a and 4c) left following assessment against SCL minimum size criteria is presented in **Figure 22**. All remaining compliant polygons are individually <100ha, but seamlessly join adjacent compliant soil units (both inside and outside the trigger area) to form a contiguous wider aggregation that is >100ha. On this basis, the compliant soil polygons displayed in Figure 22 qualify as decided SCL. They have the required cropping history, are compliant with WCZ Zonal Criteria 1-8 and meet SCL minimum size requirements.

Strategic Cropping Land (SCL) status

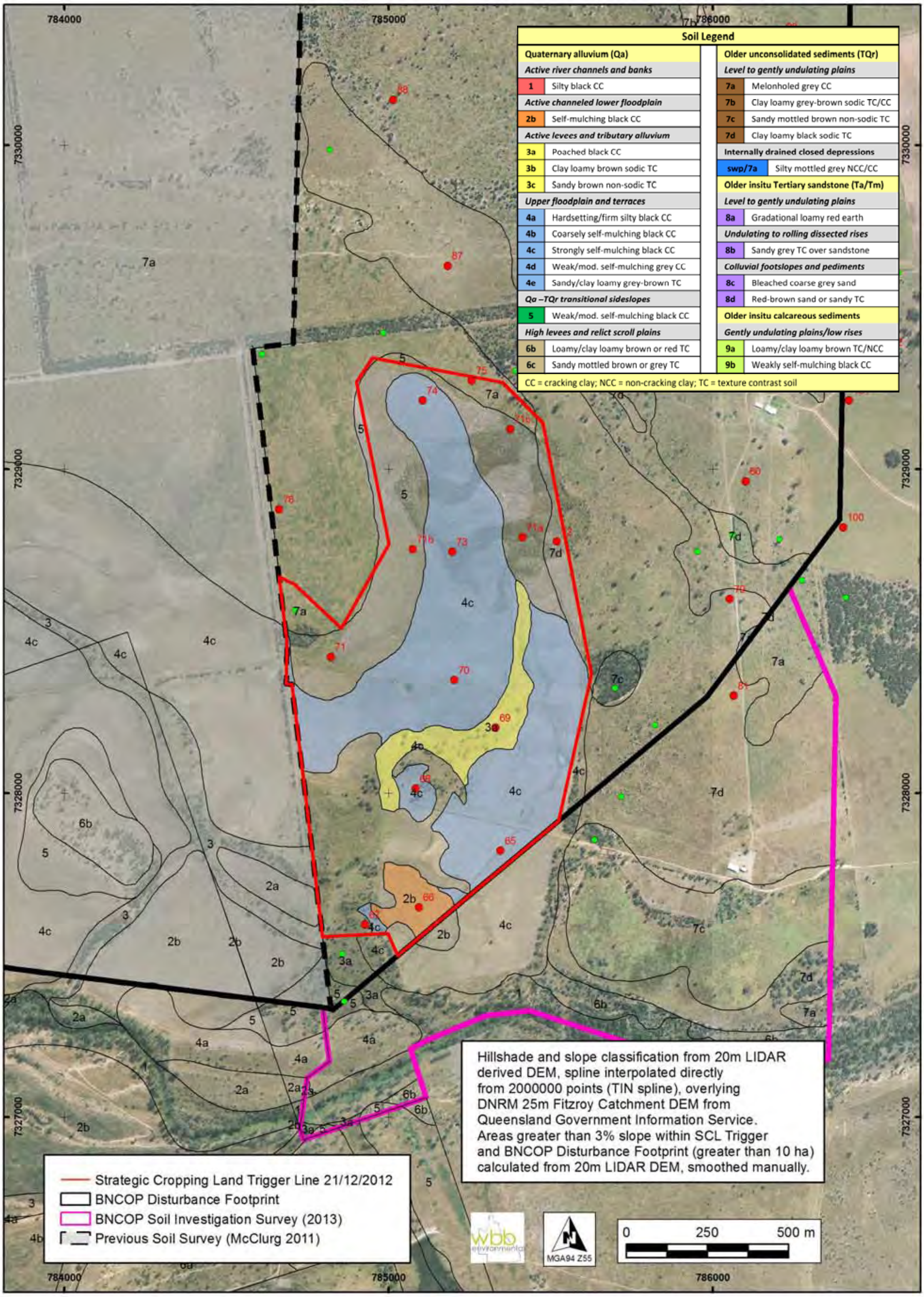
The *Strategic Cropping Land Act 2011* (Queensland Government 2011) requires SCL Zonal Criteria compliant land within the Western Cropping Zone meet both minimum size requirements and required cropping history before SCL status can be decided. **Figure 22** illustrates the total extent of land that complies with all SCL assessment requirements within the triggered portion of the BNCOP Disturbance Footprint. Compliant land comprises 3 soils and 6 polygons which include the:

- Southern 2b/4c unit which is <100ha and >80 wide, and isolated from adjacent compliant polygons within the triggered area by dissected lands >3% slope. It is however, contiguous with adjacent compliant 2b and 4c soil units external to the trigger area to the south-east. These units run north, re-enter the trigger area and are contiguous with the compliant central 3a and western 4c units in the centre;
- Eastern 4c unit which is >80m wide, individually <100ha, but contiguous to the south-east and west, both inside and outside the trigger area;
- Central linear 3a/4c unit which is mostly >80m wide (<80m in northern parts), individually <100ha, but contiguous with larger 4c units east and west; and the
- Western 4c unit which is >80m wide, individually <100ha, but contiguous to the east and west, both inside and outside the trigger area.

Assessment against WCZ SCL Zonal Criteria 1-8 and minimum size requirements (as defined in Sections 66-68 of the *Strategic Cropping Land Act 2011* (Queensland Government 2011)) indicates **66.1ha or approximately 56%** of the triggered land is compliant and **qualifies as decided SCL. Decided non-SCL** within the triggered area comprises **3.5ha** of otherwise compliant land that does not meet minimum size requirements, and a further **48.4 ha** of land that does not comply with WCZ Zonal Criteria 1-8. In total, non-compliant land covers **51.9ha or 44% of the triggered area**, and is either associated with localised dissection (slopes >3%) in the south-western corner or with soils 5, 7a and 7d that fail Criteria 6, 7 or 8 in northern parts. It is the **recommendation of this report**, in accordance with the requirements of Sections 66-68 of the *Strategic Cropping Land Act 2011* (Queensland Government 2011), that the outcomes documented herein be recorded as decided SCL and decided non-SCL as described.

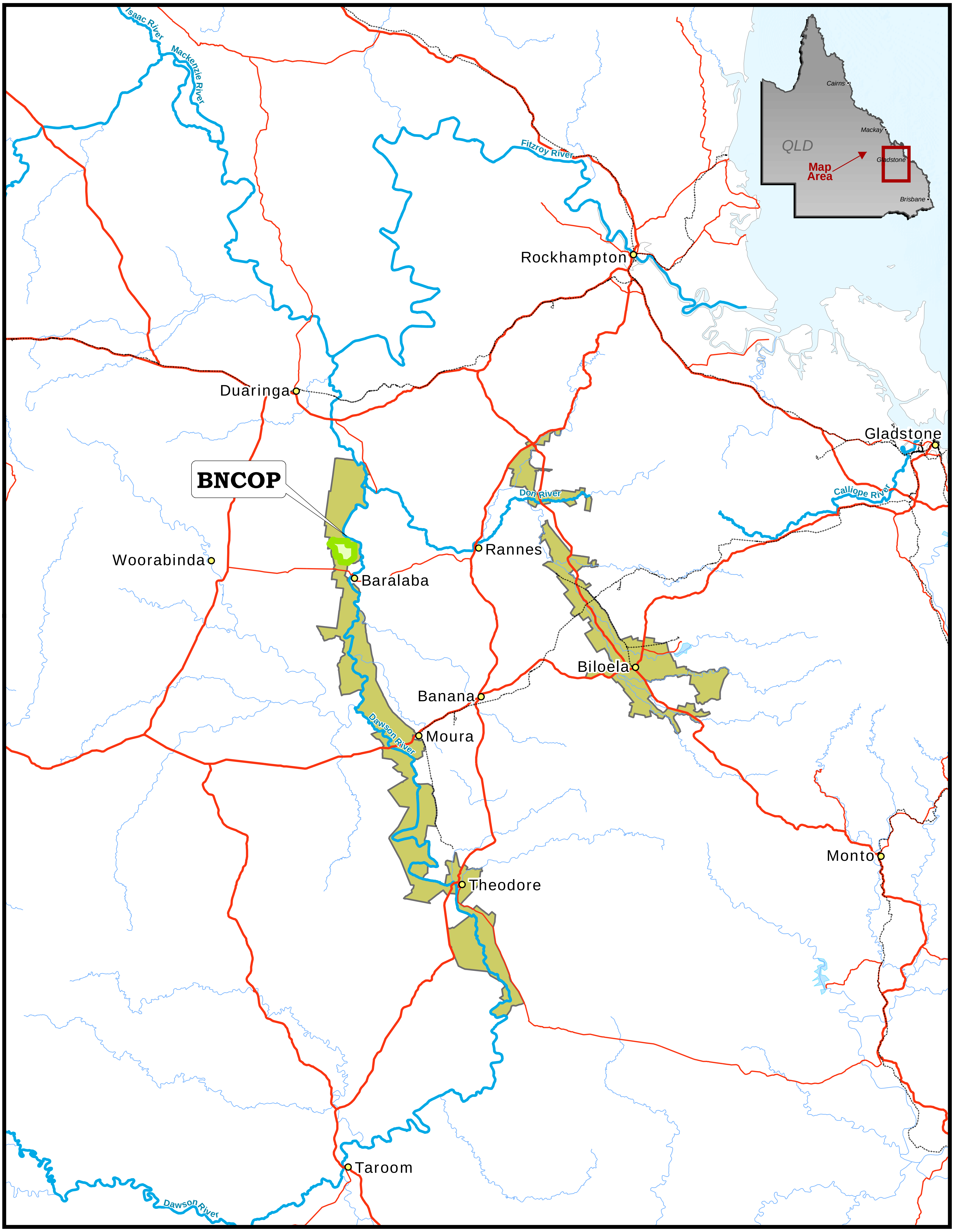
Central Queensland Regional Plan – Priority Agricultural Areas

The BNCOP Operational Area is subject to the planning requirements of the Central Queensland Regional Plan (DSDIP 2013) and is located within a designated Priority Agricultural Area (PAA) as shown in **Figure 23**. The land within this precinct is considered a strategic regional entity with significant potential for the continued or future development of highly productive agricultural land uses. Identified land uses of significance are known as Priority Agricultural Land Uses (PALU). The current intention of the planning framework will afford PALUs within a PAA primary land use status and likely planning priority over other proposed or competing uses. Assessment against proposed PAA co-existence criteria will inform the planning process and guide development decisions as to how and where compatible resource activities,such as the BNCOP, can co-exist concurrently with high value agricultural activities. DSDIP is yet to finalise any such criteria however.



Hillshade and slope classification from 20m LIDAR derived DEM, spline interpolated directly from 2000000 points (TIN spline), overlying DNRM 25m Fitzroy Catchment DEM from Queensland Government Information Service. Areas greater than 3% slope within SCL Trigger and BNCOP Disturbance Footprint (greater than 10 ha) calculated from 20m LIDAR DEM, smoothed manually.

Figure 22. Final spatial extent of decided SCL within the BNCOP Disturbance Footprint. Mapped areas are compliant for Zonal Criteria 1-8, meet WCZ minimum size requirements and qualify for cropping history.



PROJECT

BARALABA NORTH
CONTINUED OPERATIONS
PROJECT

TITLE

Figure 23
Priority
Agricultural Areas

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Legend

Populated Place...........	○
Road............................	╱
Rail.............................	╱
Watercourse.................	╱
BNCOP Operational Land.	🟩
Priority Agricultural Area.	🟩

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Table 12. SCL Zonal Criteria assessment (WCZ – Zonal Criteria 1–8, Qld. Govt. 2011) for triggered soils within the BNCOP Disturbance Footprint.

Soil Unit	Zonal Criteria 1 Slope ≤3% (DEM Spatial Analysis)		Zonal Criteria 2 Surface Rocks (>60mm) ≤20%		Zonal Criteria 3 Gilgai Microrelief (>500mm) <50%		Zonal Criteria 4 Soil Depth to Physical Barrier ≥600mm		Zonal Criteria 5 Favourable Drainage Within Soil Depth		Zonal Criteria 6 pH @300mm/600mm >5 (NR) or 5.1-8.9 (R)		Zonal Criteria 7 Salinity @≤600mm Cl <800mg/kg		Zonal Criteria 8 Profile SWS (to ERD) ≥100mm/1.0m (see Tables 13 & 14)		Zonal Criteria Compliance [1]
2b	Figures 17 & 18 for areas ≤3%	**P**	Surface cobble, stone, boulders and outcrop absent	**P**	Non-gilgaied	**P**	>1000mm	**P**	No gleyed, mottled or bleached horizons as defined in SCL Act	**P**	300mm – 8.0 600mm – 8.5 (non-rigid soil)	**P**	<5 mg/kg Cl (@ 600mm)	**P**	120mm	**P**	**Compliant where slope is ≤3%**
3a	Figures 17 & 18 for areas ≤3%	**P**	Surface cobble, stone, boulders and outcrop absent	**P**	Non-gilgaied	**P**	>1000mm	**P**	No gleyed, mottled or bleached horizons as defined in SCL Act	**P**	300mm – 7.7 600mm – 8.8 (non-rigid soil)	**P**	25 mg/kg Cl (@ 600mm)	**P**	120mm	**P**	**Compliant where slope is ≤3%**
4c	Figures 17 & 18 for areas ≤3%	**P**	Surface cobble, stone, boulders and outcrop absent	**P**	Non-gilgaied	**P**	>1000mm	**P**	No gleyed, mottled or bleached horizons as defined in SCL Act	**P**	300mm – 8.4-8.9 600mm – 8.4-8.9 (non-rigid soil)	**P**	85-438 mg/kg Cl (@ 600mm)	**P**	90-120mm	**P**	**Compliant where slope is ≤3%**
5	Figures 17 & 18 for areas ≤3%	**P**	Surface cobble, stone, boulders and outcrop absent	**P**	Non-gilgaied	**P**	>1000mm	**P**	No gleyed, mottled or bleached horizons as defined in SCL Act	**P**	300mm – 8.9 600mm – 8.7 (non-rigid soil)	**P**	820 mg/kg Cl (@ 600mm)	**F**	80 mm	**F**	**Non-compliant**
7a	Figures 17 & 18 for areas ≤3%	**P**	Surface cobble, stone, boulders and outcrop absent	**P**	melonhole VI 0.5-0.6m HI 12-20m 70% - m/s 30% - d	**P**	>1000mm	**P**	No gleyed, mottled or bleached horizons as defined in SCL Act	**P**	300mm – 8.6 600mm – 7.4 (non-rigid soil)	**P**	1500 mg/kg Cl (@ 600mm)	**F**	55 mm	**F**	**Non-compliant**
7d	Figures 17 & 18 for areas ≤3%	**P**	<2% surface cobble	**P**	Non-gilgaied	**P**	>1000mm	**P**	No gleyed, mottled or bleached horizons as defined in SCL Act	**P**	300mm – 8.8 600mm – 9.1 (rigid soil)	**F**	38 mg/kg Cl (@ 600mm)	**P**	50 mm	**F**	**Non-compliant**

Notes: Assessment uses Zonal Criteria 1-8 as defined for the Western Cropping Zone in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL Guidelines (DNRM 2011d).

Table 13. Contributing soil constraints and final ERD (Qld. Govt. 2011) for soils triggered for SCL assessment within the BNCOP Disturbance Footprint.

Soil unit	Soil classification and data source	Rep site	Soil horizon[1]	Modal depths (m)[1]	Sampled depths (m)[2]	Field texture range[3]	Measured clay (%)[4]	pH	Cl (mg/kg)	ESP (%)	Ca/Mg ratio	Estimated ERD (m)[5]	Identified ERD constraint[5]
2b	**Black Vertosol - NR** (all data comes from site 66)	**66**	Ap1	0-0.03	0-0.10	LMC-MC	66	7.2	210	na	na		
			Ap2/B21	0.03-0.25	↓	MHC							
			B22	0.25-0.80	0.25-0.35	MHC-HC	68	8.0-8.1	<5	na	na		
			↓	↓	0.55-0.65	↓	72	8.5	<5	na	na		
			B23k	0.80-1.00+	0.85-0.95	MHC-HC	75	8.7	5	na	na	**>1.0m**	**ERD not limited**
3a	**Black Vertosol - NR** (all data comes from site 69)	**69**	A11/Ap1	0-0.03	0-0.10	LMC-MC	61	6.6	30	na	na		
			A12/Ap2	0.03-0.20	↓	MHC							
			B21k	0.20-0.75	0.25-0.35	MHC-HC	52	7.5-7.7	<5	na	na		
			↓	↓	0.55-0.65	↓	59	8.4-8.8	10-25	na	na		
			B22k	0.75-1.00+	0.85-0.95	FSMC-FSMHC	52	8.6	280	na	na	**>1.0m**	**ERD not limited**

Soil unit	Soil classification and data source	Rep site	Soil horizon[1]	Modal depths (m)[1]	Sampled depths (m)[2]	Field texture range[3]	Measured clay (%)[4]	pH	Cl (mg/kg)	ESP (%)	Ca/Mg ratio	Estimated ERD (m)[5]	Identified ERD constraint[5]
4c	**Black Vertosol - NR** # (pH and Cl data ranges are from Sites 65, 67, 68, 70, 73, 74; remaining data is from Site 65 only)	**65 #**	A1/Ap1	0-0.04	0-0.10	MC	60	8.4	40	na	na		
			Ap2/B21p	0.04-0.20	↓	MHC-HC							
			B21k	0.20-0.60	0.25-0.35	MHC-HC	63	8.4-8.9	5-133	na	na		
			B22	0.60-1.00+	0.55-0.65	MHC-HC	65	8.4-9.0	80-438	na	na		
			↓	↓	0.85-0.95	↓	63	5.1-8.9	420-1165	na	na	**0.75->1.0m**	**Cl >800 mg/kg from 0.75->1.0m**
5	**Black Vertosol - NR** (all data comes from Site 71)	**71**	A1	0-0.03	0-0.10	MC	59	8.5	95	na	na		
			B21p/B21	0.03-0.35	0.25-0.35	MHC	60	8.9	30-155				
			B22	0.35-0.85	0.55-0.65	FSMC-FSMHC	66	8.7	790-820	na	na	**0.65m**	**Cl >800 mg/kg from 0.6-0.7m**
			B23	0.85-1.00+	0.85-0.95	FSMC-FSMHC	68	7.7	1600	na	na	↓	↓
7a	**Grey Vertosol - NR** (pH and Cl data ranges at 0.3m/0.6m are from Sites 75 and 88; remaining data is from Site 88 only)	**75/88**	A1	0-0.06	0-0.10	FSLMC-FSMC	45	6.8	45	na	na		
			B21k	0.06-0.45	0.25-0.35	FSMC-MHC	49	8.6-8.8	465-670	na	na		
			B22/B23	0.45-1.00+	0.55-0.65	FSMC	50	7.4-8.3	1440-1500	na	na	**0.45m**	**Cl >800 mg/kg from 0.4-0.5m**
			↓	↓	0.85-0.95	↓	52	5.3	1315	na	na	↓	↓
7d	**Black Sodosol - R** (pH, Cl and ESP data ranges at 0.3m/0.6m are from Sites 72 and 87; remaining data is from Site 87 only)	**72/87**	A1	0-0.12	0-0.10	SCL-CLS	27	6.4	5	3	1.9		
			A2je	0.12-0.15	↓	↓	↓	↓	↓	↓	↓		
			B21	0.15-0.45	0.25-0.35	SLMC-SMC	38	8.5-8.8	<5-60	5-12	1.0-2.3		
			B22k/B23	0.45-1.00+	0.55-0.65	SLC-SLMC	33	9.1	38-730	14-30	0.5-1.1	**0.45m**	**Rigid soil + pH >9.1 + inc. ESP >14% in B22 hor. from 0.4-0.5m**
			↓	↓	0.85-0.95	↓	29	9.2	1100	36	0.4	↓	↓

Notes:
1. NR = non rigid soil; R = rigid soil. Soil horizon nomenclature and modal depths are from the midpoint of modal soil profile class diagrams presented in the soil characterization section of this report.
2. Sampled depths for laboratory analysis are from the representative analytical site(s) listed for each soil group and discussed in the soil characterization section of this report.
3. Soil field texture range is from that recorded for each soil horizon from the modal soil profile class descriptions presented in the soil characterization section of this report; texture codes are in accordance with those defined in the NCST (2009).
4. Clay content (%) is that measured by laboratory PSA analysis for the relevant sample depth from the representative analytical site listed for each soil group and discussed in the soil characterization section of this report.
5. Estimated effective rooting depth (ERD) and contributing soil constraint(s) determined in accordance with the ERD definitions and criteria in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL Guidelines (DNRM 2011d).

Table 14. Estimation of profile soil water status (Qld. Govt. 2011) for soils triggered for SCL assessment within the BNCOP Disturbance Footprint.

Soil Unit	Soil Concept	Rep Site	Soil Horizon[1]	Modal Horizon Depths (m)[1]	Sampled Depths (m)[2]	Depth Factor[3]	Field Texture Range[4]	Measured Clay (%)[5]	Est. Field Text. SWS (mm/0.1m)[6]	Estimated ERD (m)[7]	Identified ERD Constraint[7]	Horizon SWS (mm)	Profile SWS (mm)	SWS to nearest 5mm
2b	**Black Vertosol - NR** SCL Site(s) - 66	**66**	Ap1	0-0.03	0-0.10	0.3	LMC-MC	66	12	↓	↓	3.6		
			Ap2/B21	0.03-0.25	↓	2.2	MHC		12	↓	↓	26.4		
			B22	0.25-0.80	0.25-0.35	5.5	MHC-HC	68	12	↓	↓	66.0		
			↓	↓	0.55-0.65	↓	↓	72	↓	↓	↓	↓		
			B23k	0.80-1.00+	0.85-0.95	2.0	MHC-HC	75	12	**>1.0m**	**ERD not limited**	24.0	**120**	**120**

Soil Unit	Soil Concept	Rep Site	Soil Horizon[1]	Modal Horizon Depths (m)[1]	Sampled Depths (m)[2]	Depth Factor[3]	Field Texture Range[4]	Measured Clay (%)[5]	Est. Field Text. SWS (mm/0.1m)[6]	Estimated ERD (m)[7]	Identified ERD Constraint[7]	Horizon SWS (mm)	Profile SWS (mm)	SWS to nearest 5mm
3a	**Black Vertosol - NR** SCL Site(s) - 69	**69**	A11/Ap1	0-0.03	0-0.10	0.3	LMC-MC	61	12	↓	↓	3.6		
			A12/Ap2	0.03-0.20	↓	1.7	MHC		12	↓	↓	20.4		
			B21k	0.20-0.75	0.25-0.35	5.5	MHC-HC	52	12	↓	↓	66.0		
			↓	↓	0.55-0.65	↓	↓	59	↓	↓	↓	↓		
			B22k	0.75-1.00+	0.85-0.95	2.5	FSMC-FSMHC	52	12	**>1.0m**	**ERD not limited**	30	**120**	**120**
4c	**Black Vertosol - NR** SCL Sites - 65, 67, 68, 70, 73, 74	**65**	A1/Ap1	0-0.04	0-0.10	0.4	MC	60	12	↓	↓	4.8		
			Ap2/B21p	0.04-0.20	↓	1.6	MHC-HC		12	↓	↓	19.2		
			B21k	0.20-0.60	0.25-0.35	4.0	MHC-HC	63	12	↓	↓	48.0		
			B22	0.60-1.00+	0.55-0.65	1.5-4.0	MHC-HC	65	12	↓	↓	18.0-48.0		
			↓	↓	0.85-0.95	↓	↓	63	↓	**0.75->1.0m**	**Cl >800 mg/kg from 0.75->1.0m**	↓	**90-120**	**90-120**
5	**Black Vertosol - NR** SCL Site(s) - 71	**71**	A1	0-0.03	0-0.10	0.3	MC	59	12	↓	↓	3.6		
			B21p/B21	0.03-0.35	0.25-0.35	3.2	MHC	60	12	↓	↓	38.4		
			B22	0.35-0.85	0.55-0.65	3.0	FSMC-FSMHC	66	12	**0.65m**	**Cl >800 mg/kg from 0.6-0.7m**	36.0	**78mm**	**80mm**
			B23	0.85-1.00+	0.85-0.95	na	FSMC-FSMHC	68	12	↓	↓	na		
7a	**Grey Vertosol - NR** SCL Site(s) - 75	**88**	A1	0-0.06	0-0.10	0.6	FSLMC-FSMC	45	12	↓	↓	7.2		
			B21k	0.06-0.45	0.25-0.35	3.9	FSMC-MHC	49	12	↓	↓	46.8		
			B22/B23	0.45-1.00+	0.55-0.65	na	FSMC	50	12	**0.45m**	**Cl >800 mg/kg from 0.4-0.5m**	na	**54mm**	**55mm**
			↓	↓	0.85-0.95	na	↓	52	↓	↓	↓	na		
7d	**Black Sodosol - R** SCL Site(s) - 72	**87**	A1	0-0.12	0-0.10	1.2	SCL-CLS	27	8	↓	↓	9.6		
			A2je	0.12-0.15	↓	0.3	↓	↓	8	↓	↓	2.4		
			B21	0.15-0.45	0.25-0.35	3.0	SLMC-SMC	38	12	↓	↓	36.0		
			B22k/B23	0.45-1.00+	0.55-0.65	na	SLC-SLMC	33	10	**0.45m**	**Rigid soil + pH >9.1 + inc. ESP>14% in B22 hor. from 0.4-0.5m**		**48mm**	**50mm**
			↓	↓	0.85-0.95	↓	↓	29	↓	↓	↓			

Notes: 1. Soil horizon nomenclature and modal depths are from the midpoint of modal soil profile class diagrams presented in the soil characterization section of this report. 2. Sampled depths are from representative analytical site(s) listed for each soil.
3. SWS multiplication factor is calculated from the difference between upper and lower modal midpoint horizon boundaries; the multiplication factor is used to quantify horizon thickness in profile SWS summations.
4. Soil field texture range is from that recorded for each soil horizon from the modal soil profile class descriptions presented in the soil characterization section of this report; texture codes are in accordance with those defined in the NCST (2009).
5. Clay content (%) is that measured by laboratory PSA analysis for the relevant sample depth from the representative analytical site listed for each soil group and discussed in the soil characterization section of this report.
6. Estimated effective rooting depth (ERD) and contributing soil constraint(s) come from Table 13; in accordance with the ERD criteria in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL Guidelines (DNRM 2011d).
7. Estimated average soil water status (SWS) per 100mm of soil depth increment uses the maximum value for the soil texture grades listed for each soil horizon from the look-up table in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL Guidelines (DNRM 2011d). Where a range is listed the maximum value is assumed to ensure profile SWS calculations do not underestimate potential SWS values within a soil group.

12. Inherent erosion potential

Inherent erosion potential (following insitu disturbance) has been assessed for soils within the BNCOP Disturbance Footprint (excluding ML80169 and ML80170), based on a range of surrogate soil characteristics thought to contribute to or influence surface erodibility (rill and gully erosion) and predisposition to tunnelling. The assessment qualitatively ranks soils within the BNCOP Disturbance Footprint in terms of inherent erosion potential and likely behaviour following insitu disturbance. It is not prescriptive however, and is not intended to directly inform or instruct the planning of rehabilitation scenarios on constructed final landforms, where elevation, gradient, slope length and water disposal options are unquantified.

Assessment of pre-mining erosion hazard specifically for cropping and grazing land uses is also available from the erosion limitation assessment undertaken as part of the pre-mining land suitability evaluation described earlier in this report.

Assessment of inherent erosion potential

Assessment of inherent erosion potential within the BNCOP Disturbance Footprint is based on the soil erodibility classes and criteria of Murphy (1984) and Charman and Murphy (2007), and considers only susceptibility to longer term post disturbance gully and tunnel erosion. It does not evaluate short term sheet erosion losses that are common immediately after insitu disturbance, or prior to and during rehabilitation (and the establishment of adequate surface cover) on constructed landforms. Where adequate remediation/control procedures are implemented in these situations (e.g. deep ripping, hay mulching, temporary earthworks/sediment control structures etc), the erosion risk from short term surficial processes is potentially manageable and less significant than longer term, spontaneous gully and tunnel processes (especially in unconsolidated landforms), where the extent and severity of the erosion threat is ongoing and can be difficult to predict, manage and control.

Processes contributing to the formation and ongoing development of gully and tunnel erosion are controlled predominantly by subsoil characteristics, particularly clay content, soil density, clay dispersion and the degree of aggregation and cracking (Charman and Murphy 2007). In most situations, factors controlling gully erosion relate primarily to the hydraulic energy of surface water flows versus the degree of cohesion in the soil material (critical shear stress). Factors contributing to sub-surface tunnel erosion are similar but rely more on the detachment, suspension and subsequent movement of dispersed clay material internally through the soil mass, usually by concentrated lateral water flow. Such flows are usually through cracks or voids in the soil mass. Strong cracking behaviour and the presence of impermeable, dispersive subsurface horizons are key factors promoting such activity (Charman and Murphy 2007). In both cases, predisposition to the development of these erosion processes is related to the presence of sodic, dispersive subsoil clay and the exposure and interaction of such material with some form of concentrated water flow; usually from changed or realigned local surface or sub-surface drainage.

Whilst assessment of inherent erosion potential within the BNCOP Disturbance Footprint follows the rationale and framework proposed by Murphy (1984) and Charman and Murphy (2007), the soil erodibility classes and criteria (originally proposed for New South Wales soils) applied during the assessment have been modified slightly and expanded to increase their relevance and applicability to Central Queensland landscapes. The scheme uses a range of inherent field and laboratory measured soil characteristics to qualitatively predict and rank potential gully and tunnel erodibility. Three classes of inherent erosion hazard (low, moderate and high) were originally proposed by Charman and Murphy (2007), but this has been expanded to include a fourth very high category to cover extremely sodic and dispersive soils specific to the Bowen Basin. The four categories are explained in greater detail in the methodology section of this report.

It is important to recognize the assessment is an estimate of inferred post-disturbance, insitu erosion potential only, and is based on inherent characteristics of each soil as described and sampled insitu prior to disturbance. The methodology, attributes and criteria described by Charman and Murphy (2007) have been adopted in full, but modified slightly (as described in the methodology section of this report) to account for soils with strongly sodic and dispersive subsoils. Such soils are relatively common in Central Queensland but were not adequately defined in the original scheme. Interpretation within the BNCOP Disturbance Footprint has used the modified criteria definitions as presented. For further information as to the rationale and underlying principles behind the original scheme, the reader is directed to the source documents (Murphy 1984, Charman and Murphy 2007).

Inherent erosion potential findings

Inherent erosion potential (post disturbance) findings following assessment against the modified erodibility framework of Charman and Murphy (2007) is discussed below, for all soils within the BNCOP Disturbance Footprint. The spatial extent of each erosion hazard category is presented in **Figure 24** and findings are summarized in **Table 15**.

L**ow inherent erosion potential** is limited to Soils 8c and 8d (98ha). These soils are deep, relatively coarse, colluvial sands associated with insitu Tertiary sandstones in the north of the Disturbance Footprint. Both soils are highly permeable, non-dispersive and dominated by coarse sand. Associated terrain is typically only gently undulating (slopes 1-3%) and high infiltration and permeability rates minimize the movement and concentration of erodible surface flows.

Soils 2b, 3a, 7c, 8a, 8b and 9a (731ha) are considered to have **moderate erosion potential** and include self-mulching alluvial clays (Soils 2b and 3a), a hardsetting massive red earth (Soil 8a) and sandy/loamy non-sodic texture contrast soils (Soils 8b and 9a). The self mulching alluvial clays (Soils 2b and 3a) are well structured, with significant shrink swell characteristics, but are prone to slaking and exhibit weakly dispersive behaviour in the lower subsoil. Soils 8a and 9a are non-dispersive, but have high levels of fine sand/silt in the upper profile (>60%), while Soil 8b has a clay subsoil that is non-dispersive to weakly dispersive and prone to slaking.

Soils 4c, 4d, 5 and 9b (111ha) have **high inherent erosion potential**. They are all well structured, weakly to strongly self mulching, uniform clays with significant shrink swell characteristics, but are prone to slaking and have undesirable levels of sodicity and dispersion in the lower subsoil (i.e. moderately to strongly sodic and dispersive). They are inherently predisposed to high erosion potential post disturbance, and erosion risk will increase significantly where works that disturb and expose the lower subsoil are undertaken.

The remaining group of soils (Soils 3b, 7a, 7b and 7d – 546ha) have **very high inherent erosion potential** and are strongly to extremely sodic and dispersive throughout the subsoil. These soils should be flagged as difficult mediums to manage during disturbance. Soils in the very high category have the potential to develop severe gully and/or tunnel erosion post disturbance on insitu slopes as gentle as only 1-2%, particularly where surface flows are allowed to concentrate and slope lengths exceed recommended design specifications.

Table 15. **Summary of inherent erosion potential findings for soils mapped within the BNCOP Disturbance Footprint.**

Inherent erosion potential	Soils	Area (ha)
Low	Soils 8c, 8d	98
Moderate	Soils 2b, 3a, 7c, 8a, 8b, 9a	731
High	Soils 4c, 4d, 5, 9b	111
Very high	Soils 3b, 7a, 7b, 7d,	546

Assessment findings will inform and guide the design and implementation of erosion and sediment control practises and/or structures during mine operations, in accordance with the industry standards *Best Practice Erosion and Sediment Control* (International Erosion Control Association Australasia, 2008) and *Soil Erosion and Sediment Control Engineering Guidelines for Queensland Construction Sites* (International Erosion Control Association Australasia, 1996).

Management recommendations and proposed erosion control measures are discussed in greater detail in the BNCOP Site Water Balance and Surface Water Assessment report (WRM 2014), while Section 5 of the EIS details the rehabilitation methodology proposed for all disturbed lands within the BNCOP Operational Area.

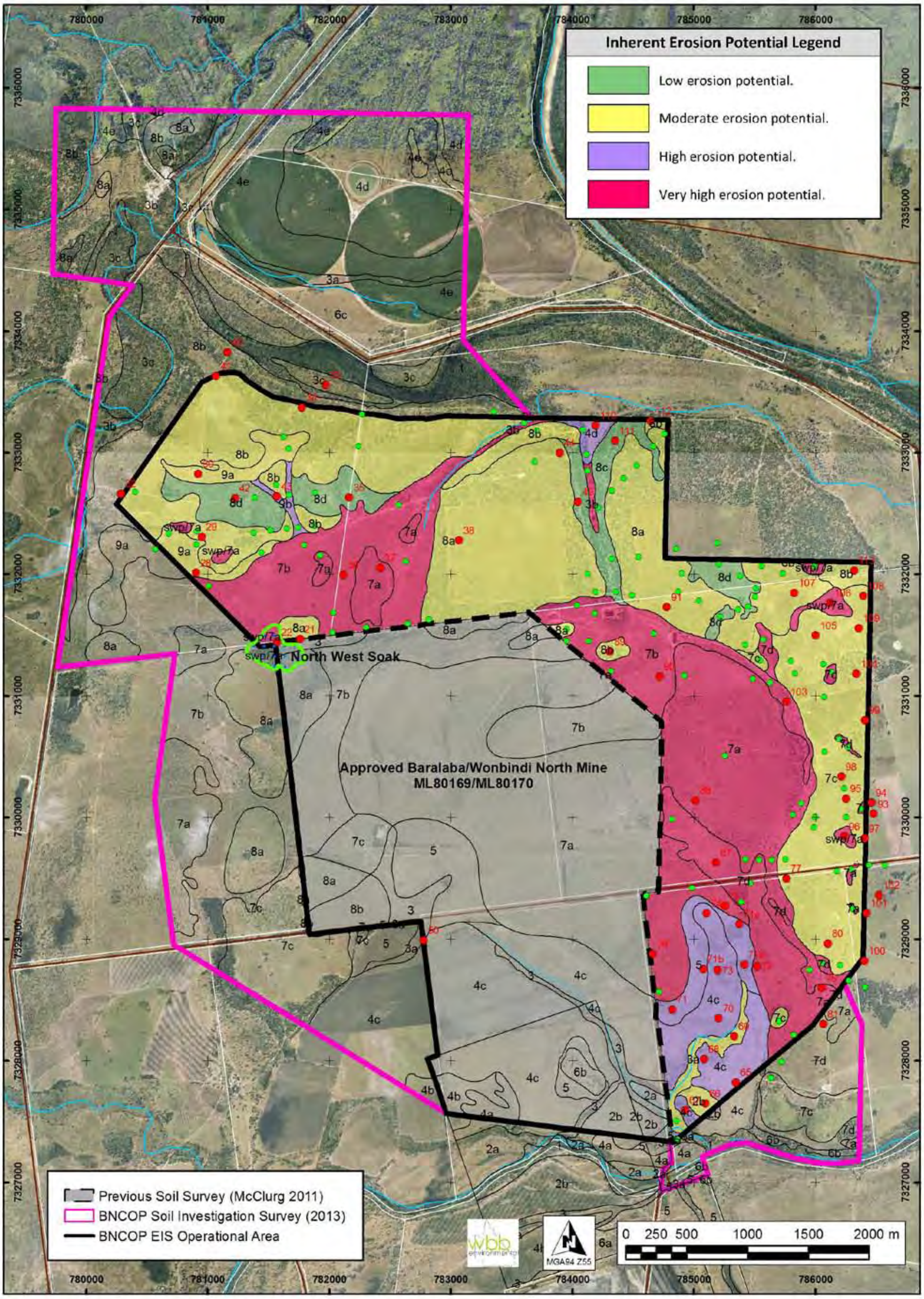

Figure 24. Inherent erosion potential for soils mapped within the BNCOP Disturbance Footprint.

13. Conclusions

The purpose of the investigation was firstly to define and quantify soil landscapes within the proposed BNCOP Disturbance Footprint (external to ML80169 and ML80170), and secondly to determine topsoil resources for salvage, and assess pre-mining land suitability, Agricultural Land Class status, Strategic Cropping Land (SCL) status and inherent erosion potential.

All soil data was collected in accordance with recognized standard land resource survey methodologies and analytical procedures (QDME (1995), Isbell (1996), McKenzie *et al* (2002), McKenzie *et al* (2008), National Committee on Soil and Terrain (2009), Rayment and Lyons (2011), and DNRM/DSITIA (2013a, 2013b)); and meets the specific data requirements prescribed by the *Guidelines for Applying the Proposed Strategic Cropping Land Criteria* (DNRM 2011d) and the *Strategic Cropping Land Act 2011* (Queensland Government 2011).

Twenty three soil types were recognized and mapped within the 2013 BNCOP Soil Investigation survey area. Of these, thirteen have been previously mapped and described within ML80169 and ML80170 (or other earlier mine expansion stages), while ten are newly described. In total, twenty soils are mapped within the actual BNCOP EIS Operational Area. Sixteen of these, occur specifically within the proposed BNCOP Disturbance Footprint (external to ML80169 and ML80170), of which seven are newly described.

Soils 1, 2a, 2b and 3a are associated with the lowest terraces and floodplains of the Dawson River anabranch, while Soils 3b and 3c (also on relatively young alluvium), are restricted to tributaries of the Dawson River, particularly Saline Creek. Soils 4a-4e are predominantly cracking clay soils of the upper terraces and floodplains of the Dawson River system, while soils 6a-6c are sandy or loamy surfaced profiles that occupy high level, elevated alluvium found on relict levees and scroll plains. Soils 7a-7d are extensive and occupy level to gently undulating plains developed on older unconsolidated Cainozoic (TQr) sediments. Soil 5 is transitional between the more recent floodplain landscapes and the older elevated Cainozoic surface, while Soils 8a-8d occupy undulating landscapes developed on insitu Tertiary sandstones in the north of the survey area. Soils 9a-9b are of limited occurrence, and appear related to outcropping calcareous sediments.

Assessment of topsoil resources for stripping has identified a range of soil materials for salvage. Minimal stripping depths (<0.2m) are available from Soils 5, 7a, 7b, 7d, swp/7a and 9b, moderate depths (0.2-0.5m) from Soils 3b, 4c, 4d, 7c, 8a, 8b, and 9a and significant depths (>0.5m) from Soils 2b, 3a, 8c and 8d. The largest volumes (>500,000m^3) are available from Soils 7c, 8a, 8b and 8d through a combination of greater depth and wider spatial extent. Cumulative stripping volumes for all lands within the BNCOP Disturbance Footprint suggest a total of 5,825,600 m^3 is potentially available for salvage and stockpiling.

Assessment of dryland cropping suitability within the BNCOP Disturbance Footprint, in accordance with DNRM/DSITIA (2013b), indicates 96 ha or 6.5% of the area (Soils 2b, 3a, 4c and 4d) is suitable for summer cropping (Classes 1-3), while a further 68 ha or 4.5% (Soils 5, 9a and 9b) is marginal (Class 4). The remaining 1322 ha or 89% (Soils 3b, 7a, 7b, 7c, 7d, 8a, 8b, 8c, 8d, swp/7a) is unsuitable (Class 5).

Assessment of grazing suitability within the BNCOP Disturbance Footprint, in accordance with QDME (1995), indicates land suitable for improved pasture development occupies about 675ha or 45.5% of the area. Of this, 365ha or 24.5% (Soils 2b, 3a, 4c, 4d, 5, 7a) is capable of reliably fattening cattle in most seasons (Classes 1-2), while a further 310ha or 21% (Soils 3b, 7b, 7d, 9b, swp/7a) is better suited to "growing out" younger cattle (Class 3). Of the remaining area, 713ha or 48% is lower fertility country (Soils 7c, 8a, 8b, 9a) that is marginal for improved pasture development (and associated fattening/growing activities), but is suited to year round breeding herd utilisation (Class 4). A small area in the north (98ha or 6.5%) comprises very sandy, infertile soils (Soils 8c, 8d) that have limited grazing potential and are best suited to wet season breeding use only (Class 5 – requiring dry season destocking when grazed in isolation).

Assessment against revised 2013 state-wide Agricultural Land Class (ALC) criteria (DNRM/DSITIA 2013a) was undertaken to simplify the complexity associated with detailed suitability assessments and provide an accurate and succinct summary as to the pre-mining agricultural potential of lands within the BNCOP Disturbance Footprint. Assessment findings indicate there is 96 ha of Class A1 Crop Land (6.5%), 68 ha of Class B Limited Crop Land (4.5%), 546 ha of Class C1 Pasture Land (37%) and 776 ha of Class C2 Pasture Land (52%) that may be affected.

The *Strategic Cropping Land Act 2011* (Queensland Government 2011) requires triggered land within the Western Cropping Zone qualify for cropping history, comply with Zonal Criteria and meet minimum size requirements before Strategic Cropping Land (SCL) status can be decided. SCL trigger mapping (DNRM 2011a) indicated 118ha of likely (or potential) SCL required assessment within the BNCOP Disturbance Footprint. Spatial analysis of SCL findings indicates the triggered land comprises 66.1ha of decided SCL that complies with all SCL requirements (i.e. qualifies for relevant cropping history, complies with Zonal Criteria and meets minimum size criteria); 3.5ha of decided non-SCL that is otherwise compliant but does not meet minimum size requirements (i.e. excised land due to fragmentation by dissected slopes >3%); and 48.4ha of decided non-SCL that fails to comply with Zonal Criteria 1, 6, 7 or 8. It is the recommendation of this report, in accordance with the requirements of Sections 66-68 of the *Strategic Cropping Land Act 2011* (Queensland Government 2011), that the outcomes documented herein be validated and recorded as decided SCL and decided non-SCL as described.

Additionally, the BNCOP Disturbance Footprint lies within lands along the Dawson River mapped as a Priority Agricultural Area (PAA) under the Central Queensland Regional Plan (DSDIP 2013). This land has been identified as a strategic regional entity with significant potential for the continued or future development of highly productive agricultural land uses (known as *Priority Agricultural Land Uses* (PALUs)). The current intention of the planning framework will afford PALUs within a PAA primary land use status and likely planning priority over other proposed or competing uses. Assessment against proposed PAA co-existence criteria will inform the planning process and guide development decisions as to how and where compatible resource activities, such as the BNCOP, can co-exist concurrently with high value agricultural activities. DSDIP is yet to finalise any such criteria however.

Inherent erosion potential (following insitu disturbance) has been assessed for soils within the BNCOP Disturbance Footprint (excluding ML80169 and ML80170), based on the soil erodibility classes and criteria of Murphy (1984) and Charman and Murphy (2007). The assessment provides a qualitative evaluation of surface erodibility hazard (rill and gully activity) and predisposition to tunnelling. Four classes of inherent erosion hazard (low, moderate, high or very high) are recognized. Soils 8c and 8d (98ha) have low inherent erosion potential, Soils 2b, 3a, 7c, 8a, 8b, and 9a (731ha) are considered moderate, while Soils 4c, 4d, 5 and 9b (111ha) are inherently predisposed to high erosion potential following disturbance. The remaining group of soils, namely Soils 3b, 7a, 7b and 7d (546ha), are characterized by strongly sodic and extremely dispersive, shallow subsoils, and have very high inherent erosion potential. Assessment findings will inform and guide the design and implementation of erosion and sediment control practises and/or structures during mine operations (in accordance with *Best Practice Erosion and Sediment Control* (International Erosion Control Association Australasia, 2008) and *Soil Erosion and Sediment Control Engineering Guidelines for Queensland Construction Sites* (International Erosion Control Association Australasia, 1996)).

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Appendix 1 – AMG locations for all detailed field sites (113) within the 2013 BNCOP Soil Investigation survey area.

Detailed field site locations for field sites 1-113 – 2013 BNCOP Soil Investigation survey area

Site No	GDA94 easting	GDA94 northing	Zone
1	780719	7335559	55
2	780359	7335742	55
3	780179	7335680	55
4	779898	7335769	55
5	780169	7335229	55
6	779832	7334729	55
7	780873	7335193	55
8	781199	7335306	55
9	782909	7335146	55
10	782273	7334989	55
11	782468	7334104	55
12	782133	7334650	55
13	781898	7334441	55
14	781043	7334820	55
15	781038	7334956	55
16	781127	7334617	55
17	782015	7335712	55
18	781906	7335397	55
19	783263	7334711	55
20	780711	7335390	55
21	781760	7331466	55
22	781569	7331443	55
23	780890	7331361	55
24	780566	7331358	55
25	780156	7331780	55
26	780030	7331918	55
27	780342	7335402	55
28	780903	7332012	55
29	780951	7332307	55
30	780922	7332825	55
31	779867	7332241	55
32	780284	7332663	55
33	781969	7333559	55
34	781775	7333371	55
35	782164	7332630	55
36	782116	7331994	55
37	782419	7332054	55
38	783067	7332278	55
39	780276	7334391	55
40	781161	7333825	55
41	781067	7333631	55
42	781224	7332625	55
43	781568	7332640	55
44	783896	7332998	55
45	784046	7332595	55
46	781323	7329009	55
47	781656	7328700	55
48	782004	7328833	55
49	782506	7328940	55
50	782777	7328990	55
51	781534	7330596	55
52	782802	7327770	55
53	782833	7328275	55
54	782171	7328282	55
55	782299	7328592	55
56	782316	7329084	55
57	781583	7329278	55

Site No	GDA94 easting	GDA94 northing	Zone
58	781296	7329529	55
59	781344	7329289	55
60	781081	7329596	55
61	781090	7329350	55
62	780922	7329487	55
63	780641	7329799	55
64	781119	7330676	55
65	785346	7327822	55
66	785094	7327648	55
67	784928	7327594	55
68	785084	7328014	55
69	785330	7328202	55
70	785203	7328349	55
71	784822	7328421	55
71a	785414	7328789	55
71b	785075	7328753	55
71c	785376	7329123	55
72	785520	7328777	55
73	785197	7328745	55
74	785105	7329212	55
75	785257	7329274	55
76	784662	7328876	55
77	785761	7329498	55
78	786091	7327928	55
79	786053	7328599	55
80	786102	7328963	55
81	786065	7328301	55
82	786368	7327956	55
83	785787	7327683	55
84	785594	7327345	55
85	786185	7327581	55
86	785716	7327595	55
87	785183	7329628	55
88	785014	7330141	55
89	784310	7331365	55
90	784717	7331160	55
91	784777	7331730	55
92	780573	7335630	55
93	786479	7330033	55
94	786461	7330122	55
95	786252	7330154	55
96	786239	7329845	55
97	786403	7329827	55
98	786214	7330335	55
99	786406	7330801	55
100	786403	7328821	55
101	786421	7329213	55
102	786521	7329362	55
103	785761	7330951	55
104	786338	7331181	55
105	786003	7331496	55
106	786122	7331764	55
107	785826	7331847	55
108	786394	7331821	55
109	786357	7331556	55
110	784192	7333224	55
111	784353	7333098	55
112	784645	7333260	55
113	786318	7332030	55

Appendix 2 – pH and salinity (EC $_{1:5}$) screening data for determining ERD for all detailed field sites (113) within the 2013 BNCOP Soil Investigation survey area.

pH $_{1.5}$ data for all detailed field sites within the 2013 BNCOP Soil Investigation survey area.

Soil Lscape	Site No.	pH $_{1:5}$												
		0.1m	0.2m	0.3m	0.4m	0.5m	0.6m	0.7m	0.8m	0.9m	1.0m	1.1m	1.2m	1.5m
1	**na**	-		-			-			-				
2a	**na**	-		-			-			-				
2b	**66**	7.54		7.76			8.61			8.69				
3a	**13**	7.72		8.41			8.59			8.59				
	15	-		-			-			-				
	50	6.83		7.85			7.98			6.56				
	69	6.77		7.41			8.72			8.52				
3b	**27**	5.87		5.56			6.57			7.54				
	31	-		-			-			-				
3c	**2**	5.96		5.94			6.25			6.06				
	7	6.45		6.76			6.86			9.61				
	33	6.84		6.52			6.47			6.28				
	39	6.12		6.16			6.24			5.98				
4a	**na**	-		-			-			-				
4b	**52**	8.33		8.59			8.90			8.92				
4c	**53**	8.17		8.40			8.66			8.73				
	54	8.15		8.57			8.86			8.83				
	55	8.28		8.78			8.84			8.76				
	65	8.42		8.72			8.79	8.92	8.69	8.43				
	67	7.37		8.71			8.85			8.70				
	68	7.40		8.68			8.97			8.92				
	70	8.25		8.74			8.58			6.33				
	73	8.22		8.64			8.47			6.66				
	74	8.69		8.94		8.84	8.72			6.72				
4d	**9**	7.96		8.20			7.90			8.64				
	10	7.84		8.61			9.01			8.93				
	18	8.46		8.54			8.74			8.81				
	110	8.27		8.71	9.09	8.74	8.67			8.48				
4e	**3**	6.56		5.81			6.81			8.30				
	8	6.43		7.37			8.66			8.88				
	12	6.38		6.61			7.30			7.71				
	14	-		-			-			-				
	17	6.05		6.40			7.13			8.78				
	19	-		-			-			-				
5	**49**	7.85		8.94			8.35			5.29				
	71	8.69		9.03	8.97	8.65	8.65	8.31		8.00				

Soil Lscape	Site No.	pH $_{1:5}$												
		0.1m	0.2m	0.3m	0.4m	0.5m	0.6m	0.7m	0.8m	0.9m	1.0m	1.1m	1.2m	1.5m
6a	**na**	-		-			-			-				
6b	**84**	6.22		7.23			8.61			9.15				
6c	**11**	5.86		6.33			6.26			6.29				
	16	-		-			-			-				
7a	**23**	7.32		8.52			5.77			4.94				
	37	7.86		8.87		8.85	8.48			7.03				
	63	7.04		8.31			5.97			5.30				
	75	8.11	8.55	8.66	8.33	7.94	7.75			5.63				
	76	-		-			-			-				
	88	7.94	8.88	8.66	8.41	8.19	7.99			5.44				
7b	**24**	6.91		8.57			9.06			8.47				
	36	6.66		7.75		9.18	9.07	9.32	9.32	9.04				
	59	6.43		7.03			8.20			8.71				
	60	8.19		8.35			7.45			5.10				
	61	-		-			-			-				
	62	6.90		7.28			7.79			8.33				
	64	6.84		8.49			9.26			9.47				
	90	7.37	7.83	8.03	8.32	8.41	7.96			5.60				
	103	7.44		8.67	8.46	8.61	8.68			8.73				
7c	**46**	6.21		6.37			6.73			7.04				
	47	6.47		6.82			6.90			7.16				
	48	6.17		6.03			6.36			6.85				
	56	-		-			-			-				
	57	8.12		8.17			8.44			8.20				
	77	6.09		6.44			8.23			8.87				
	80	-		-			-			-				
	83	8.55		8.76			8.67			9.00				
	85	6.65		7.01			7.36			8.15				
	86	-		-			-			-				
	93	6.41		6.64			7.45			8.17				
	95	6.33		6.69			7.22			7.78				
	97	-		-			-			-				
	98	6.03		6.59			5.40			5.99				
	99	6.16		6.34			6.45			6.64				
	100	8.42		7.93			7.88			7.22				
	101	-		-			-			-				
	104	6.23		6.88			5.85			6.12				
	105	5.98		6.00			6.49			8.03				
	108	6.15		6.01			6.27			6.92				
	109	-		-			-			-				
7d	**72**	7.85		9.01			9.22		8.83	8.81				

Soil Lscape	Site No.	$pH_{1:5}$												
		0.1m	0.2m	0.3m	0.4m	0.5m	0.6m	0.7m	0.8m	0.9m	1.0m	1.1m	1.2m	1.5m
	78	6.00		7.82			8.88			9.08				
	79	7.01		8.03		9.06	8.91	8.96	8.91	8.76				
	81	-		-			-			-				
	82	-		-			-			-				
	87	6.36		8.45	9.18	9.16	9.09	9.17		8.94				
	94	6.83		7.88			8.40		8.40	8.42				
	102	7.23		6.89			7.07			7.31				
swp 7a	**22**	5.69		6.85			7.15			7.33				
	96	6.91		7.57			8.35	8.42	7.92	8.20				
	106	5.50		6.80			7.34			8.46				
8a	**5**	5.72		5.80			5.99			6.01				
	20	-		-			-			-				
	21	8.15		8.41			8.40			8.42				
	38	5.75		6.08			6.27			6.23				
	44	-		-			-			-				
	51	6.26		5.67			5.40			5.37				
	58	5.52		5.27			5.77			5.93				
	91	-		-			-			-				
	107	5.67		6.18			6.17			6.02				
8b	**1**	5.42		6.14			7.67			8.77				
	4	5.60		5.44			5.12		5.28	-				
	6	4.79		5.26			5.12			5.12				
	26	-		-			-			-				
	29	6.39		6.13			5.97			6.10				
	32	-		-			-			-				
	34	6.42		5.51			5.63			6.09				
	40	5.81		5.84			6.10			6.36				
	41	5.17		4.99			6.46			6.92				
	89	5.52		5.34			7.07		8.09	8.41				
	92	5.53		5.88			5.90			5.13				
	112	-		-			-			-				
	113	6.20		5.96			6.38			6.21				
8c	**45**	-		-			-			-				
	111	-		-			-			-				
8d	**35**	6.42		6.49			6.57			6.64				
	42	-		-			-			-				
9a	**25**	5.92		7.08			8.89			8.81				
	28	6.11		5.90			6.83			7.50				
	30	6.37		7.24			8.66		9.02	8.79				
9b	**43**	7.09		8.06		9.05	9.16	8.87	8.75	8.98				

$EC_{1:5}$ data for field sites within the 2013 BNCOP Soil Investigation survey area.

Soil Lscape	Site No.	$EC_{1:5}$												
		0.1m	0.2m	0.3m	0.4m	0.5m	0.6m	0.7m	0.8m	0.9m	1.0m	1.1m	1.2m	1.5m
1	**na**	-		-			-			-				
2a	**na**	-		-			-			-				
2b	**66**	0.069		0.062			0.119			0.124				
3a	**13**	0.119		0.188			0.251			0.355				
	15	-		-			-			-				
	50	0.049		0.058			0.274			0.919				
	69	0.086		0.045			0.107			0.294				
3b	**27**	0.043		0.028			0.071			0.108				
	31	-		-			-			-				
3c	**2**	0.030		0.028			0.034			0.026				
	7	0.049		0.048			0.046			0.045				
	33	0.050		0.033			0.027			0.025				
	39	0.030		0.024			0.022			0.020				
4a	**na**	-		-			-			-				
4b	**52**	0.107		0.150			0.215			0.241				
4c	**53**	0.082		0.091			0.133			0.145				
	54	0.078		0.088			0.125			0.119				
	55	0.070		0.104			0.113			0.087				
	65	0.139		0.192			0.255	0.281	0.293	0.513				
	67	0.079		0.154			0.276			0.677				
	68	0.431		0.238			0.273			0.511				
	70	0.132		0.160			0.328			0.609				
	73	0.101		0.141			0.261			0.810				
	74	0.142		0.202		0.392	0.483			0.913				
4d	**9**	0.183		0.161			0.093			0.162				
	10	0.109		0.166			0.442			0.729				
	18	0.184		0.193			0.267			0.467				
	110	0.134		0.182	0.344	0.510	0.724			1.431				
4e	**3**	0.055		0.051			0.109			0.278				
	8	0.063		0.088			0.173			0.179				
	12	0.068		0.048			0.078			0.108				
	14	-		-			-			-				
	17	0.053		0.070			0.098			0.370				
	19	-		-			-			-				
5	**49**	0.086		0.144			0.555			0.800				
	71	0.151		0.242	0.332	0.641	0.755	1.069		1.111				

Soil Lscape	Site No.	EC $_{1:5}$												
		0.1m	0.2m	0.3m	0.4m	0.5m	0.6m	0.7m	0.8m	0.9m	1.0m	1.1m	1.2m	1.5m
6a	na	-		-			-			-				
6b	84	0.068		0.061			0.087			0.296				
6c	11	0.034		0.037			0.033			0.026				
	16	-		-			-			-				
7a	23	0.089		0.260			0.703			0.753				
	37	0.054		0.225		0.537	0.636			0.701				
	63	0.054		0.251			0.670			0.805				
	75	0.141	0.281	0.426	0.735	0.944	1.147			1.080				
	76	-		-			-			-				
	88	0.094	0.333	0.527	0.890	1.097	1.115			1.005				
7b	24	0.047		0.101			0.488			0.715				
	36	0.034		0.110		0.255	0.357	0.540	0.615	0.662				
	59	0.031		0.029			0.106			0.279				
	60	0.117		0.457			0.670			0.684				
	61	-		-			-			-				
	62	0.042		0.036			0.034			0.039				
	64	0.056		0.229			0.908			0.833				
	90	0.093	0.265	0.510	0.817	0.841	0.701			0.586				
	103	0.077		0.360	0.600	0.726	0.702			0.713				
7c	46	0.032		0.025			0.026			0.037				
	47	0.031		0.036			0.023			0.025				
	48	0.025		0.020			0.019			0.024				
	56	-		-			-			-				
	57	0.056		0.036			0.057			0.062				
	77	0.032		0.025			0.054			0.188				
	80	-		-			-			-				
	83	0.096		0.073			0.064			0.083				
	85	0.049		0.039			0.049			0.067				
	86	-		-			-			-				
	93	0.040		0.027			0.028			0.075				
	95	0.039		0.031			0.027			0.031				
	97	-		-			-			-				
	98	0.059		0.056			0.137			0.283				
	99	0.062		0.041			0.047			0.097				
	100	0.089		0.041			0.062			0.138				
	101	0.095		0.033			0.030			0.034				
	104	0.036		0.037			0.079			0.101				
	105	0.026		0.022			0.022			0.053				
	108	0.033		0.026			0.024			0.026				
	109	-		-			-			-				
7d	72	0.105		0.150			0.232		0.401	0.481				

Soil Lscape	Site No.	EC $_{1:5}$												
		0.1m	0.2m	0.3m	0.4m	0.5m	0.6m	0.7m	0.8m	0.9m	1.0m	1.1m	1.2m	1.5m
	78	0.083		0.072			0.150			0.521				
	79	0.050		0.101		0.397	0.502	0.719	0.776	0.776				
	81	-		-			-			-				
	82	-		-			-			-				
	87	0.034		0.087	0.178	0.409	0.648	0.836		1.011				
	94	0.032		0.071			0.190		0.333	0.405				
	102	0.095		0.033			0.030			0.034				
swp **7a**	**22**	0.033		0.043			0.057			0.100				
	96	0.060		0.071			0.201	0.333	0.504	0.566				
	106	0.031		0.037			0.039			0.127				
8a	**5**	0.026		0.022			0.024			0.026				
	20	-		-			-			-				
	21	0.109		0.121			0.087			0.095				
	38	0.029		0.022			0.020			0.020				
	44	-		-			-			-				
	51	0.042		0.022			0.028			0.030				
	58	0.024		0.020			0.020			0.020				
	91	-		-			-			-				
	107	0.028		0.026			0.025			0.028				
8b	**1**	0.037		0.066			0.170			0.748				
	4	0.027		0.021			0.107		0.077	-				
	6	0.019		0.016			0.015			0.015				
	26	-		-			-			-				
	29	0.028		0.023			0.019			0.027				
	32	-		-			-			-				
	34	0.034		0.020			0.023			0.023				
	40	0.024		0.018			0.028			0.034				
	41	0.020		0.017			0.024			0.032				
	89	0.029		0.022			0.077		0.194	0.329				
	92	0.022		0.024			0.201			0.301				
	112	-		-			-			-				
	113	0.041		0.023			0.021			0.021				
8c	**45**	-		-			-			-				
	111	-		-			-			-				
8d	**35**	0.036		0.029			0.029			0.027				
	42	-		-			-			-				
9a	**25**	0.026		0.062			0.300			0.459				
	28	0.030		0.022			0.043			0.077				
	30	0.038		0.049			0.152		0.333	0.350				
9b	**43**	0.043		0.048		0.300	0.365	0.509	0.664	0.637				

Appendix 3 – Effective rooting depth (ERD) and PAWC calculations for soils mapped within the BNCOP Disturbance Footprint (DNRM 2011d, Queensland Government 2011).

Soil Unit	ERD [1]	Soil Horizon[2]	Modal Horizon Depths (m)[2]	Depth Factor[3]	Field Texture Range[4]	Est. Field Text. SWS (mm/0.1m)[5]	Horizon SWS (mm)	Profile SWS (mm)	SWS to nearest 5mm
2b	>1.0m	Ap1	0-0.03	0.3	LMC-MC	12	3.6		
	no restrictions	Ap2/B21	0.03-0.25	2.2	MHC	12	26.4		
		B22	0.25-0.80	5.5	MHC-HC	12	66.0		
		B23k	0.80-1.00+	2.0	MHC-HC	12	24.0	**120**	**120**
3a	0.8->1.0m	A11/Ap1	0-0.03	0.3	LMC-MC	12	3.6		
	salinity >0.8dS/m or Cl >800ppm	A12/Ap2	0.03-0.20	1.7	MHC	12	20.4		
		B21k	0.20-0.75	5.5	MHC-HC	12	66.0		
		B22k	0.75-1.00+	0.5-2.5	FSMC-FSMHC	12	30	**96-120**	**95-120**
3b	0.5-0.6m	A1/A2e	0-0.35	3.5	FSCL-CLFS	8	28.0		
	rigid soil + ESP >15%	B21	0.35-0.60	1.5-2.5	FSLC-FSLMC	10	15.0-25.0	**43-53**	**45-55**
4c	0.75->1.0m	A1/Ap1	0-0.04	0.4	MC	12	4.8		
	salinity >0.8dS/m or Cl >800ppm	Ap2/B21p	0.04-0.20	1.6	MHC-HC	12	19.2		
		B21k	0.20-0.60	4.0	MHC-HC	12	48.0		
		B22	0.60-1.00+	1.5-4.0	MHC-HC	12	18.0-48.0	**90-120**	**90-120**
4d	0.7->1.0m	A1	0-0.06	0.6	LMC-MC	12	7.2		
	salinity >0.8dS/m or Cl >800ppm	B21	0.06-0.40	3.4	MC-MHC	12	40.8		
		B22/B23	0.40-1.00+	3.0-6.0	MC-MHC	12	36.0-72.0	**84-120**	**85-120**
5	0.6-0.7m	A1	0-0.03	0.3	MC	12	3.6		
	salinity >0.8dS/m or Cl >800ppm	B21p/B21	0.03-0.35	3.2	MHC	12	38.4		
		B22	0.35-0.70	2.5-3.5	FSMC-FSMHC	12	30.0-42.0	**72-84**	**70-85**
7a	0.4-0.6m	A1	0-0.06	0.6	FSLMC-FSMC	12	7.2		
	salinity >0.8dS/m or Cl >800ppm	B21k	0.06-0.40	3.4	FSMC-MHC	12	40.8		
		B22/B23	0.40-0.60	2.0	FSMC	12	24.0	**48-72**	**50-70**
7b	0.3-0.5m	A1/A2je	0-0.13	1.3	FSCL-FSLC	6-10	7.8-13.0		
	salinity >0.8dS/m or Cl >800ppm	B21	0.13-0.50	1.7-3.7	FSMC-FSMHC	12	20.4-44.4	**28-57**	**30-60**
	Rigid soil ESP>15%								
7c	>1.0m	A1/A2je	0-0.55	5.5	LS-SL	4-5	22.0-27.5		
	no restrictions	B21	0.55-0.90	3.5	SLC-SLMC	10	35.0		
		B22	0.90-1.00+	1.0	SLMC-SMC	12	12.0	**69-75**	**70-75**

Soil Unit	ERD	Soil Horizon[1]	Modal Horizon Depths (m)[1]	Depth Factor[3]	Field Texture Range[4]	Est. Field Text. SWS (mm/0.1m)[6]	Horizon SWS (mm)	Profile SWS (mm)	SWS to nearest 5mm
7d	0.45m	A1	0-0.12	1.2	SCL-CLS	8	9.6		
	Rigid soil ESP>15%	A2je	0.12-0.15	0.3	SCL-CLS	8	2.4		
		B21	0.15-0.45	3.0	SLMC-SMC	12	36.0	**48**	**50**
8a	>1.0m	A1	0-0.20	2.0	SL-SCL	5-6	10.0-12.0		
	no restrictions	B1	0.20-0.50	3.0	SCL-CLS	6-8	18.0-24.0		
		B2	0.50-1.00+	5.0	CLS-SLC	8-10	40.0-50.0	**68-86**	**70-85**
8b	0.8->1.0	A1/A2e	0-0.50	5.0	S-LS	4	20.0		
	no restrictions	B21/B22	0.50-1.00+	3.0-5.0	SLC-SMC	10-12	30.0-60.0	**50-80**	**50-80**
8c	>1.0m - no restrictions	A1/A2e	0-1.00+	10.0	S-LS	4	40.0	**40**	**40**
8d	>1.0m - no restrictions	A11/A12/A3/B1	0-1.00+	10.0	S-LS	4	40.0	**40**	**40**
9a	>1.0m	A1/A2j	0-0.25	2.5	SL-SLC	5-10	12.5-25.0		
	no restrictions	B21	0.25-0.60	3.5	LMC	10	35.0		
		B22	0.60-1.00+	4.0	LMC	10	40.0	**87-100**	**85-100**
9b	0.7m	A11	0-0.03	0.3	LMC	10	3.0		
	salinity >0.8dS/m or Cl >800ppm	A12	0.03-0.20	1.7	MC	12	20.4		
		B21	0.20-0.70	5.0	MHC	12	60.0	**83**	**85**

Notes:

1. Effective rooting depth (ERD) and contributing soil constraint(s) are in accordance with the ERD definition and criteria in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL Guidelines (DNRM 2011d).
2. Soil horizon nomenclature and modal depths are from the midpoint of modal soil profile class diagrams presented in the soil characterization section of this report.
3. SWS multiplication factor is calculated from the difference between upper and lower modal midpoint horizon boundaries; the multiplication factor is used to quantify horizon thickness in profile SWS summations.
4. Soil field texture range is from that recorded for each soil horizon from the modal soil profile class descriptions presented in the soil characterization section of this report; texture codes are as defined in NCST (2009).
5. Estimated average soil water status (SWS) per 100mm of soil depth increment is for the soil texture grades listed for each soil horizon using values from the look-up table in the *Strategic Cropping Land Act 2011* (Queensland Government 2011) and SCL Guidelines (DNRM 2011d). Where a range in texture is listed the maximum value is assumed to ensure profile SWS calculations do not underestimate potential SWS values within a soil group.

Appendix 4 – Sampling depths and analytical methodologies used to characterise samples from the 2013 BNCOP Soil Investigation.

Sampling depths and analytical methodologies used in the investigation.

1. Profile analyses[1] – 0.1m sample depths taken at 0.3m intervals - representative profiles

Sample depths(m) – 0-0.1, 0.25-0.35, 0.55-0.65, 0.85-0.95, 1.15-1.25		Method	Moisture Status
Analyses	CEC[2]	15I3	Air dry @ 40ºC
	Exchangeable cations pH 8.5 (Ca, Mg, Na, K, meq/100g) [2]	15C1	Air dry @ 40ºC
	ECEC[2]	15J1	Air dry @ 40ºC
	Exchangeable cations pH 7.0 (Ca, Mg, Na, K, meq/100g) [2]	15A1	Air dry @ 40ºC
	Exchange acidity (Al, H meq/100g) [2]	15G1	Air dry @ 40ºC
	Air dry moisture content (ADMC %)	2A1	Oven dry @ 105ºC
	Particle size analysis (coarse sand, fine sand, silt, clay (%))	2Z2	Oven dry @ 105ºC
	Dispersion ratio (R1)	2Z1	Oven dry @ 105ºC
	Exchangeable sodium percentage (ESP %)	15N1	NA
	Ca/Mg ratio	15M1	NA

2. pH and salinity analyses[1] – 0.1m sample depths taken at 0.3m intervals - representative profiles

Sample depths(m) – 0-0.1, 0.25-0.35, 0.55-0.65, 0.85-0.95, 1.15-1.25		Method	Moisture Status
Analyses	Soil pH $_{1:5}$	4A1	Air dry @ 40ºC
	Electrical conductivity (EC $_{1:5}$ dS/m)	3A1	Air dry @ 40ºC
	Soluble chloride (Cl ppm)	5A2	Air dry @ 40ºC

3. pH and salinity analyses[1] – 0.3m and 0.6m for SCL compliance - Criteria 6 and 7

Sample depths(m) – 0.3 and 0.6		Method	Moisture Status
Analyses	Soil pH $_{1:5}$	4A1	Air dry @ 40ºC
	Soluble chloride (Cl ppm)	5A2	Air dry @ 40ºC

4. pH and salinity analyses[1] – 0.1m sample depths - ERD screening data/all detailed field sites

Sample depths(m) – 0.1, 0.3, 0.6, 0.9, 1.2		Method	Moisture Status
Analyses	Soil pH $_{1:5}$	4A1	Air dry @ 40ºC
	Electrical conductivity (EC $_{1:5}$ dS/m)	3A1	Air dry @ 40ºC

5. surface soil fertility analyses[1] – sample depth 0-0.1 m (Bulk)

Sample depths (m) – 0-0.1		Method	Moisture Status
Analyses	Organic carbon (%)	8B1	Air dry @ 40ºC
	Total Nitrogen (%)	7A2	Air dry @ 40ºC
	Available Phosphorous (Colwell)(ppm)	9B2	Air dry @ 40ºC
	Exchangeable Calcium and Potassium – pH 8.5 (Ca meq/100g)	15C1	Air dry @ 40ºC
	Exchangeable Calcium and Potassium – pH 7.0 (Ca meq/100g)	15A1	Air dry @ 40ºC

1. Method codes from Rayment and Lyons (2011). Testing undertaken by Agricultural Chemistry Pty Ltd. ABN 73 147 287 372.
2. CEC, ECEC and exchangeable cations (15C1 and 15A1) are reported on an air dry basis @ 40°C.

Appendix 5 – Fertility, pH, salinity, cation chemistry, particle size and dispersion data for sampled representative sites within the 2013 BNCOP Soil Investigation survey area.

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Reference 13/81 Page: 1 of 11

Date Received: 18/10/2013
Date Completed:

FINAL REPORT

Project:

Baralaba North CO Project EIS Soils Investigation 2013

All results in this report relate only to the items tested. Results are expressed on an "as received basis".

Client Name: Soil Mapping

Contact: Jon Burgess

Sample Type: soil

Number of samples: 121

Agricultural Chemistry Pty Ltd
Soil Analysis Report
Batch Number: 13/81

Date Received: 18/10/2013
Date Completed: 16/12/2013

Client: Soil Mapping

Lab No	Soil Type	Site	Horizon	Depth	pH	EC	Cl	Ca	Mg	K	Na	CEC	ECEC	ESP
				m		mS/cm	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%
1144		65		0.3	8.8	0.230	38							
1145				0.6	8.9	0.301	85							
1179				0.9	8.6	0.458	420							
1352				1.0	8.4	0.655	660							
1180				1.2	7.1	0.907	1030							
1146		66		0.3	8.0	0.087	<5							
1147				0.6	8.5	0.164	<5							
1148		67		0.3	8.6	0.177	5							
1149				0.6	8.7	0.311	155							
1353				0.7	8.8	0.325	200							
1354				0.8	8.8	0.449	350							
1355				0.9	8.6	0.649	650							
1356				1.0	8.5	0.812	880							
1150		68		0.3	8.4	0.253	133							
1151				0.6	8.8	0.329	130							
1357				0.7	8.9	0.409	265							
1358				0.8	8.9	0.227	370							
1359				0.9	8.9	0.548	455							
1360				1.0	8.8	0.646	650							
1152		69		0.3	7.7	0.063	<5							
1153				0.6	8.8	0.192	25							
1154		70		0.3	8.8	0.234	10							
1155				0.6	8.7	0.312	245							
1361				0.7	8.0	0.374	370							
1362				0.8	7.3	0.474	560							
1363				0.9	6.1	0.595	770							
1364				1.0	5.7	0.741	1050							
1156		71		0.3	8.9	0.266	30							
1157				0.6	8.7	0.825	820							
1158		72		0.3	8.8	0.161	<5	16.6	7.3	0.191	1.08	23		5
1159				0.6	9.1	0.278	38	10.6	10.0	0.178	3.10	22		14
1160		73		0.3	8.7	0.200	15							
1161				0.6	8.4	0.316	215							
1365				0.7	7.3	0.422	335							
1366				0.8	5.5	0.634	545							
1367				0.9	5.1	0.886	890							
1368				1.0	4.3	1.034	1150							
1162		74		0.3	8.9	0.238	28							
1163				0.6	8.7	0.520	438							
1369				0.7	8.5	0.633	615							
1370				0.8	8.2	0.844	905							
1184				0.9	7.1	0.935	1165							
1185				1.2	5.0	1.251	1750							
1164		75		0.3	8.6	0.475	465							
1165				0.6	7.4	1.054	1500							

Agricultural Chemistry Pty Ltd
Soil Analysis Report
Batch Number: 13/81 **Date Received: 18/10/2013**
Date Completed: 16/12/2013

Client: Soil Mapping

Lab No	Soil Type	Site	Horizon	Depth	pH	EC	Cl	Pbic	Total-N	Ca	Mg	K	Na	CEC	ECEC	ESP
				m		mS/cm	mg/kg	mg/kg	%	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%
1166	2b	66	Ap1/Ap2	0 - 0.1	7.2	0.346	210	73	0.140	27.0	8.4	2.50	0.471	38		1
1167			B21	0.25 - 0.35	8.1	0.078	<5			34.1	9.3	0.999	0.814	41		2
1168			B21	0.55 - 0.65	8.5	0.160	<5			32.5	12.0	0.734	1.90	42		5
1169			B22k	0.85 - 0.95	8.7	0.180	5			27.7	13.9	0.672	3.74	43		9
1170				1.15 - 1.25	8.9	0.236	15									
1171	3a	69	A11/A12	0 - 0.1	6.6	0.081	30	83	0.195	18.1	9.8	1.33	0.418		30	1
1172			B21	0.25 - 0.35	7.5	0.057	<5			22.8	7.5	0.330	0.764	30		3
1173			B21k	0.55 - 0.65	8.4	0.094	10			23.8	10.1	0.273	1.85	33		6
1174			B22	0.85 - 0.95	8.6	0.288	280			17.6	10.9	0.230	3.91	30		13
1175				1.15 - 1.25	6.2	0.453	650									
1216	3b	27	A11	0 - 0.1	6.2	0.059	40	28	0.105	5.3	2.6	0.629	0.199		9	2
1217			A12	0.25 - 0.35	5.6	0.021	5			2.2	1.5	0.132	0.242		4	6
1218			B21	0.55 - 0.65	6.8	0.070	35			3.6	4.0	0.142	1.69		9	18
1219			B22	0.85 - 0.95	7.9	0.096	73			3.6	3.8	0.13	1.67	9		19
1220				1.15 - 1.25	8.3	0.255	265									

Lab No	Soil Type	Site	Horizon	Depth	PSA-CS	PSA-FS	PSA-Silt	PSA-Clay	R1	ADMC
				m	%	%	%	%		%
1166	2b	66	Ap1/Ap2	0 - 0.1	1	10	23	66	0.37	3.8
1167			B21	0.25 - 0.35	1	9	22	68	0.39	5.2
1168			B21	0.55 - 0.65	2	6	19	72	0.44	4.8
1169			B22k	0.85 - 0.95	1	6	18	75	0.58	4.2
1170				1.15 - 1.25						
1171	3a	69	A11/A12	0 - 0.1	2	17	18	61	0.44	3.4
1172			B21	0.25 - 0.35	10	24	15	52	0.36	3.4
1173			B21k	0.55 - 0.65	9	21	12	59	0.45	4.4
1174			B22	0.85 - 0.95	12	22	16	52	0.72	3.8
1175				1.15 - 1.25						
1216	3b	27	A11	0 - 0.1	8	45	29	21	0.65	1.0
1217			A12	0.25 - 0.35	9	49	25	21	0.75	1.1
1218			B21	0.55 - 0.65	14	46	13	29	0.99	1.2
1219			B22	0.85 - 0.95	19	50	10	24	0.92	1.0
1220				1.15 - 1.25						

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Agricultural Chemistry Pty Ltd
Soil Analysis Report
Batch Number: 13/81

Date Received: 18/10/2013
Date Completed: 16/12/2013

Client: Soil Mapping

Lab No	Soil Type	Site	Horizon	Depth	pH	EC	Cl	Pbic	Total-N	Ca	Mg	K	Na	CEC	ECEC	ESP
				m		mS/cm	mg/kg	mg/kg	%	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%
1176	4c	65	A11p/A12p	0 - 0.1	8.4	0.165	40	56	0.149	34.1	7.5	1.33	0.966	37		3
1177			B21k	0.25 - 0.35	8.8	0.218	40			31.9	10.6	0.609	3.35	40		8
1178			B21k	0.55 - 0.65	9.0	0.307	80			24.7	12.1	0.496	5.24	39		13
1179			B22	0.85 - 0.95	8.6	0.458	420			19.0	11.9	0.462	6.17	35		18
1180				1.15 - 1.25	7.1	0.907	1030									
1221	4d	110	A1	0 - 0.1	7.4	0.128	10	36	0.255	22.2	4.9	1.02	0.089	28		<1
1222			B21k	0.25 - 0.35	9.0	0.189	18			17.5	11.1	0.407	1.45	26		6
1223			B22	0.55 - 0.65	9.0	0.829	525			12.2	14.7	0.37	5.06	28		18
1224			B22	0.85 - 0.95	8.8	1.391	1600			11.5	16.0	0.394	5.85	28		21
1225				1.15 - 1.25	8.4	1.700	2250									
1226	5	71	A11p/B21p	0 - 0.1	8.5	0.194	95	32	0.116	24.1	9.2	0.955	1.41	33		4
1227			B22	0.25 - 0.35	8.9	0.370	155			19.2	12.7	0.343	4.35	32		14
1228			B22	0.55 - 0.65	8.7	0.821	790			15.5	14.7	0.352	6.55	34		19
1229			B23	0.85 - 0.95	7.7	1.180	1600			12.7	14.7	0.382	6.77	34		20
1230			B23	1.15 - 1.25	5.5	1.305	1850									

Lab No	Soil Type	Site	Horizon	Depth	PSA-CS	PSA-FS	PSA-Silt	PSA-Clay	R1	ADMC
				m	%	%	%	%		%
1176	4c	65	A11p/A12p	0 - 0.1	2	14	23	60	0.39	3.7
1177			B21k	0.25 - 0.35	2	12	21	63	0.47	4.1
1178			B21k	0.55 - 0.65	3	11	22	65	0.68	3.7
1179			B22	0.85 - 0.95	1	12	27	63	0.79	3.4
1180				1.15 - 1.25						
1221	4d	110	A1	0 - 0.1	22	26	12	39	0.30	2.6
1222			B21k	0.25 - 0.35	18	21	13	49	0.50	3.0
1223			B22	0.55 - 0.65	16	20	14	54	0.70	3.9
1224			B22	0.85 - 0.95	14	21	9	53	0.61	3.6
1225				1.15 - 1.25						
1226	5	71	A11p/B21p	0 - 0.1	9	17	17	59	0.32	3.4
1227			B22	0.25 - 0.35	9	15	18	60	0.65	3.6
1228			B22	0.55 - 0.65	7	14	15	66	0.75	4.3
1229			B23	0.85 - 0.95	6	14	14	68	0.78	3.1
1230			B23	1.15 - 1.25						

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Agricultural Chemistry Pty Ltd
Soil Analysis Report
Batch Number: 13/81

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Date Completed: 16/12/2013

Client: Soil Mapping

Lab No	Soil Type	Site	Horizon	Depth	pH	EC	Cl	Pbic	Total-N	Ca	Mg	K	Na	CEC	ECEC	ESP
				m		mS/cm	mg/kg	mg/kg	%	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%
1186	7a	88	A1	0 - 0.1	6.8	0.071	45	20	0.140	12.3	7.9	0.336	0.782		21	4
1187			B21k	0.25 - 0.35	8.8	0.629	670			11.9	10.6	0.187	3.45	24		14
1188			B22	0.55 - 0.65	8.3	1.160	1440			9.5	11.1	0.208	4.02	23		17
1189			B23	0.85 - 0.95	5.3	1.004	1315			6.5	10.8	0.191	6.75		24	28
1190				1.15 - 1.25	4.9	0.968	1300									
1231	7b	36	A1	0 - 0.1	6.7	0.045	20	6.0	0.090	4.5	3.0	0.296	0.302		8	4
1232			B21	0.25 - 0.35	7.6	0.105	73			5.5	9.3	0.110	2.25	17		13
1233			B22k	0.55 - 0.65	9.2	0.393	315			4.9	8.0	0.091	2.32	13		18
1234			B22k	0.85 - 0.95	9.3	0.650	650			4.0	9.6	0.109	3.72	14		27
1235				1.15 - 1.25	7.9	0.602	800									
1236	7b	90	A1/B21	0 - 0.1	6.4	0.051	30	7.5	0.095	4.3	5.3	0.204	0.75		11	7
1237			B21	0.25 - 0.35	8.7	0.642	780			7.8	10.2	0.116	3.42	19		18
1238			B22	0.55 - 0.65	8.2	0.732	1080			5.3	9.0	0.111	3.88	16		24
1239			B22	0.85 - 0.95	5.2	0.597	880			2.9	5.9	0.069	4.71		14	35
1240				1.15 - 1.25	4.7	0.555	815									

Lab No	Soil Type	Site	Horizon	Depth	PSA-CS	PSA-FS	PSA-Silt	PSA-Clay	R1	ADMC
				m	%	%	%	%		%
1186	7a	88	A1	0 - 0.1	9	27	18	45	0.41	2.5
1187			B21k	0.25 - 0.35	11	28	16	49	0.60	3.0
1188			B22	0.55 - 0.65	10	27	15	50	0.62	2.8
1189			B23	0.85 - 0.95	9	24	16	52	0.74	2.5
1190				1.15 - 1.25						
1231	7b	36	A1	0 - 0.1	13	58	11	20	0.66	0.9
1232			B21	0.25 - 0.35	10	39	12	40	0.81	2.1
1233			B22k	0.55 - 0.65	17	43	10	34	0.86	1.3
1234			B22k	0.85 - 0.95	14	41	11	37	0.95	1.6
1235				1.15 - 1.25						
1236	7b	90	A1/B21	0 - 0.1	12	45	17	29	0.58	1.3
1237			B21	0.25 - 0.35	10	36	17	39	0.66	2.0
1238			B22	0.55 - 0.65	10	39	17	37	0.89	1.8
1239			B22	0.85 - 0.95	12	41	12	34	0.95	1.3
1240				1.15 - 1.25						

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Agricultural Chemistry Pty Ltd
Soil Analysis Report
Batch Number: 13/81 **Date Received: 18/10/2013**
Date Completed: 16/12/2013

Client: Soil Mapping

Lab No	Soil Type	Site	Horizon	Depth	pH	EC	Cl	Pbic	Total-N	Ca	Mg	K	Na	CEC	ECEC	ESP
				m		mS/cm	mg/kg	mg/kg	%	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%
1241	7c	99	A1	0 - 0.1	6.3	0.042	15	11	0.090	2.4	0.97	0.423	0.041		4	1
1242			A21	0.25 - 0.35	6.6	0.024	5			2.7	0.44	0.29	0.041		3	1
1243			B2	0.65 - 0.75	7.2	0.026	2			4.8	4.2	0.202	0.564		10	6
1244			B2	0.85 - 0.95	7.2	0.035	8			5.6	5.4	0.305	0.884		12	7
1245				1.15 - 1.25	8.1	0.073	35									
1191	7d	87	A1	0 - 0.1	6.4	0.034	5	28	0.140	6.5	3.4	0.194	0.330		10	3
1192			B21	0.25 - 0.35	8.5	0.087	60			7.4	7.3	0.130	1.83	15		12
1193			B22	0.55 - 0.65	9.1	0.672	730			3.0	6.6	0.140	3.63	12		30
1194			B22	0.85 - 0.95	9.2	0.976	1100			2.8	6.3	0.129	3.92	11		36
1195				1.15 - 1.25	9.3	0.991	1150									
1196	8a	38	A1	0 - 0.1	6.2	0.020	<5	1.0	0.070	2.7	0.99	0.307	0.021		4	1
1197			B1	0.25 - 0.35	6.3	0.010	<5			2.1	0.90	0.180	0.028		3	1
1198			B2	0.55 - 0.65	6.4	0.010	<5			3.2	2.4	0.215	0.043		6	1
1199			B2	0.85 - 0.95	6.2	0.011	<5			2.6	2.5	0.087	0.058		5	1
1200				1.15 - 1.25	6.0	0.007	<5									

Lab No	Soil Type	Site	Horizon	Depth	PSA-CS	PSA-FS	PSA-Silt	PSA-Clay	R1	ADMC
				m	%	%	%	%		%
1241	7c	99	A1	0 - 0.1	29	55	8	10	0.64	0.4
1242			A21	0.25 - 0.35	31	51	7	11	0.88	0.5
1243			B2	0.65 - 0.75	20	33	5	44	0.57	1.3
1244			B2	0.85 - 0.95	15	27	1	53	0.67	1.8
1245				1.15 - 1.25						
1191	7d	87	A1	0 - 0.1	18	42	11	27	0.50	1.4
1192			B21	0.25 - 0.35	17	35	7	38	0.66	1.9
1193			B22	0.55 - 0.65	19	39	8	33	0.99	1.3
1194			B22	0.85 - 0.95	18	40	11	29	0.99	1.8
1195				1.15 - 1.25						
1196	8a	38	A1	0 - 0.1	18	62	6	15	0.74	0.7
1197			B1	0.25 - 0.35	16	57	8	20	0.51	0.7
1198			B2	0.55 - 0.65	12	38	4	47	0.24	1.6
1199			B2	0.85 - 0.95	12	42	5	43	0.17	1.4
1200				1.15 - 1.25						

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Agricultural Chemistry Pty Ltd
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Client: Soil Mapping

Lab No	Soil Type	Site	Horizon	Depth	pH	EC	Cl	Pbic	Total-N	Ca	Mg	K	Na	CEC	ECEC	ESP
				m		mS/cm	mg/kg	mg/kg	%	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%
1201	8b insitu	40	A1	0 - 0.1	6.1	0.016	<5	2.0	0.060	2.3	1.0	0.147	0.015		4	1
1202			A2e	0.25 - 0.35	6.3	0.012	<5			1.6	1.4	0.069	0.062		3	2
1203			B21	0.55 - 0.65	6.1	0.018	<5			12.4	8.2	0.378	0.799		22	4
1204			B22	0.85 - 0.95	6.7	0.027	10			13.2	8.1	0.298	1.011		23	5
1205				1.15 - 1.25	7.6	0.062	50									
1206	8b colluvial	29	A1	0 - 0.1	6.9	0.031	<5	2.0	0.060	2.2	0.71	0.374	0.018		3	1
1207			A21j	0.25 - 0.35	6.9	0.014	<5			1.3	0.37	0.233	0.015		2	1
1208			A22e/j	0.55 - 0.65	6.6	0.014	<5			1.5	0.70	0.151	0.020		2	1
1209			B2	0.85 - 0.95	6.4	0.018	<5			8.0	3.6	0.518	0.204		12	2
1210			B2	1.15 - 1.25	6.6	0.016	5									

Lab No	Soil Type	Site	Horizon	Depth	PSA-CS	PSA-FS	PSA-Silt	PSA-Clay	R1	ADMC
				m	%	%	%	%		%
1201	8b insitu	40	A1	0 - 0.1	60	29	3	9	0.89	0.5
1202			A2e	0.25 - 0.35	65	22	5	10	0.87	0.5
1203			B21	0.55 - 0.65	34	13	8	48	0.38	2.9
1204			B22	0.85 - 0.95	34	13	10	44	0.63	2.9
1205				1.15 - 1.25						
1206	8b colluvial	29	A1	0 - 0.1	41	44	7	9	0.79	0.4
1207			A21j	0.25 - 0.35	43	42	7	10	0.85	0.3
1208			A22e/j	0.55 - 0.65	37	44	7	13	0.83	0.5
1209			B2	0.85 - 0.95	26	28	6	41	0.51	2.4
1210			B2	1.15 - 1.25						

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Lab No	Soil Type	Site	Horizon	Depth	pH	EC	Cl	Pbic	Total-N	Ca	Mg	K	Na	CEC	ECEC	ESP
				m		mS/cm	mg/kg	mg/kg	%	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%
1211	9a	30		0 - 0.1	6.7	0.048	5	4.0	0.099	5.7	5.5	0.710	0.071		12	1
1212				0.25 - 0.35	7.9	0.041	5			9.7	12.6	0.370	0.303	22		1
1213				0.55 - 0.65	8.9	0.196	85			9.3	16.7	0.255	0.835	25		3
1214				0.85 - 0.95	9.1	0.301	215			7.5	16.0	0.196	0.865	21		4
1215				1.15 - 1.25	9.0	0.355	353									
1246	9b	43	A11/A12	0 - 0.1	6.5	0.060	30	9.5	0.135	14.2	7.0	0.676	0.726		23	3
1247			B21	0.25 - 0.35	8.4	0.069	25			16.7	10.6	0.290	1.9	28		7
1248			B21	0.55 - 0.65	9.0	0.502	475			16.4	17.8	0.308	5.5	37		15
1249			B21	0.85 - 0.95	8.9	0.760	900			16.8	19.3	0.329	5.9	37		16
1250			B22k	1.15 - 1.25	9.0	0.715	810									
1181	5	74	A1p/B21p	0 - 0.1	8.1	0.139	60									
1182			B21k	0.25 - 0.35	8.7	0.252	55									
1183			B22	0.55 - 0.65	8.6	0.473	400									
1184			B23	0.85 - 0.95	7.1	0.935	1165									
1185				1.15 - 1.25	5.0	1.251	1750									

Lab No	Soil Type	Site	Horizon	Depth	PSA-CS	PSA-FS	PSA-Silt	PSA-Clay	R1	ADMC
				m	%	%	%	%		%
1211	9a	30		0 - 0.1	17	51	11	23	0.58	1.7
1212				0.25 - 0.35	11	40	10	41	0.42	2.7
1213				0.55 - 0.65	13	34	11	41	0.37	3.7
1214				0.85 - 0.95	33	21	15	34	0.77	2.8
1215				1.15 - 1.25						
1246	9b	43	A11/A12	0 - 0.1	11	31	21	38	0.47	2.8
1247			B21	0.25 - 0.35	17	35	10	39	0.52	2.9
1248			B21	0.55 - 0.65	14	23	14	51	0.66	3.7
1249			B21	0.85 - 0.95	14	19	14	54	0.66	4.2
1250			B22k	1.15 - 1.25						

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Agricultural Chemistry Pty Ltd

METHOD DESCRIPTIONS

Soil

Reference: 13/81

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Methods used to Analyse Samples

Analyte	ALHS*	Uncertainty %	LOQ	Unit	Name	Method Description
pH	4A1	1.1	0.1	pH	pH	1:5 water extr, pH meter
EC	3A1	5.4	0.01	dS/m	Electrical conductivity	1:5 water extr, EC meter
Cl	5A2	10.0	10.0	mg/kg	Chloride	1:5 water extr, (AA) colorimetric
NO3-N	7C2	6.7	1.0	mg/kg	Nitrate-nitrogen	1:5 water extr, (AA) colorimetric
NH4-N	7C2	7.8	0.6	mg/kg	Ammonium-nitrogen	1M KCl extr, (AA) colorimetric
Bicarb.P	9B2	16.8	1.0	mg/kg	Bicarb.ext.phosphorus	0.5M NaHCO3 @ pH 8.5, (AA) colorimetric
TN	7A2	12.9	0.01	%	Total Kjeldahl Nitrogen	Sulphuric acid digest, (AA) colorimetric
OC	8B1	9.7	0.02	%	Organic Carbon	Walkley & Black, (H2SO4/K2Cr2O7), titr.
Ca (Neut)	15A1	10.3	0.10	meq/100g	Exchangeable calcium	1M NH4Cl @ pH 7.0 shake, AAS
Mg (Neut)	15A1	6.6	0.10	meq/100g	Exchangeable magnesium	1M NH4Cl @ pH 7.0 shake, AAS
Na (Neut)	15A1	7.3	0.03	meq/100g	Exchangeable sodium	1M NH4Cl @ pH 7.0 shake, AAS
K (Neut)	15A1	3.9	0.02	meq/100g	Exchangeable potassium	1M NH4Cl @ pH 7.0 shake, AAS
ECEC	15J1	5.0	1	meq/100g	Effective cation ex.capacity	Sum of exchangeable cations
ESP	15N1	5.0	3	%	Exchangeable Na%	(Exchangeable Na/sum of exch.cations)%
Sand	no ref	22.1	1.0	%	Particle size, sand	Hydrometer, gravimetric
Silt	no ref	16.6	1.0	%	Particle size, silt	Hydrometer, gravimetric
Clay	no ref	12.7	1.0	%	Particle size, clay	Hydrometer, gravimetric

*** Australian Laboratory Handbook of Soil and Water Chemical Methods (1992)**

For Manager
Analytical Services: ______________________

Agricultural Chemistry Pty Ltd

METHOD DESCRIPTIONS

Soil

Reference: 13/81

Page 10 of 11

Methods used to Analyse Samples

Analyte	ALHS*	Uncertainty %	LOQ	Unit	Name	Method Description
Ca (Alc)	15C1	7.2	0.18	meq/100g	Exchangeable calcium	1M NH4Cl (alcoholic) @ pH 8.5 leach, AAS
Mg (Alc)	15C1	4.7	0.31	meq/100g	Exchangeable magnesium	1M NH4Cl (alcoholic) @ pH 8.5 leach, AAS
Na (Alc)	15C1	9.6	0.09	meq/100g	Exchangeable sodium	1M NH4Cl (alcoholic) @ pH 8.5 leach, AAS
K (Alc)	15C1	4.8	0.02	meq/100g	Exchangeable potassium	1M NH4Cl (alcoholic) @ pH 8.5 leach, AAS
CEC	15I3	5.7	1.0	meq/100g	Cation Exchange Capacity	KNO3 + Ca(NO3)2 extr, (AA) colorimetric
DTPA-Cu	12A1	17.1	0.26	mg/kg	DTPA ext. copper	DTPA extraction, AAS
DTPA-Zn	12A1	16.4	0.10	mg/kg	DTPA ext. zinc	DTPA extraction, AAS
DTPA-Mn	12A1	9.0	0.32	mg/kg	DTPA ext. manganese	DTPA extraction, AAS
DTPA-Fe	12A1	13.0	0.23	mg/kg	DTPA ext. iron	DTPA extraction, AAS
ADMC	2A1	11.9	0.4	%	Air Dried Moisture Content	Gravimetric oven dry @ 105C
R1	NA	20.2	NA		Dispersion Ratio	Ratio [Aqueous dispersible (Silt + Clay):Total (Silt + Clay)]
SO4-S	10B3	11.5	0.6	mg/kg	Sulfate sulfur	Ca(H2PO4)2 @ pH 4.0 extractable sulfate-sulfur, ICPOES
Al	15G1	NA	NA	meq/100g	Exchangeable Aluminium	Exch. Hydrogen and Aluminium by 1M KCl
H+	15G1	NA	NA	meq/100g	Exchangeable Acidity	Exch. Hydrogen and Aluminium by 1M KCl
15 Bar		NA	NA		15 Bar Analysis	Pressure Plate/Gravimetric oven dry @ 105C
1/3 Bar		NA	NA		15 Bar Analysis	Pressure Plate/Gravimetric oven dry @ 105C

*** Australian Laboratory Handbook of Soil and Water Chemical Methods (1992)**

For Manager
Analytical Services: ______________________

Agricultural Chemistry Pty Ltd

QUALITY CONTROL DATA

Reference: 13/81
Page: 11 of 11

Soil

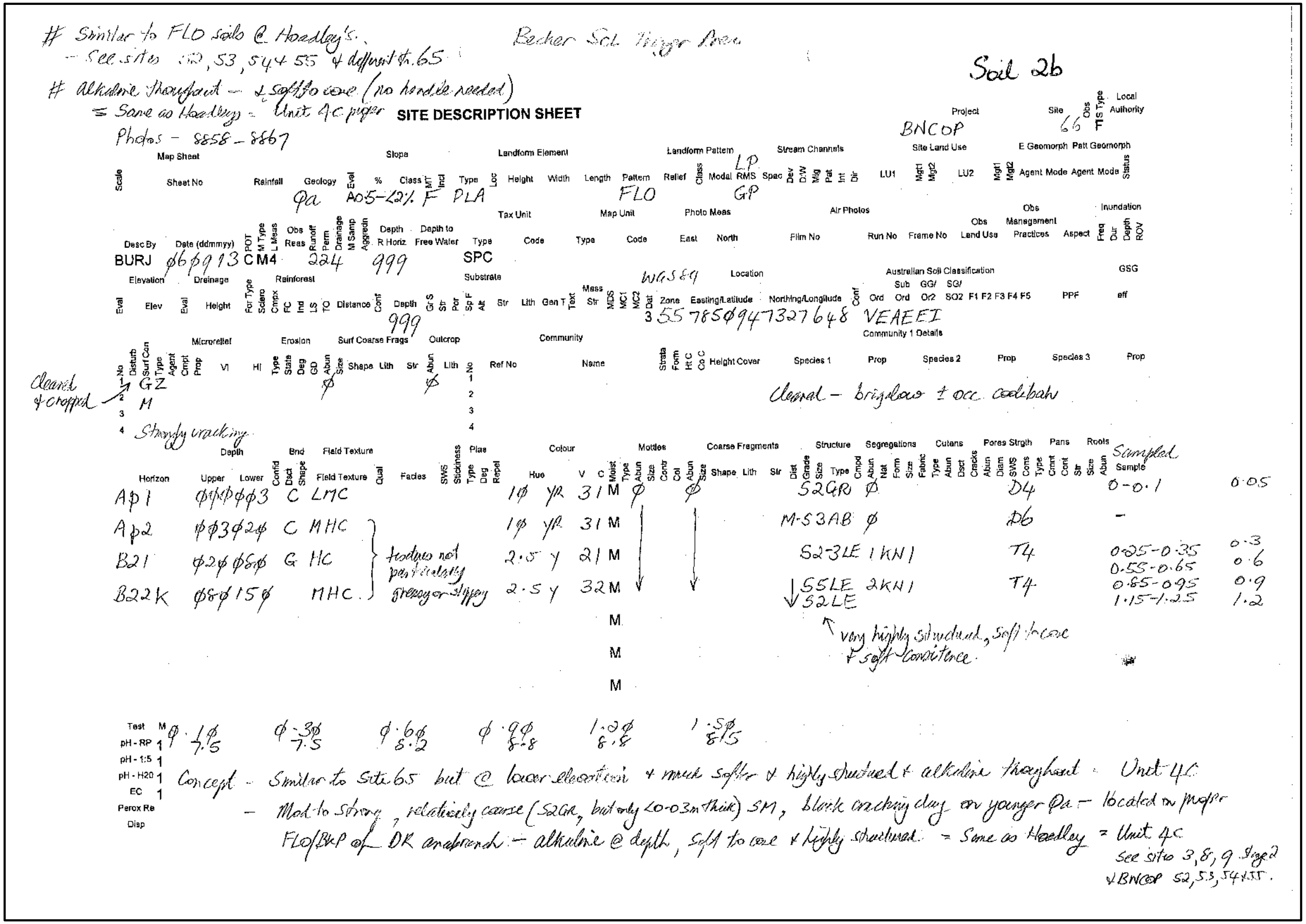
*** Australian Laboratory Handbook of Soil and Water Chemical Methods (1992)**

Test Method	Units		Actual Value	Acceptance Criteria [Range]
pH	pH	cane	5.3, 5.2,	4.9 - 5.4
EC	dS/m	cane	.041, .043	.031 - .050
Cl	mg/kg	cane	15, 15	12 - 18
NO3-N	mg/kg	cane		0.2 - 1.0
NH4-N	mg/kg	NA		NA
Bicarb.P	mg/kg	51-13	29.5	23 - 34
Total N	%	34-12	.044, .044	.040 - .050
Total P	%	ALS		
Organic Carbon	%	B		1.82 - 2.3
Ca (Exch. cations)pH7	meq/100g	52-13	7.6	7.12 - 8.84
Mg (Exch. cations)pH7	meq/100g	52-13	4.16	3.57 - 4.91
Na (Exch. cations)pH7	meq/100g	52-13	0.591	.463 - .659
K (Exch. cations)pH7	meq/100g	52-13	0.405	.361 - .444
Exch. Acidity	meq/100g			NA
ECEC	meq/100g	A		NA
CEC	meq/100g	S12		58 - 73
ESP	%	A		NA
Coarse sand	%	RD	31, 31, 31, 31	29 -33
Fine Sand	%	RD	31, 30, 30, 30	27 - 32
Silt	%	RD	12, 12, 13, 13	11 - 16
Clay	%	RD	28, 28, 27, 27	21 - 29
R1		RD	.46, .44, .47, .45	.40 - .57

Test Method	Units	Test Soil	Actual Value	Acceptance Criteria [Range]
DTPA-Cu	mg/kg	SB		2.37 - 3.25
DTPA-Zn	mg/kg	SB		3.15 - 3.81
DTPA-Mn	mg/kg	SB		97.7 - 145.0
DTPA-Fe	mg/kg	SB		23.3 - 32.6
Suflate-sulfur	mg/kg	B		6 - 12
ADMC	%			NA
15 Bar	%	G		23 - 30
0.33 Bar	%	G		32 - 51
Ca (Exch. cations)pH8.5	meq/100g	S12	34.7, 36.2	27.7 - 37.4
Mg (Exch. cations)pH8.5	meq/100g	S12	23.2, 24.3	22.88 - 26.5
Na (Exch. cations)pH8.5	meq/100g	S12	2.12, 2.10	2.0 - 2.28
K (Exch. cations)pH8.5	meq/100g	S12	1.769	1.64 - 2.09

Appendix 6 – Soil profile field data for sampled representative sites within the 2013 BNCOP Soil Investigation survey area.

BNCOP 2013 Soil Investigation – Soil 2b
Representative Field Site – 66



Similar to FLO soils @ Hoadley's.
– See sites 52, 53, 54 + 55 + different to 65

Becher Sch. Trigger Area

Alkaline throughout – + soft to core (no handle needed)
= Same as Hoadley – Unit 4C paper

Photos – 8858 – 8867

Soil 2b

SITE DESCRIPTION SHEET

Project: BNCOP
Site: 66
Obs: 1

Slope: Geology: Qa; Eval: A; %: 0.5–<2%; Class: F; Type: PLA

Landform Pattern: LP; Pattern: FLO; Relief: GP

Desc By: BURJ
Date (ddmmyy): 060913
POT: C; M Type: M4
Obs Reas: 2; Runoff: 2; Perm: 4
Depth R Horiz: 999
Type: SPC

Substrate Depth: 999

WGS84
Location: Zone 55; Easting/Latitude 0785094; Northing/Longitude 7327648

Australian Soil Classification: VE AE EI

Disturb: GZ / M
Cleared + cropped
Erosion Abun: 0
Outcrop Abun: 0
Strongly cracking

Community 1 Details: Cleared – brigalow ± occ. coolibah

Horizon	Depth Upper	Depth Lower	Bnd	Field Texture	Hue	V	C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Strength	Sample	
Ap1	000	003	C	LMC	10 YR	3	1	M	0	0	S2GR 0	D4	0-0.1	0.05
Ap2	003	020	C	MHC	10 YR	3	1	M			M-S3AB 0	D6	–	
B21	020	080	G	HC	2.5 Y	2	1	M			S2-3LE 1KN1	T4	0.25-0.35 0.55-0.65	0.3 0.6
B22K	080	150		MHC	2.5 Y	3	2	M			S5LE 2KN1 S2LE	T4	0.85-0.95 1.15-1.25	0.9 1.2

Sampled

Texture not particularly greasy or slippery

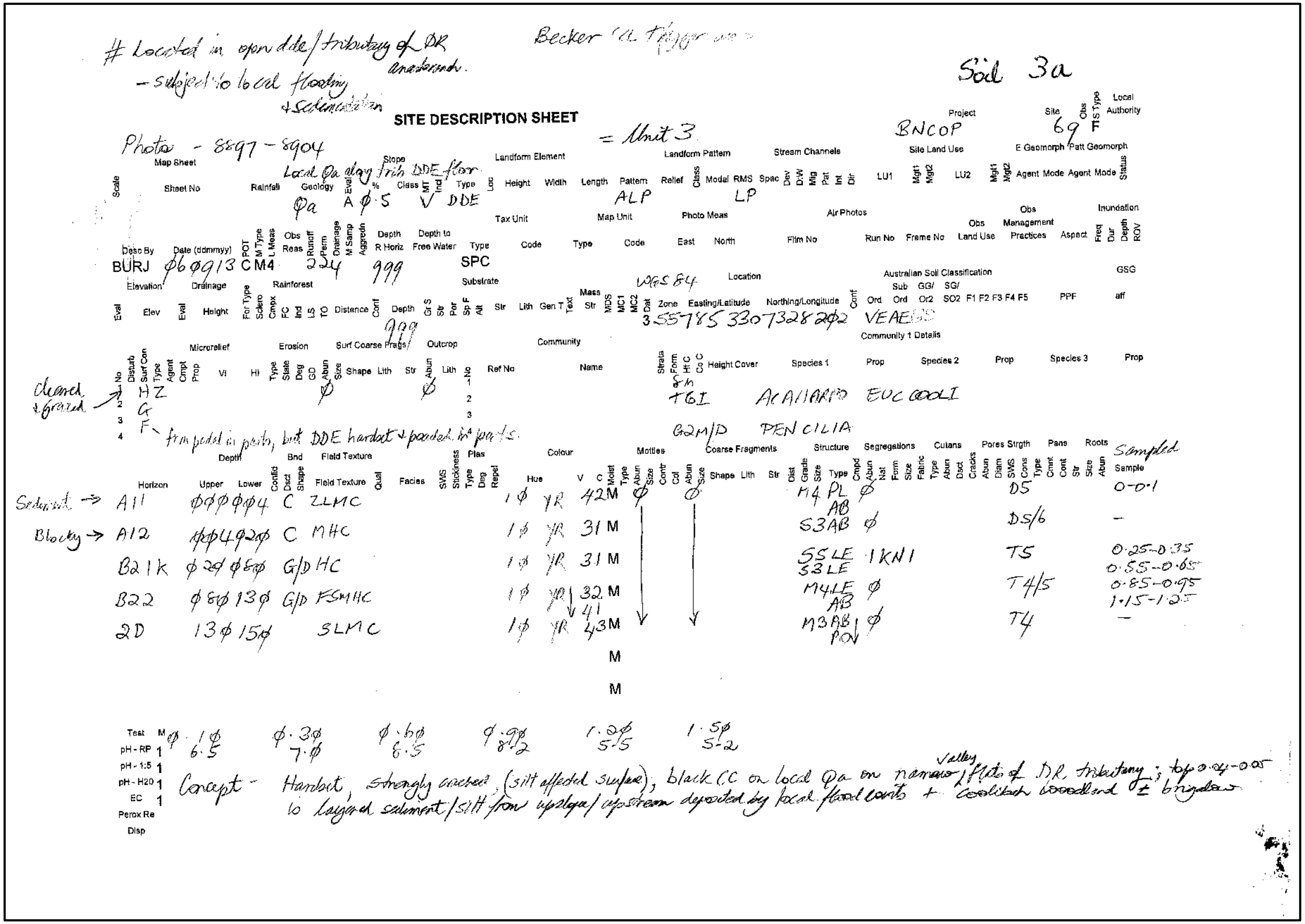
Very highly structured, soft to core + soft consistence

Test M	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP 1	7.5	7.5	8.2	8.8	8.8	8.5

pH - 1:5 1
pH - H20 1
EC 1
Perox Re
Disp

Concept – Similar to Site 65 but @ lower elevation + much softer + highly structured + alkaline throughout. Unit 4C
– Mod to strong, relatively coarse (S2GR, but only <0.03m thick) SM, black cracking clay on younger Qa – located on major FLO/BKP of DR anabranch – alkaline @ depth, soft to core + highly structured = Same as Hoadley = Unit 4C
See sites 3, 8, 9 Stage 2
+ BNCOP 52, 53, 54 + 55.

BNCOP 2013 Soil Investigation – Soil 3a
Representative Field Site – 69



Located in open ddle / tributary of DR anabranch.
– subject to local flooding + sedimentation

Becker 'a Trigger

Soil 3a

SITE DESCRIPTION SHEET = Unit 3.

Photo – 8897 – 8904

Project: BNCOP
Site: 69
TS Type: F

Local Qa along trib DDE floor

Geology: Qa
Slope Eval: A
Slope %: 0.5
MT: V
Landform Element Type: DDE
Landform Pattern: ALP
Modal: LP

Desc By: BURJ
Date (ddmmyy): 060913
POT: C
M Type: M4
Runoff: 2
Perm: 2
Drainage: 4
Depth R Horiz: 999
Type: SPC
Distance: 999

WGS 84
Dat: 3
Zone: 55
Easting/Latitude: 785 330
Northing/Longitude: 7328 202
Australian Soil Classification: VEAE

Cleared + grazed
Disturb: H Z, G, F
fron pedal in parts, but DDE hardset + pedal in parts.
Erosion Abun: 0
Outcrop Abun: 0

Community 1 Details
Strata Form: Sm, TGI, G2M/D
Species 1: ACA HARPO, PEN CILIA
Species 2: EUC COOLI

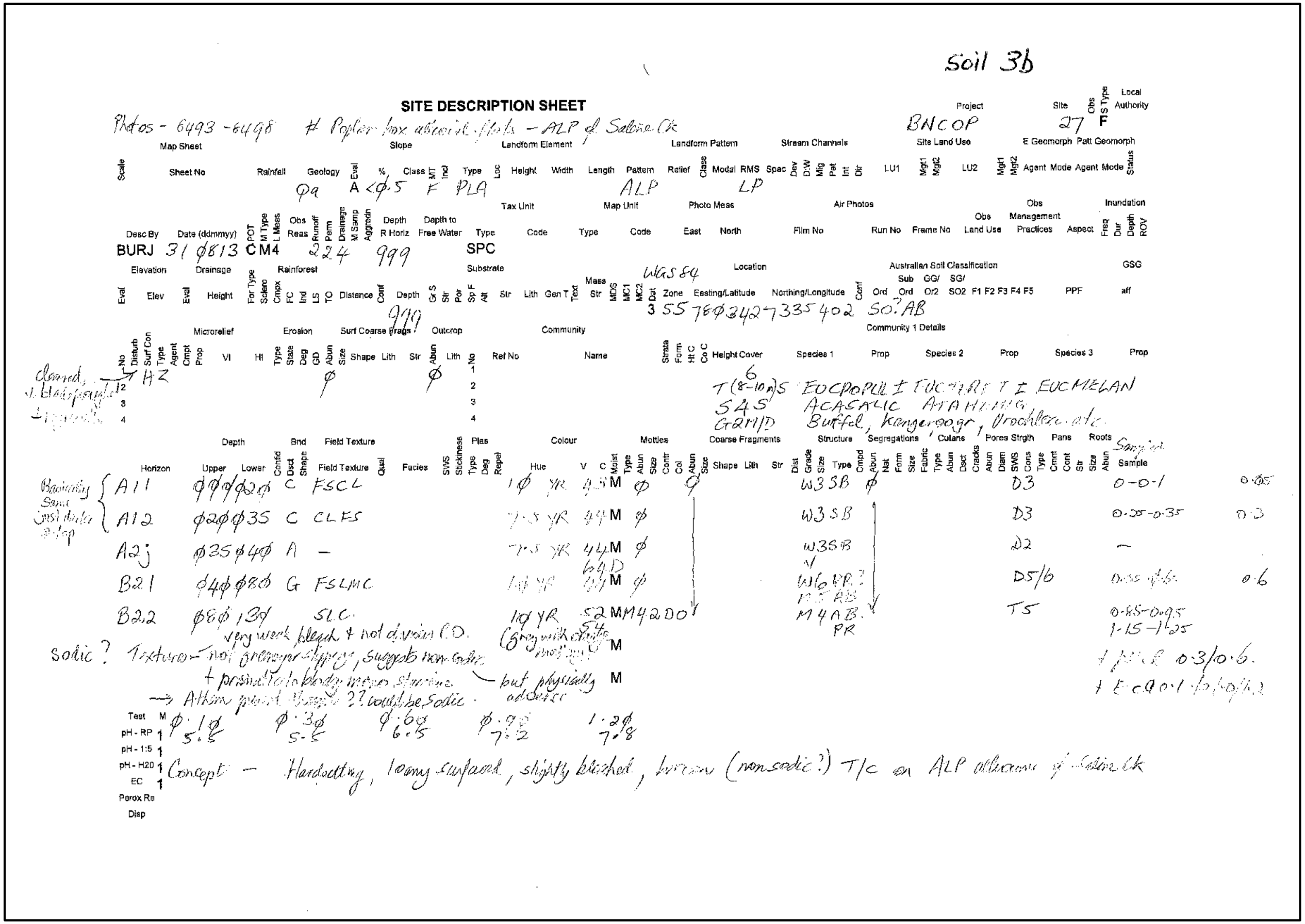
Sampled

Horizon	Upper	Lower	Bnd Dsct	Field Texture	Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations	Strgth	Sample
Sediment → A11	000	004	C	ZLMC	10 YR	42	M	0	0	M4 PL AB	0	D5	0-0.1
Blocky → A12	004	020	C	MHC	10 YR	31	M			S3AB	0	D5/6	–
B21k	020	080	G/D	HC	10 YR	31	M			S5LE S3LE	1KN1	T5	0.25-0.35 0.55-0.65
B22	080	130	G/D	FSMHC	10 YR	32 41	M			M4LE AB	0	T4/5	0.85-0.95 1.15-1.25
2D	130	150		SLMC	10 YR	43	M			M3AB PON	0	T4	–
							M						
							M						

Test	M					
pH - RP 1	0.10 6.5	0.30 7.0	0.60 6.5	0.90 8.2	1.20 5.5	1.50 5.2
pH - 1:5 1						
pH - H20 1						
EC 1						
Perox Re						
Disp						

Concept – Hardset, strongly cracked, (silt affected surface), black CC on local Qa on narrow valley flats of DR tributary; top 0.04-0.05 to layered sediment / silt from upslope / upstream deposited by local flood waters + coolibah woodland ± brigalow

BNCOP 2013 Soil Investigation – Soil 3b
Representative Field Site – 27



Soil 3b

SITE DESCRIPTION SHEET

Project: BNCOP
Site: 27
S Type: F

Photos - 6493 - 6498 # Poplar box alluvial flats – ALP of Saline Ck

Geology: Qa
Slope: Eval A, % <0.5, Class F
Landform Element: Type PLA
Landform Pattern: Pattern ALP
Modal RMS: LP

Desc By: BURJ
Date (ddmmyy): 310813
POT: C
M Type: M4
Obs Reas: 2
Runoff: 2
Perm: 4
Depth R Horiz: 999
Tax Unit Type: SPC
Substrate Depth: 999

Location: WGS 84
Dat: 3
Zone: 55
Easting/Latitude: 780342
Northing/Longitude: 7335402
Australian Soil Classification: SO? AB

Microrelief: cleared, v. bladygrass + legumes → Disturb / Surf Con: HZ
Erosion Abun: 0
Outcrop Abun: 0

Community 1 Details:
T (8-10m) 6 S – EUCPOPUL I EUC[illegible] T I EUCMELAN
S4S – ACASALIC ATAH[illegible]
G2M/D – Buffel, Kangaroogr, Urochloa etc.

Horizon	Upper	Lower	Dsct	Field Texture	Hue	V C	Moist	Mottles	Coarse Fragments Abun	Structure	Segregations Abun	Strgth	Sample
A11	000	020	C	FSCL	10 YR	43	M	0	0	W3SB	0	D3	0-0.1 0.05
A12	020	035	C	CLFS	7.5 YR	44	M	0		W3SB		D3	0.20-0.35 0.3
A2j	035	040	A	—	7.5 YR	44	M	0		W3SB		D2	—
B21	040	080	G	FSLMC	10 YR	64D 44	M	0		W6 PR? M5AB		D5/6	0.55-0.6 0.6
B22	080	130		SLC	10 YR	52 54	M	M42DO		M4AB. PR		T5	0.85-0.95 1.15-1.25

Basically same (just darker at top) – A11, A12

very weak bleach + not diverse C.O. (Grey with distinct mottles)

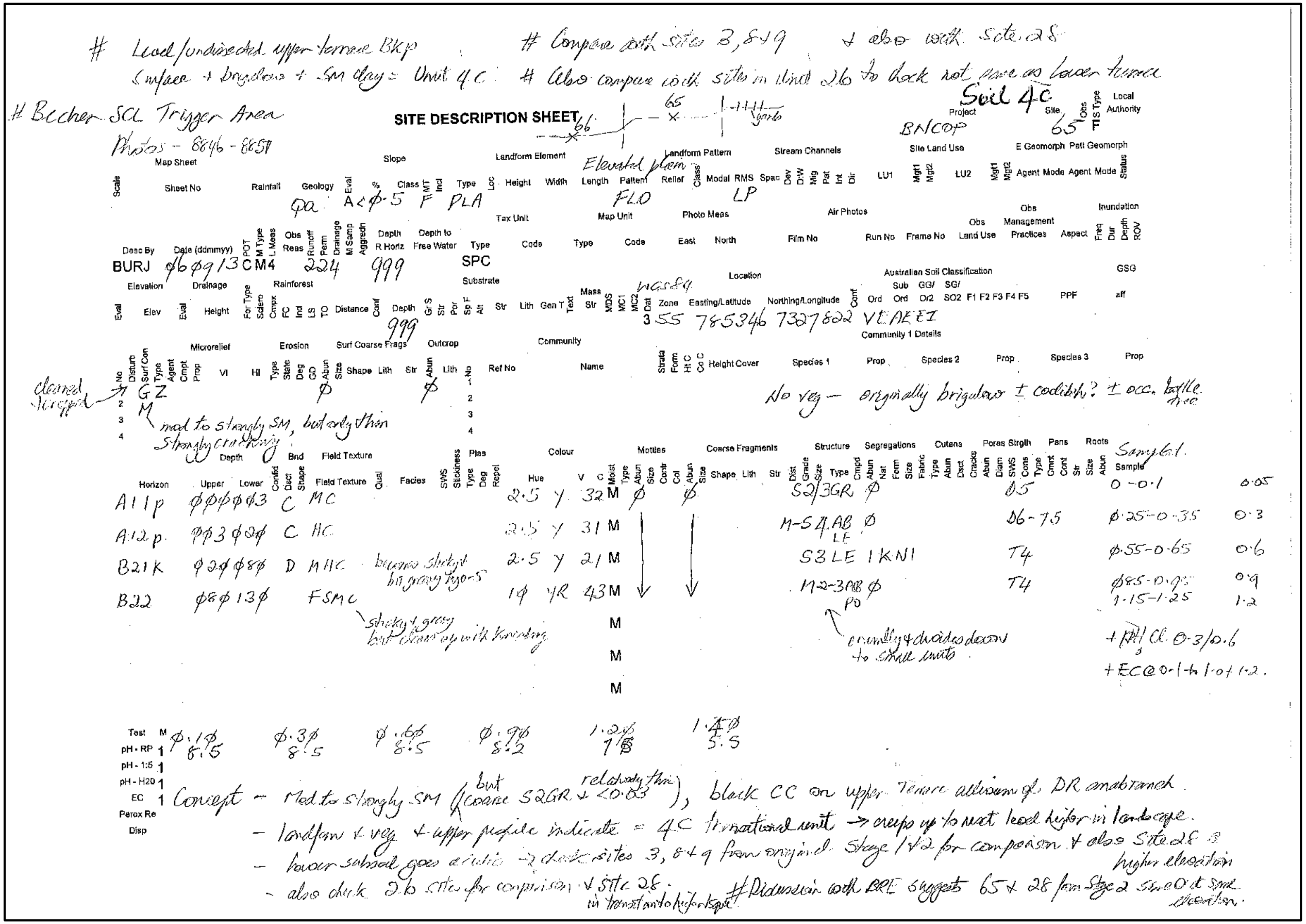
sodic? Texture – not greasy or slippery, suggests non-sodic + prismatic to blocky macro structure – but physically adverse
→ Atherm [illegible] ?? could be sodic.

+ [illegible] 0.3/0.6.
+ E c @ 0.1 [illegible]

Test	M					
		0.10	0.30	0.60	0.90	1.20
pH - RP	1	5.5	5.5	6.5	7.2	7.8
pH - 1:5	1					
pH - H20	1					
EC	1					
Perox Re						
Disp						

Concept – Hardsetting, loamy surfaced, slightly bleached, brown (non-sodic?) T/C on ALP alluvium of Saline Ck

BNCOP 2013 Soil Investigation – Soil 4c
Representative Field Site – 65



Level/undissected upper terrace BKp (surface + brigalow + SM clay = Unit 4C

Compare with sites 3, 8+9 + also with Site 28

Also compare with sites in Unit 2b to check not same as lower terrace

Becher SCL Trigger Area

Photos - 8846 - 8851

SITE DESCRIPTION SHEET

66 65 yards

Project: BNCOP
Soil 4C
Site: 65
Obs: 1
F/S Type: F

Landform Element: Elevated plain
Geology: Qa
Slope: Eval A, % <0.5, Class F
Type: PLA
Pattern: FLO
Modal: LP

Desc By: BURJ
Date (ddmmyy): 060913
POT: C
M Type: M4
Obs Reas: 224
Depth R Horiz: 999
Type: SPC
Substrate Depth: 999
Dat: WGS84 3
Zone: 55
Easting/Latitude: 785346
Northing/Longitude: 7327822
Australian Soil Classification: VE AE EI

Disturb: G (cleared scraped)
Surf Con: Z M (mod to strongly SM, but only thin strongly cracking)
Erosion Abun: 0
Outcrop Abun: 0

Community 1 Details: No veg – originally brigalow ± codibh? ± occ. bottle tree

Horizon	Upper	Lower	Bnd	Field Texture	Hue	V	C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations	Strgth	Sample
A11p	000	003	C	MC	2.5 Y	3	2	M	0	0	S2/3GR	0	05	0 -0.1 0.05
A12p	003	020	C	HC	2.5 Y	3	1	M			M-S4AB LE	0	06-7.5	0.25-0.35 0.3
B21K	020	080	D	MHC	2.5 Y	2	1	M			S3LE	1KN1	T4	0.55-0.65 0.6
B22	080	130		FSMC	10 YR	4	3	M			M2-3AB PO	0	T4	085-0.95 0.9 1.15-1.25 1.2
								M						
								M						
								M						

Sample 6.1

B21K: becomes sticky + bit greasy 10YR5

B22: sticky + greasy but clears up with kneading

M2-3AB PO: crumbly + divides down to small units

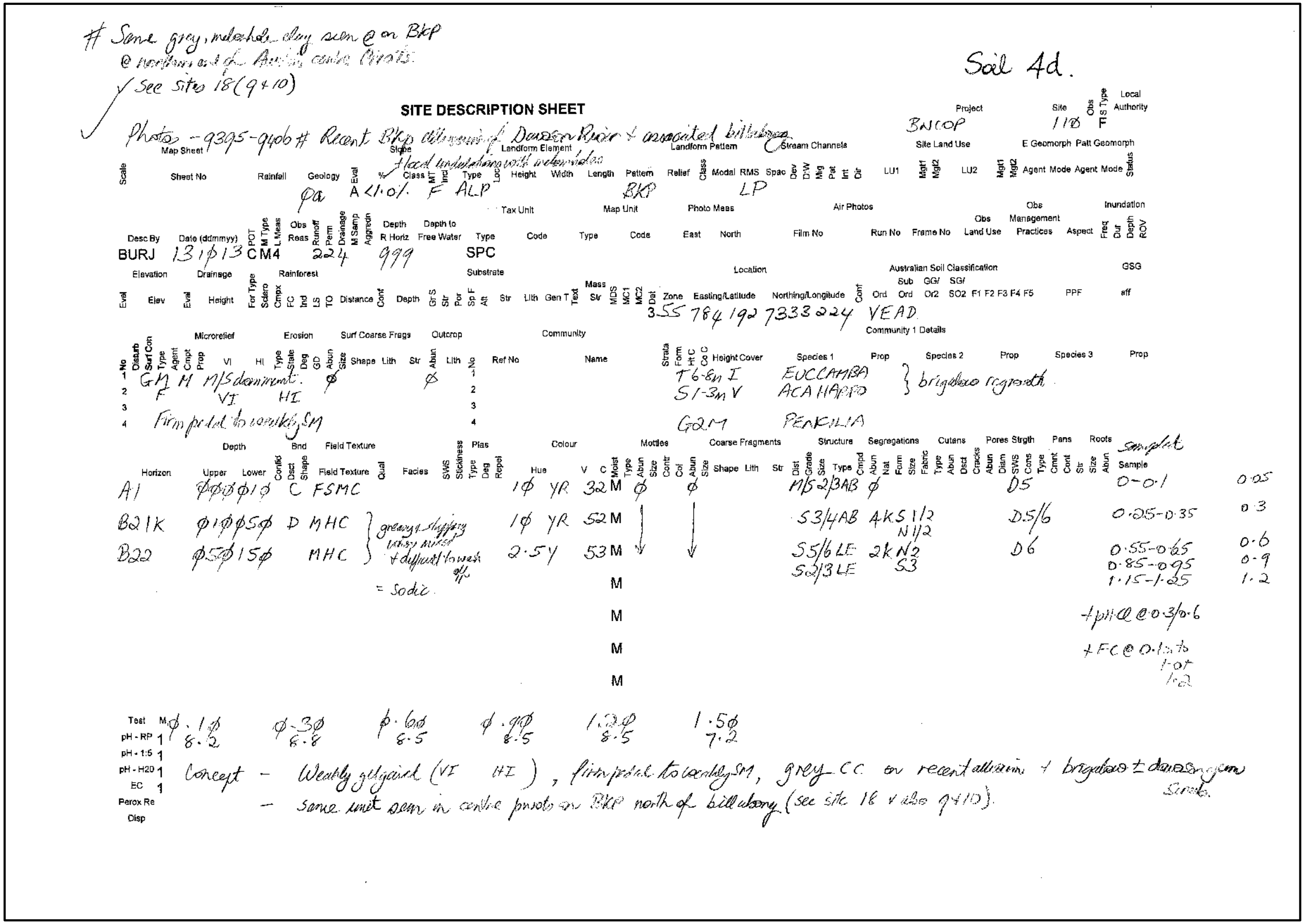
+ pH/Cl 0.3/0.6
+ EC @ 0.1 to 1.0 + 1.2.

Test	M					
		0.10	0.30	0.60	0.90	1.20	1.50
pH - RP	1	8.5	8.5	8.5	8.2	7.5	5.5
pH - 1:5	1						
pH - H20	1						
EC	1						
Perox Re							
Disp							

Concept – Med to strongly SM (but coarse S2GR + relatively thin <0.03), black CC on upper Terrace alluvium of DR anabranch.
– landform + veg. + upper profile indicate = 4C transitional unit → creeps up to next level higher in landscape.
– lower subsoil goes acidic → check sites 3, 8+9 from original Stage 1/2 for comparison + also Site 28 @ higher elevation
– also check 2b sites for comparison + Site 28. in transition to higher landscape

Discussion with BRE suggests 65 + 28 from Stage 2 same @ same elevation.

BNCOP 2013 Soil Investigation – Soil 4d
Representative Field Site – 110



Same grey, melonhole clay seen @ on BKP @ northern end of Austin centre [illegible]
✓ See sites 18 (9 + 10)

Soil 4d.

SITE DESCRIPTION SHEET

Project: BNCOP
Site: 110
Obs
TS Type: F
Local Authority

Photos – 9395–9406 # Recent BKP alluvium of Dawson River + associated billabong

Map Sheet
Slope
Landform Element: Flood undulations with melonholes
Landform Pattern
Stream Channels
Site Land Use
E Geomorph
Patt Geomorph

Scale
Sheet No
Rainfall
Geology: Qa
Slope Eval: A
Slope %: <1.0%
Slope Class: F
Landform Element Type: ALP
Landform Pattern: BKP
Relief Class: LP

Desc By: BURJ
Date (ddmmyy): 131013
POT: C
M Type: M
L Meas: 4
Runoff: 2
Perm: 2
Drainage: 4
Depth R Horiz: 999
Tax Unit Type: SPC

Location: Zone 55; Easting/Latitude 784192; Northing/Longitude 7333224
Dat: 3
Australian Soil Classification: VEAD

Microrelief: GM; Agent: F; Cmpt: M; M/S dominant; VI; HI
Firm pedal to weakly SM
Surf Coarse Frags Abun: 0
Outcrop Abun: 0

Community 1 Details:

Strata	Height Cover	Species 1	Species 2
T	6–8m I	EUCCAMBA	} brigalow regrowth
S	1–3m V	ACA HARPO	
G	2 M	PENCILIA	

Horizon	Depth Upper	Depth Lower	Bnd	Field Texture		Colour Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations	Strgth	Sample
A1	0.00	0.10	C	FSMC		10 YR	32	M	0	0	M/S 2/3 AB	0	D5	0–0.1
B21K	0.10	0.50	D	MHC	} greasy + slippery when moist + difficult to wash off = Sodic	10 YR	52	M	↓	↓	S 3/4 AB	AKS 1/2 N 1/2	D5/6	0.25–0.35
B22	0.50	1.50		MHC		2.5Y	53	M			S 5/6 LE S 2/3 LE	2K N2 S3	D6	0.55–0.65 0.85–0.95 1.15–1.25
								M						
								M						
								M						
								M						

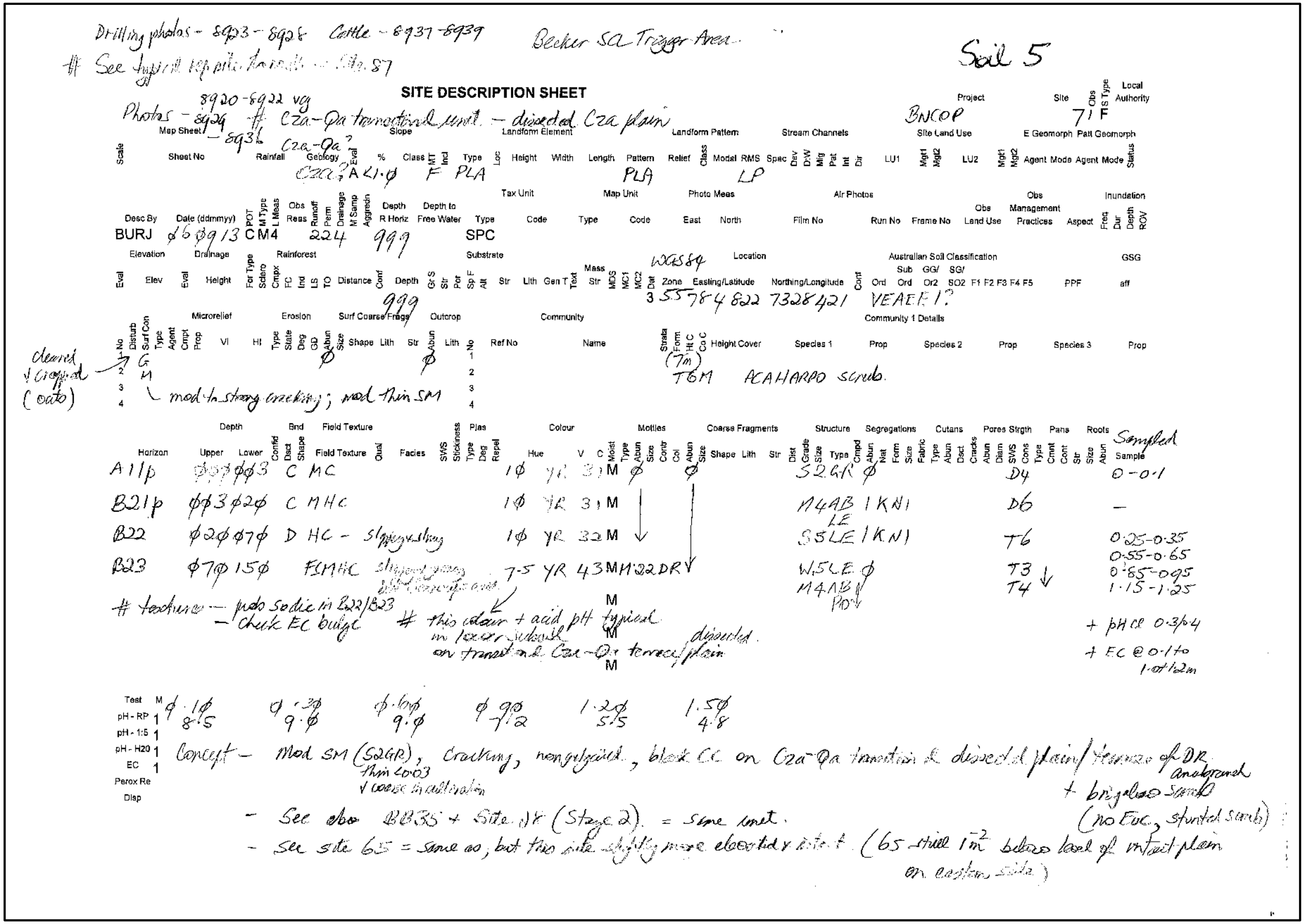
Sample plot: 0.05, 0.3, 0.6, 0.9, 1.2
+ pH Cl @ 0.3/0.6
+ EC @ 0.1 to 1.0 + 1.2

Test						
M	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP 1	8.2	8.8	8.5	8.5	8.5	7.2

pH - 1:5 1
pH - H20 1
EC 1
Perox Re
Disp

Concept – Weakly gilgaied (VI HI), firm pedal to weakly SM, grey CC on recent alluvium + brigalow ± dawson gum scrub.
– Same unit seen in centre photo on BKP north of billabong (see site 18 + also 9+10).

BNCOP 2013 Soil Investigation – Soil 5
Representative Field Site – 71



Drilling photos – 8923 – 8928 Cattle – 8937 – 8939 Becker SA Trigger Area

See typical [illegible] [illegible] – Site 87

Soil 5

SITE DESCRIPTION SHEET

Photos – 8920 – 8922 veg, 8924 – 8936 # Cza – Qa transitional unit – dissected Cza plain

Project: BNCOP Site: 71 Obs: F

Geology: Cza – Qa? Cza? Eval: A Slope %: <1.0 Class: F Landform Element Type: PLA Landform Pattern: PLA Relief Model: LP

Desc By: BURJ Date (ddmmyy): 060913 POT: C M Type: M L Meas: 4 Runoff: 2 Perm: 2 Drainage: 4 Depth R Horiz: 999 Type: SPC

Substrate Depth: 999 Dat: 3 Zone: 55 (WGS84) Easting/Latitude: 784822 Northing/Longitude: 7328421

Australian Soil Classification: VE AE E 1?

Surf Con: 1 G, 2 M (cleared + cropped (oats)) – mod to strong cracking; mod thin SM

Surf Coarse Frags Abun: 0 Outcrop Abun: 0

Community: (7m) T6M ACAHARPO scrub.

Horizon	Upper	Lower	Bnd	Field Texture	Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations Abun	Strgth	Sample (Sampled)
A11p	000	003	C	MC	10YR	31	M	0	0	S2GR	0	D4	0 – 0.1
B21p	003	020	C	MHC	10YR	31	M	↓	↓	M4AB 1KNI		D6	–
B22	020	070	D	HC – slippery/slicky	10YR	32	M	↓	↓	LE S5LE 1KNI		T6	0.25 – 0.35
B23	070	150		FSMHC slippery [illegible] [illegible]	7.5YR	43	M	M 22 DR	↓	W5LE 0 M4AB PO	↓	T3 T4 ↓	0.55 – 0.65 0.85 – 0.95 1.15 – 1.25

texture – probs sodic in B22/B23 – check EC bulge

this colour + acid pH typical in lower subsoil on transitional Cza – Qa terrace/plain dissected.

+ pH CL 0.3/0.4

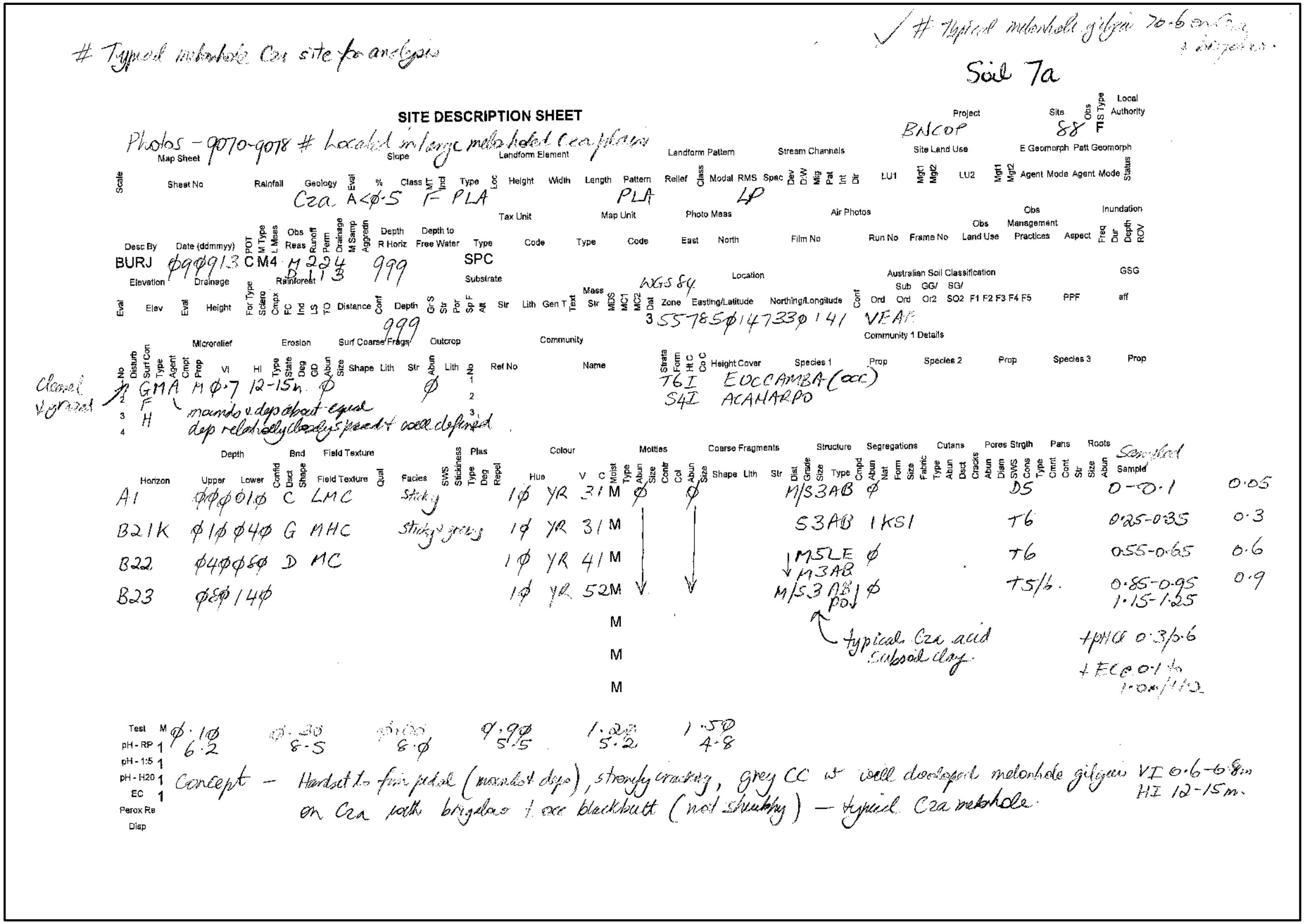
+ EC @ 0.1 to 1.0 + 1.2m

Test	M					
	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP 1	8.5	9.0	9.0	7.2	5.5	4.8
pH - 1:5 1						
pH - H20 1						
EC 1						
Perox Re						
Disp						

Concept – Mod SM (S2GR), thin <0.03 + coarse in cultivation, cracking, nongilgaied, black CC on Cza-Qa transition & dissected plain/terrace of DR anabranch + brigalow scrub (no Euc, stunted scrub)

- See also BB35 + Site 18 (Stage 2) = same unit.
- See site 65 = same as, but this site slightly more elevated + [illegible] (65 still 1m² below level of intact plain on eastern side)

BNCOP 2013 Soil Investigation – Soil 7a
Representative Field Site – 88



Typical melonhole Cza site for analysis

✓ # Typical melonhole gilgai 70·6 on Cza [illegible]

Soil 7a

SITE DESCRIPTION SHEET

Project: BNCOP
Site: 88
Obs: F

Photos – 9070-9078 # Located in large melonholed Cza plains

Geology: Cza
Slope: A<0·5
Landform Element: F PLA
Landform Pattern: PLA
Relief: LP

Desc By: BURJ
Date (ddmmyy): 090913
PQT: C
M Type: M4
Obs Reas: M
Drainage: 2 2 4 / B 1 3
Depth R Horiz: 999
Substrate Type: SPC
Depth: 999

Location: WGS 84
Dat: 3
Zone / Easting/Latitude / Northing/Longitude: 55785014733014 1 41
Australian Soil Classification: VEAA

Microrelief:
1 GMA M 0·7 12-15m 0 0
2 F
3 H

mounds & deps about equal
deps relatively closely spaced + well defined

Closed
Vegetated

Community 1 Details:
T6I EUCCAMBA (occ)
S4I ACAHARPO

Horizon	Depth Upper	Depth Lower	Bnd	Field Texture	Facies	Colour	Moist	Mottles	Coarse Fragments	Structure	Segregations	Strgth	Sample	
A1	000	010	C	LMC	Sticky	10 YR 31	M	0	0	M/S3AB	0	DS	0-0·1	0·05
B21K	010	040	G	MHC	Sticky & greasy	10 YR 31	M	↓	↓	S3AB	1KS1	T6	0·25-0·35	0·3
B22	040	080	D	MC		10 YR 41	M	↓	↓	M5LE ↓ M3AB	0	T6	0·55-0·65	0·6
B23	080	140				10 YR 52	M	↓	↓	M/S3AB PO	0	T5/6	0·85-0·95 1·15-1·25	0·9
							M							
							M							
							M							

typical Cza acid subsoil clay

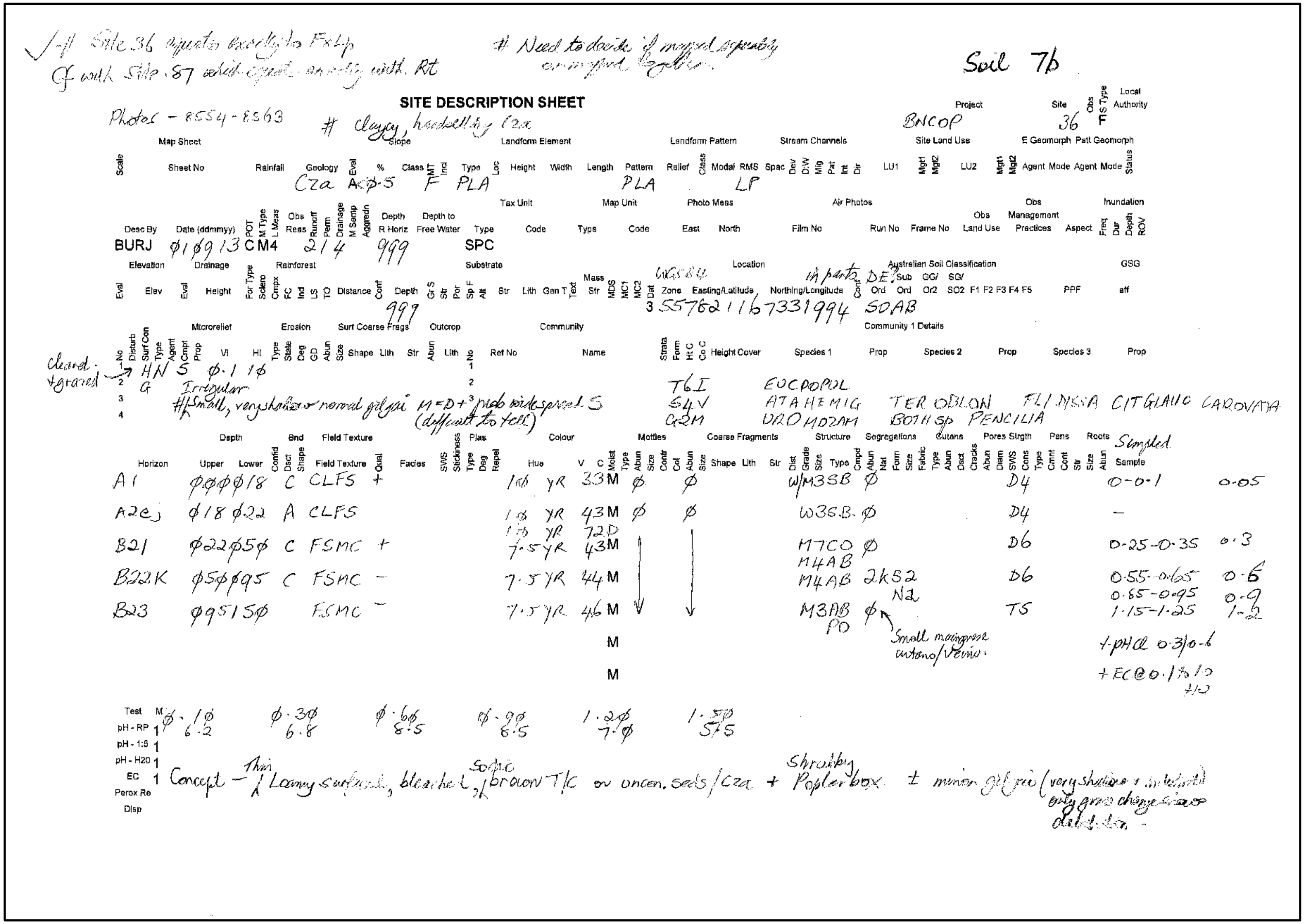
Sampled

+pHCa 0·3/0·6
+ECe 0·1 to 1·0m/H2O

Test	M					
	0·10	0·30	0·60	0·90	1·20	1·50
pH - RP	1 6·2	8·5	8·0	5·5	5·2	4·8
pH - 1:5	1					
pH - H20	1					
EC	1					
Perox Re						
Disp						

Concept – Hardset to firm pedal (mounds & deps), strongly cracking, grey CC w well developed melonhole gilgai VI 0·6-0·8m HI 12-15m. on Cza with brigalow & occ blackbutt (not shrubby) – typical Cza melonhole.

BNCOP 2013 Soil Investigation – Soil 7b
Representative Field Site – 36



✓ # Site 36 equates exactly to Fx Lp
Cf with Site 87 which equates exactly with Rt

Need to decide if mapped separately or mapped together

Soil 7b

SITE DESCRIPTION SHEET

Photos – 8554 - 8563

clayey, hardsetting Cza

Project: BNCOP
Site: 36
Obs: F
Geology: Cza
Slope Eval / %: Ac0.5
Class: F
Landform Element Type: PLA
Landform Pattern: PLA
Modal: LP

Desc By: BURJ
Date (ddmmyy): 010913
POT: C
M Type: M4
Runoff / Perm / Drainage: 2 1 4
Depth R Horiz: 999
Tax Unit Type: SPC

Substrate Depth: 999
Location: WGS84
Dat / Zone / Easting/Latitude / Northing/Longitude: 3 557621167331994
Australian Soil Classification: in parts DE? SO AB

Microrelief:
- 1 HN S 0.1 10 ← cleared + grazed
- 2 G Irregular
- 3 # Small, very shallow normal gilgai M=D+ prob widespread S (difficult to tell)
- 4

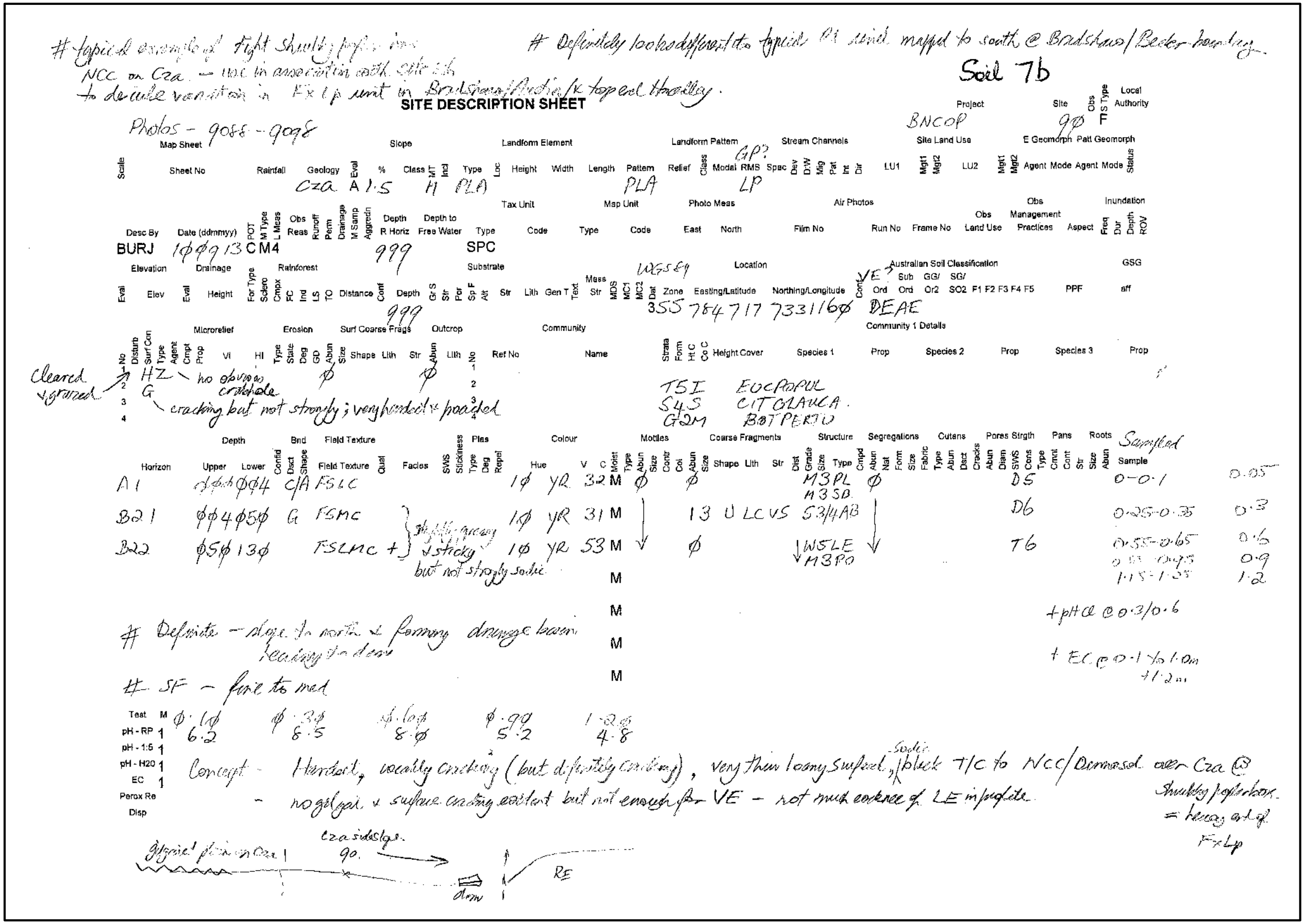
Strata Form	Species 1	Species 2	Species 3	
T6I	EUCPOPUL			
S4V	ATAHEMIG	TER OBLON	FLINDSSA CITGLAUC	CAROVATA
G2M	URO MOZAM	BOTH sp	PENCILIA	

Horizon	Upper	Lower	Bnd	Field Texture	Qual	Hue	V C	Moist	Mottles	Coarse Fragments	Structure	Segregations	Pores Strgth	Sample (Sampled)	
A1	000	018	C	CLFS	+	10YR	33	M	0	0	W/M3SB	0	D4	0-0.1	0.05
A2ej	018	022	A	CLFS		10YR 10YR	43 72	M D	0	0	W3SB	0	D4	–	
B21	022	050	C	FSMC	+	7.5YR	43	M	↓	↓	M7CO M4AB	0	D6	0.25-0.35	0.3
B22K	050	095	C	FSMC	–	7.5YR	44	M	↓	↓	M4AB	2KS2 N2	D6	0.55-0.65 0.65-0.95	0.6 0.9
B23	095	150		FSMC	–	7.5YR	46	M	↓	↓	M3AB PO	0 ← Small manganese cutans/Veins	T5	1.15-1.25	1.2
								M						+pHCl 0.3/0.6	
								M						+EC@0.1 to 1.0 1.2	

Test						
M	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP 1	6.2	6.8	8.5	8.5	7.0	5.5
pH - 1:5 1						
pH - H20 1						
EC 1						
Perox Re						
Disp						

Concept – Thin Loamy surface, bleached, sodic brown T/C on uncon. seds/Cza + Shrubby Poplar box ± minor gilgai (very shallow + indistinct only grass change since disturbance) –

BNCOP 2013 Soil Investigation – Soil 7b
Representative Field Site – 90



typical example of tight Shrubby poplar box NCC on Cza – occ in association with site 5b to denote variation in Fx Lp unit in Bradshaw/Nudie/K topsoil Heavilly.

Definitely looks different to typical [illegible] unit mapped to south @ Bradshaw/Becker boundary.

Soil 7b

SITE DESCRIPTION SHEET

Project: BNCOP
Site: 90
FS Type: F

Photos – 9088 – 9098

Geology: Cza
Eval: A
Slope %: 1.5
Slope Class: H
Landform Element Type: PLA
Landform Pattern: PLA
Modal: GP?
RMS: LP

Desc By: BURJ
Date (ddmmyy): 100913
POT: C
M Type: M
L Meas: 4
Depth R Horiz: 999
Type: SPC

Substrate Depth: 999

Location: WGS84
Zone: 55
Easting/Latitude: 784717
Northing/Longitude: 7331160
Australian Soil Classification: VE?
Ord: DE
Sub Ord: AE

Cleared & grazed
Microrelief: 1 HZ – no obvious crabhole
2 G – cracking but not strongly; very hardset & poached
Surf Coarse Frags Abun: 0
Outcrop Abun: 0

Community 1 Details:

Strata/Form/Ht C/Co C	Species 1
T5I	EUCPOPUL
S4S	CITGLAUCA.
G2M	BOTPERTU

Horizon	Upper	Lower	Bnd	Field Texture	Hue	V C	Moist	Mottles Abun	Coarse Fragments	Structure	Segregations Abun	Pores Strgth	Sample	Sampled
A1	000	004	C/A	FSLC	10 YR	32	M	0	0	M3PL M3SB.	0	D5	0–0.1	0.05
B21	004	050	G	FSMC	10 YR	31	M	↓	13 U LCVS	53/4AB	↓	D6	0.25–0.35	0.3
B22	050	130		FSLMC +	10 YR	53	M	↓	0	↓ WSLE M3PO	↓	T6	0.55–0.65	0.6
							M						0.85–0.95	0.9
							M						1.15–1.25	1.2
							M							
							M							
							M							

} slightly greasy & sticky but not strongly sodic

+pH Cl @ 0.3/0.6

+ EC @ 0.1 to 1.0m +1.2m

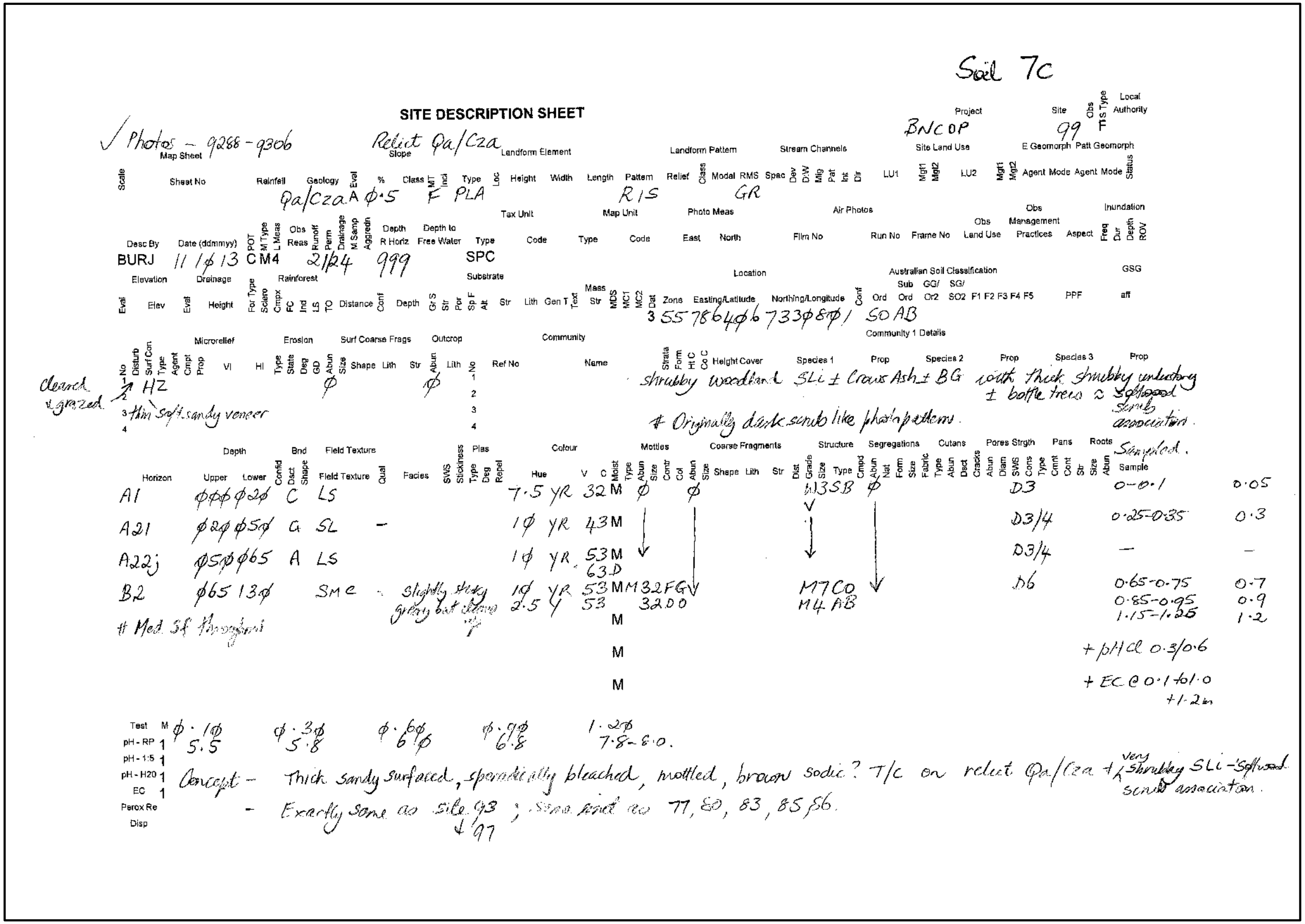
Definite – slope to north & forming drainage basin leading to dam

SF – fine to med

Test	M	0.10	0.30	0.60	0.90	1.20
pH - RP	1	6.2	8.5	8.0	5.2	4.8
pH - 1:5	1					
pH - H20	1					
EC	1					
Perox Re						
Disp						

Concept – Hardset, locally cracking (but definitely cracking), very thin loamy surfaced, sodic black T/C to NCC/Dermosol over Cza @ Shrubby poplar box.
– no gilgai & surface cracking evident but not enough for VE – not much evidence of LE in profile.
= heavy end of Fx Lp

BNCOP 2013 Soil Investigation – Soil 7c
Representative Field Site – 99



Soil 7c

SITE DESCRIPTION SHEET

Project: BNCOP
Site: 99
Obs:
T/S Type: F
Local Authority:

✓ Photos – 9288-9306

Map Sheet:
Slope: Relict Qa/Cza
Geology: Qa/Cza
Eval: A
%: 0.5
Class: F
Landform Element Type: PLA
Landform Pattern: R I S
Modal RMS: GR

Desc By: BURJ
Date (ddmmyy): 11/0/13
POT: C
M Type: M4
Obs Reas: 2
Drainage: 4
Depth R Horiz: 999
Type: SPC

Dat: 3
Zone: 55
Easting/Latitude: 786406
Northing/Longitude: 7330801
Australian Soil Classification Ord: SO
Sub Ord: AB

Microrelief:
1 HZ
2 cleared & grazed
3 thin soft sandy veneer
4

Surf Coarse Frags Abun: 0
Outcrop Abun: 0

Community Name: shrubby woodland
Species 1: SLi ± Crows Ash ± BG with thick shrubby understory ± bottle trees ≈ Softwood Scrub association.

Originally dark scrub like photo patterns.

Sampled.

Horizon	Upper	Lower	Dsct	Field Texture	Qual	Facies / Plas	Hue	V C	Moist	Mottles	Coarse Fragments Abun	Structure	Segregations Abun	Strgth	Sample	
A1	000	020	C	LS			7.5 YR	32	M	0	0	W3SB	0	D3	0-0.1	0.05
A21	020	050	G	SL	—		10 YR	43	M	↓	↓	↓	↓	D3/4	0.25-0.35	0.3
A22j	050	065	A	LS			10 YR	53 63	M D	↓	↓	↓	↓	D3/4	—	—
B2	065	130		SMC		slightly sticky greasy but [illegible]	10 YR 2.5 Y	53 53	M	M32FG 32DO	↓	M7CO M4AB	↓	D6	0.65-0.75 0.85-0.95 1.15-1.25	0.7 0.9 1.2
									M							
									M							
									M							

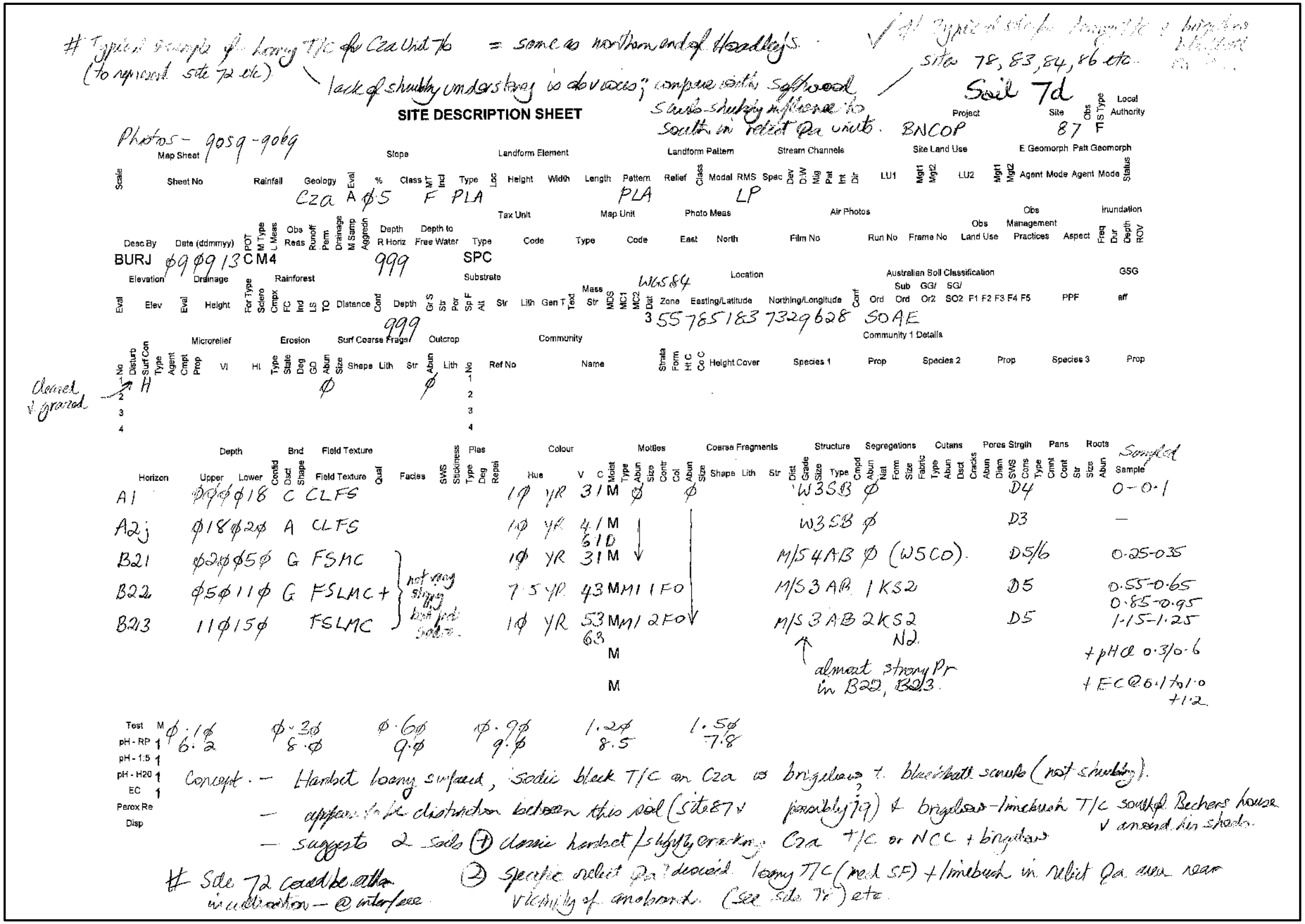
Med. SF throughout

+ pHCl 0.3/0.6
+ EC @ 0.1 to 1.0 + 1.2m

Test M	0.10	0.30	0.60	0.90	1.20
pH - RP 1	5.5	5.8	6.0	6.8	7.8-8.0.
pH - 1:5 1					
pH - H20 1					
EC 1					
Perox Re					
Disp					

Concept – Thick sandy surfaced, sporadically bleached, mottled, brown sodic? T/C on relict Qa/Cza + very shrubby SLi-Softwood scrub association.
– Exactly same as site 93 & 97; same kind as 77, 80, 83, 85, 86.

BNCOP 2013 Soil Investigation – Soil 7d
Representative Field Site – 87



Typical example of loamy T/C for Cza Unit 7b (to represent site 72 etc) = same as northern end of Headley's.
\ lack of shrubby understorey is obvious; compare with Softwood scrub-shrubby influence to South in relict Qa units.

✓ [illegible] sites 78, 83, 84, 86 etc. [illegible]

Soil 7d

SITE DESCRIPTION SHEET

Project: BNCOP
Site: 87
Obs Type: F

Photos – 9059 - 9069

Geology: Cza
Slope Eval: A
Slope %: 05
Slope Class: F
Landform Element Type: PLA
Landform Pattern: PLA
Relief Modal RMS: LP

Desc By: BURJ
Date (ddmmyy): 090913
POT: C
M Type: M
L Meas: 4
Depth R Horiz: 999
Substrate Type: SPC
Depth: 999
Location: WGS84
Zone: 3 55
Easting/Latitude: 785183
Northing/Longitude: 7329628
Australian Soil Classification: SOAE

Cleared & grazed → Disturb: H
Erosion Abun: 0
Outcrop Abun: 0

Horizon	Depth Upper	Depth Lower	Bnd Dsct	Field Texture	Colour Hue	V/C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations	Strgth	Sample
A1	000	018	C	CLFS	10 YR	3/1	M	0	0	W3SB	0	D4	0-0.1
A2j	018	020	A	CLFS	10 YR	4/1 6/1	M D			W3SB	0	D3	—
B21	020	050	G	FSMC	10 YR	3/1	M			M/S4AB	0 (W5CO).	D5/6	0.25-035
B22	050	110	G	FSLMC+	7.5 YR	43	M	M1 1FO		M/S3AB	1KS2	D5	0.55-0.65 0.85-0.95
B23	110	150		FSLMC	10 YR	53 63	M	M1 2FO		M/S3AB	2KS2 Nd.	D5	1.15-1.25

B21–B23: not very strong but prob sodic.

↑ almost strong Pr in B22, B23.

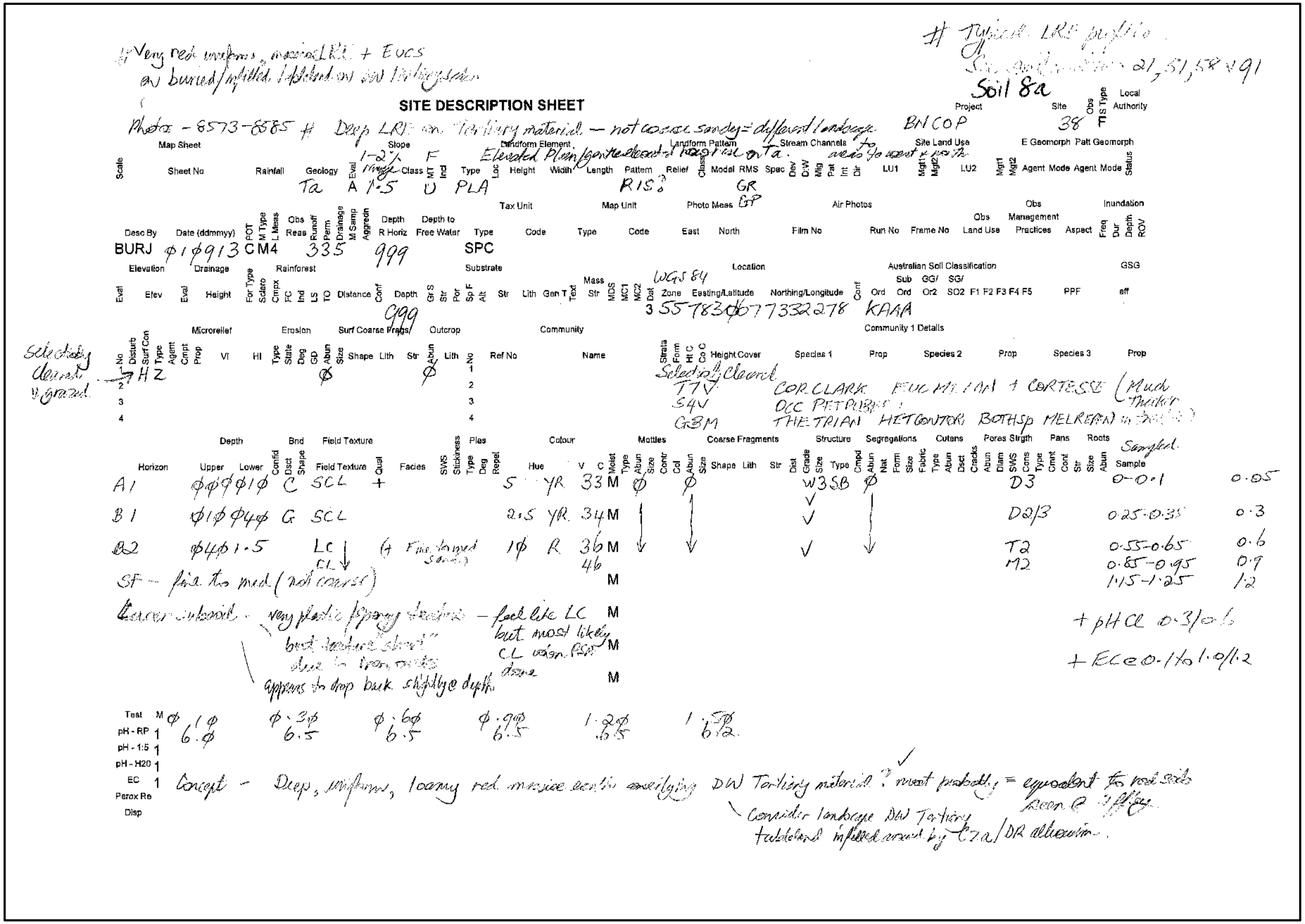
Sampled: +pHCl 0.3/0.6; +EC@0.1 to 1.0 +1.2.

Test						
Depth	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP	6.2	8.0	9.0	9.0	8.5	7.8

Concept. – Hardset loamy surfaced, sodic black T/C on Cza w brigalow + blackbutt scrub (not shrubby).
– appears to be distinction between this soil (site 87 & possibly 79) + brigalow-limebush T/C south of Bechers house & around his sheds.
– suggests 2 soils ① classic hardset/slightly cracking Cza T/C or NCC + brigalow
② specific relict Qa? derived loamy T/C (red SF) + limebush in relict Qa area near vicinity of anabranch (see site 78) etc.

Site 72 could be either in cultivation – @ interface

BNCOP 2013 Soil Investigation – Soil 8a
Representative Field Site – 38



Very red uniform, massive LRE + Eucs
on buried/infilled tableland on DW Tertiary [illegible]

Typical LRE profile
[illegible] 21, 51, 58 & 91

Soil 8a

SITE DESCRIPTION SHEET

Photos – 8573-8585 # Deep LRE on Tertiary material – not coarse sandy = different landscape

Project: BNCOP
Site: 38
Obs
TS Type: F
Local Authority

Map Sheet
Slope: 1-2% range
Landform Element: Elevated Plain/gentle [illegible]
Landform Pattern: [illegible] on Ta.
Stream Channels: to areas to west & north
Site Land Use
E Geomorph
Patt Geomorph

Scale | Sheet No | Rainfall | Geology: Ta | Eval: A | 1.5 | Class: D | MT | Ind | Type: PLA | Loc | Height | Width | Length | Pattern: RIS? | Relief | Class | Model | RMS: GR | Spac | Dev | D:W | Mig | Pat | Int | Dir | LU1 | Mgt1 | Mgt2 | LU2 | Mgt1 | Mgt2 | Agent | Mode | Agent | Mode | Status

Tax Unit
Map Unit
Photo Meas: GP
Air Photos
Obs Management
Inundation

Desc By: BURJ | Date (ddmmyy): 010913 | POT: C | M Type: M4 | L Meas | Obs Reas | Runoff: 3 | Perm: 3 | Drainage: 5 | M Samp | Aggregn | Depth R Horiz: 999 | Depth to Free Water | Type: SPC | Code | Type | Code | East | North | Film No | Run No | Frame No | Obs Land Use | Practices | Aspect | Freq | Dur | Depth | ROV

Elevation
Drainage
Rainforest
Substrate
Location: WGS 84
Australian Soil Classification
GSG

Eval | Elev | Eval | Height | For Type | Sclero | Cmpx | FC | Ind | LS | TO | Distance | Conf | Depth: 999 | Gr S | Str | Por | Sp F | Alt | Str | Lith | Gen T | Text | Mass Str | MDS | MC1 | MC2 | Dat: 3 | Zone: 55 | Easting/Latitude: 783067 | Northing/Longitude: 7332278 | Conf | Ord: K | Sub Ord: A | GG/ Or2: A | SG/ SO2: A | F1 | F2 | F3 | F4 | F5 | PPF | eff

Microrelief
Erosion
Surf Coarse Frags
Outcrop
Community
Community 1 Details

Selectively cleared & grazed

No	Disturb	Surf Con	Type	Agent	Cmpt	Prop	VI	HI	Type	State	Deg	GD	Abun	Size	Shape	Lith	Str	Abun	Lith
1	H	Z											0					0	
2																			
3																			
4																			

No	Ref No	Name	Strata	Form	Ht C	Co C	Height	Cover	Species 1	Prop	Species 2	Prop	Species 3	Prop
		Selectively Cleared												
1			T	7	V				COR CLARK		EUC MELAN		+ CORTESSE	(Much thicker
2			S	4	V				OCC PETPUBE					
3			G	3	M				THE TRIAN		HETCONTOR		BOTHSP MELREPEN	in [illegible])
4														

Depth | Bnd | Field Texture | Plas | Colour | Mottles | Coarse Fragments | Structure | Segregations | Cutans | Pores | Strgth | Pans | Roots

Horizon	Upper	Lower	Bnd	Field Texture	Qual	Facies	Hue	V C	Moist	Mottles Abun	Col Abun	Structure	Segregations Abun	Strgth	Sample (Sampled)	
A1	0.00	0.10	C	SCL	+		5 YR	33	M	0	0	W3SB	0	D3	0–0.1	0.05
B1	0.10	0.40	G	SCL			2.5 YR	34	M	↓	↓	✓	↓	D2/3	0.25–0.35	0.3
B2	0.40	1.5		LC ↓ CL		(+ Fine to med sand)	10 R	36 46	M	↓	↓	✓	↓	T2 M2	0.55–0.65 0.85–0.95 1.15–1.25	0.6 0.9 1.2

SF – fine to med (not coarse)

Coarser subsoil – very plastic/spongy texture – feel like LC but most likely CL when PSA done
but texture short due to iron oxides
appears to drop back slightly @ depth

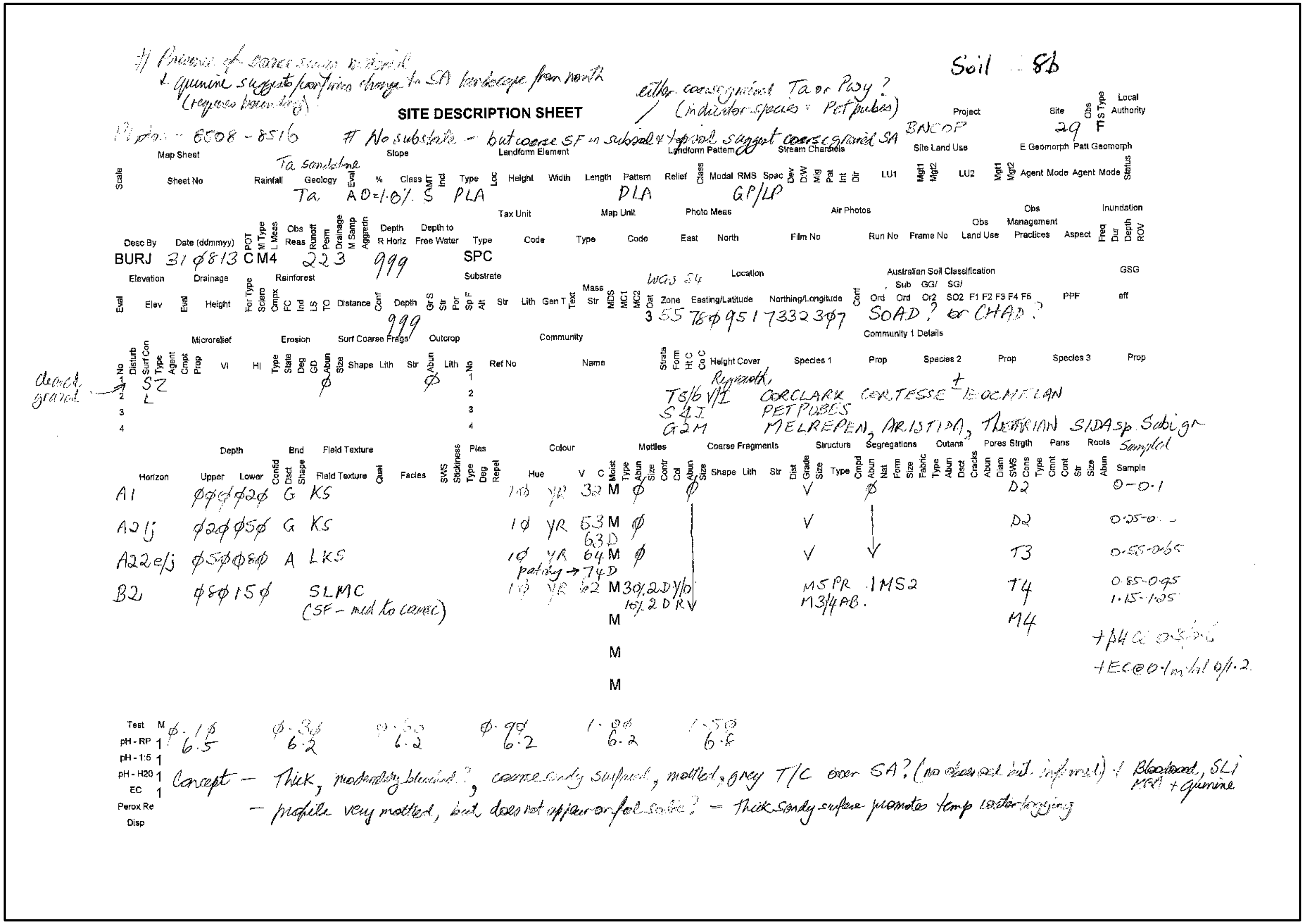
+ pH Cl 0.3/0.6

+ EC @ 0.1 to 1.0/1.2

Test	M						
		0.10	0.30	0.60	0.90	1.20	1.50
pH - RP	1	6.0	6.5	6.5	6.5	6.5	6.2
pH - 1:5	1						
pH - H20	1						
EC	1						
Perox Re							
Disp							

Concept – Deep, uniform, loamy red massive earths overlying DW Tertiary material ? most probably ✓ = equivalent to red soils seen @ [illegible]
Consider landscape DW Tertiary tableland infilled around by Cza/DR alluvium.

BNCOP 2013 Soil Investigation – Soil 8b
Representative Field Site – 29



Presence of coarse sand in topsoil + quinine suggests possible change to SA landscape from north (requires boundary)

either coarse grained Ta or Pawy? / (indicator species = Pet pubes)

Soil 8b

SITE DESCRIPTION SHEET

Photos – 6508 - 8516

No substrate – but coarse SF in subsoil + topsoil suggest coarse grained SA

Project: BNCOP
Site: 29

Map Sheet: Scale, Sheet No
Rainfall
Geology: Ta (Ta sandstone)
Slope: Eval A, % 0–1.0%, Class S
Landform Element: Type PLA
Landform Pattern: PLA
GP/LP

Desc By: BURJ
Date (ddmmyy): 310813
POT: C
M Type: M4
Runoff: 2
Perm: 2
Drainage: 3
Depth R Horiz: 999
Substrate Type: SPC
Rainforest Depth: 999
Location: WGS 84, Dat 3, Zone 55, Easting/Latitude 780951, Northing/Longitude 7332307
Australian Soil Classification: SOAD? or CHAD?

Surf Con (cleared, grazed →): 1 SZ, 2 L
Surf Coarse Frags: Abun 0
Outcrop: Abun 0

Community 1 Details: Regrowth
T5/6 V/I: CORCLARK, CORTESSE ± EUCMELAN
S4I: PETPUBES
G2M: MELREPEN, ARISTIDA, THEMTRIAN, SIDA sp. Sabigr

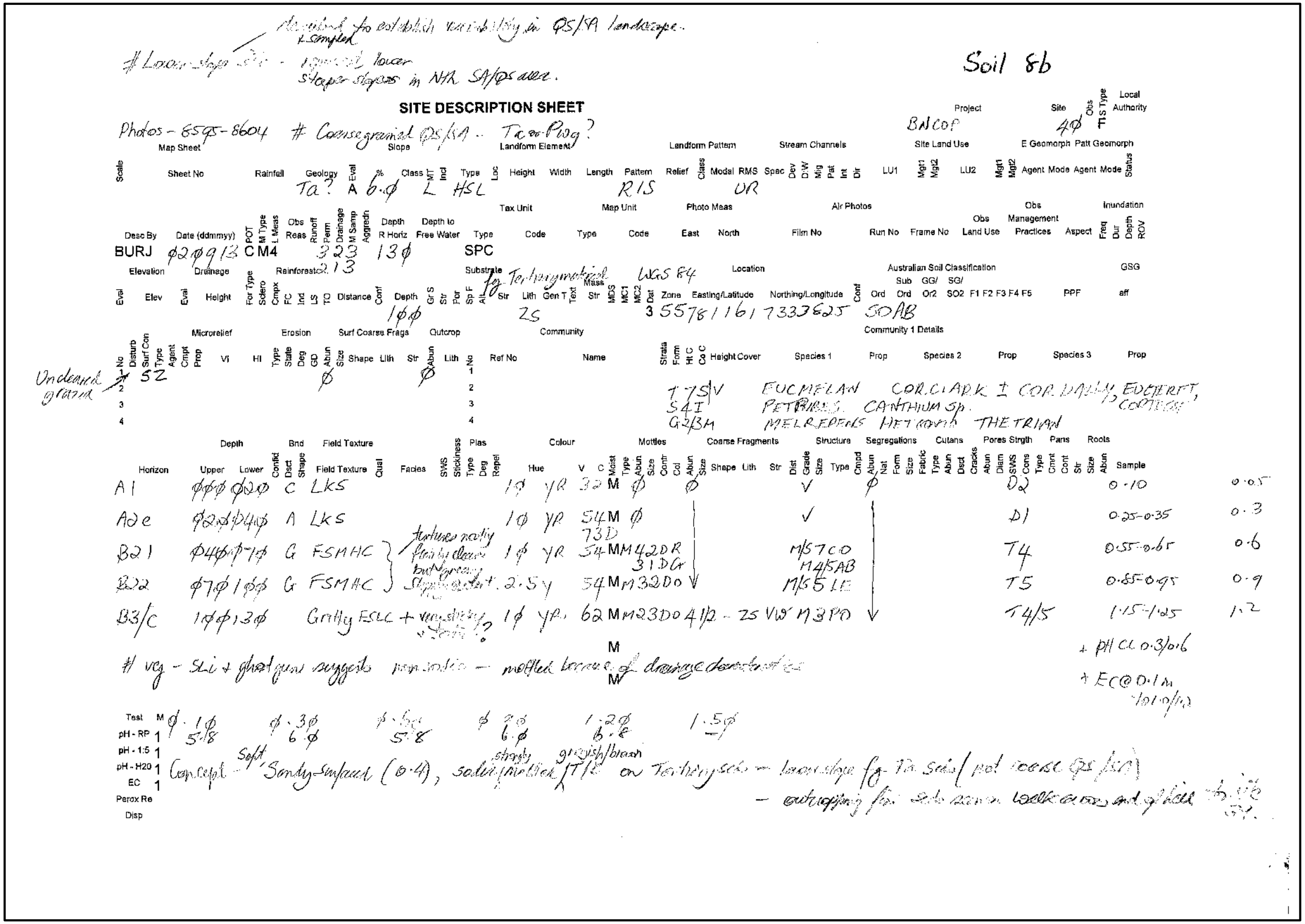
Roots: Sampled

Horizon	Depth Upper	Depth Lower	Bnd Dsct	Field Texture	Colour Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure Grade	Segregations Abun	Strgth	Sample
A1	000	020	G	KS	10 YR	32	M	0	0	V	0	D2	0–0.1
A21j	020	050	G	KS	10 YR	53 63D	M	0		V		D2	0.25–0. –
A22e/j	050	080	A	LKS	10 YR patchy →	64 74D	M	0		V	V	T3	0.55–0.65
B2	080	150		SLMC (SF – med to coarse)	10 YR	62	M	30% 2 D Y/O 10% 2 D R		M5PR M3/4AB.	1MS2	T4	0.85–0.95 1.15–1.05
							M					M4	
							M						+pH @ 0.5–0.6
							M						+EC@0.1m/hl 0/1.2.

Test	M	0.10	0.30	0.60	0.90	1.00	1.50
pH - RP	1	6.5	6.2	6.2	6.2	6.2	6.8
pH - 1:5	1						
pH - H20	1						
EC	1						
Perox Re							
Disp							

Concept – Thick, moderately bleached?, coarse sandy surface, mottled, grey T/C over SA? (no observed but inferred) + Bloodwood, SLI, MRA + quinine
– profile very mottled, but does not appear or feel sodic? = Thick sandy surface promotes temp waterlogging

BNCOP 2013 Soil Investigation – Soil 8b
Representative Field Site – 40



described to establish variability in QS/SA landscape. + sampled

Lower slope [illegible] - typical lower steeper slopes in Nth SA/QS area.

Soil 8b

SITE DESCRIPTION SHEET

Photos - 6595-8604 # Coarsegrained QS/SA - Ta or Pwg?

Project: BNCOP
Site: 40
Obs / TS Type: 1 F

Geology: Ta?
Slope Eval: A
%: 6.0
Class: L
Landform Element Type: HSL
Landform Pattern: RIS
Relief Modal: UR

Desc By: BURJ
Date (ddmmyy): 020913
POT: C
M Type: M4
Runoff / Perm / Drainage: 3 2 3
Depth R Horiz: 130
Type: SPC
Drainage: 2 1 3

Substrate: fg Tertiary material
Depth: 100
Lith: ZS
Location: WGS 84
Dat: 3
Zone: 55
Easting/Latitude: 781161
Northing/Longitude: 7333625
Australian Soil Classification: SO AB

Undeared grazed
Disturb: 5
Surf Con: Z
Surf Coarse Frags Abun: 0
Outcrop Abun: 0

Strata Form / Ht C / Co C	Species 1	Species 2	Species 3
T 7 S V	EUC MELAN	COR CLARK I COR DALLY, EUC TERET,	CORTEN
S 4 I	PETRIES	CANTHIUM sp.	
G 2 3 M	MEL REPENS	HET CONT	THE TRIAN

Horizon	Upper	Lower	Bnd	Field Texture		Colour	Mottles	Coarse Fragments	Structure	Segregations	Pores Strgth	Sample	
A1	000	020	C	LKS		10 YR 32 M	0	0	✓	0	D2	0 -10	0·05
A2e	020	040	A	LKS		10 YR 54 M 73D	0		✓		D1	0.25-0.35	0·3
B21	040	070	G	FSMHC	textures really fairly clear but greasy	10 YR 54 M	M 42 D R 31 D Gr		M/S 7 CO M 4/5 AB		T4	0.55-0.65	0·6
B22	070	100	G	FSMHC	slightly [illegible]	2.5Y 54 M	M 32 D O		M/S 5 LE		T5	0.85-0.95	0·9
B3/C	100	130		Gritty ESLC + very sticky?		10 YR 62 M	M 23 D O	4 1/2 - ZS	VW M 3 PO		T4/5	1.15-1.25	1.2

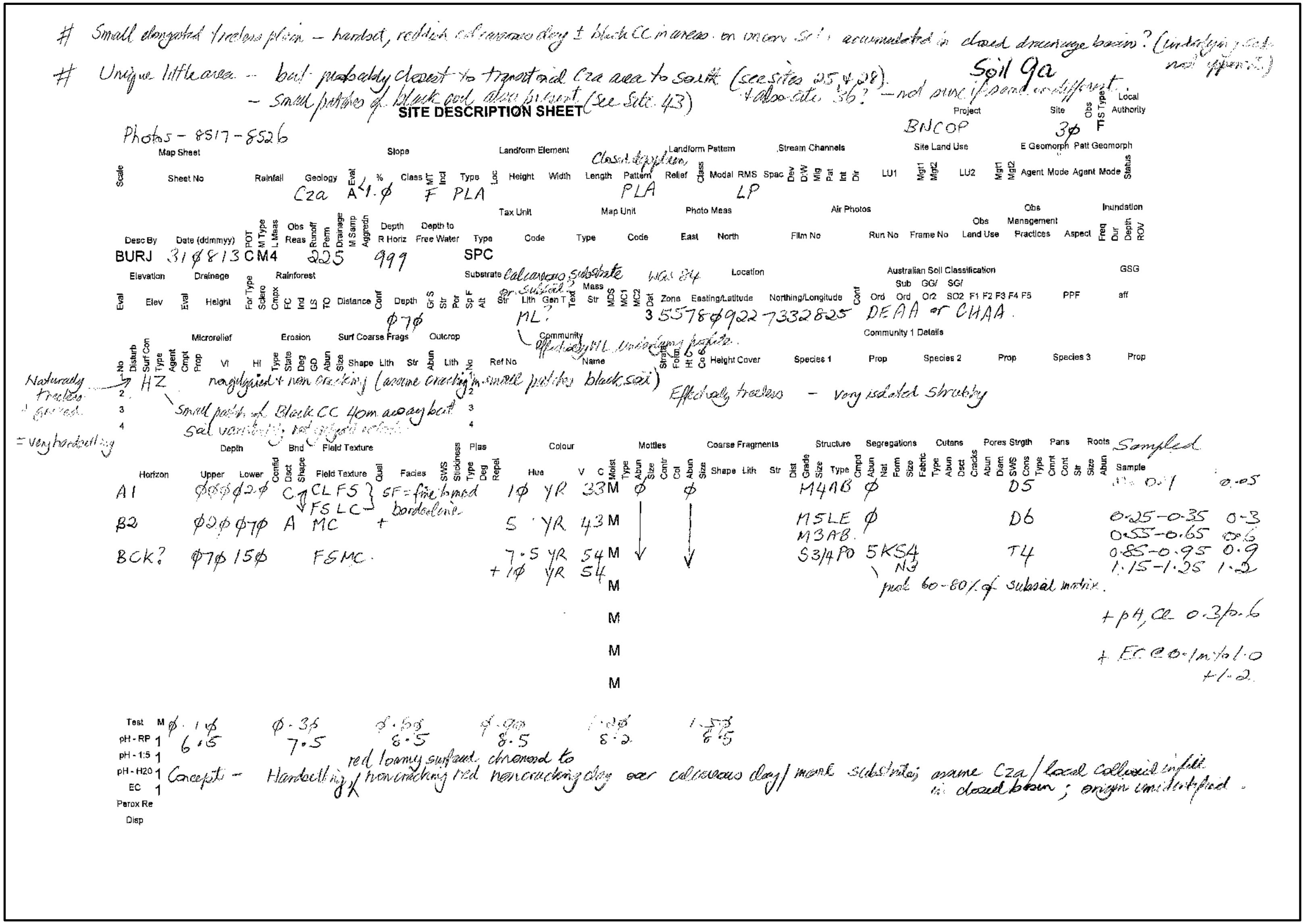
veg - SLi + ghost gum suggests non sodic - mottled because of drainage [illegible]

+ pH CL 0.3/0.6
+ EC@ 0.1m
10/09/13

Test M	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP 1	5.8	6.0	5.8	6.0	6.8	-
pH - 1:5 1						
pH - H20 1						
EC 1						
Perox Re						
Disp						

Concept - Soft Sandy surfaced (0.4), strongly sodic mottled greyish/brown T/R on Tertiary seds - lower slope fg Ta seds (not coarse QS/SA)
- outcropping [illegible] [illegible] [illegible] and [illegible]

BNCOP 2013 Soil Investigation – Soil 9a
Representative Field Site – 30



Small elongated treeless plain – hardset, reddish calcareous clay ± black CC in areas. on uncon soil accumulated in closed drainage basin? (underlying rock not apparent)

Unique little area – but probably closest to transported Cza area to south (see sites 25 & 28). + also site 36? – not sure if same or different.
– small patches of black soil also present (see Site 43)

Soil 9a

SITE DESCRIPTION SHEET

Photos – 8517 – 8526

Project: BNCOP
Site: 30
Obs
TS Type: F
Local Authority

Map Sheet: Scale, Sheet No
Rainfall
Geology: Cza
Slope: Eval A, % <1.0, Class, MT, Incl
Landform Element: Type PLA, Loc, Height, Width, Length
Landform Pattern: Pattern PLA (Closed depression), Relief, Class, Modal, RMS LP
Stream Channels: Spac, Dev, D:W, Mig, Pat, Int, Dir
Site Land Use: LU1, Mgt1, Mgt2, LU2, Mgt1, Mgt2
E Geomorph: Agent, Mode
Patt Geomorph: Agent, Mode, Status

Desc By: BURJ
Date (ddmmyy): 310813
POT C
M Type M
L Meas 4
Obs Reas
Runoff 2
Perm 2
Drainage 5
M Samp
Aggregn
Depth R Horiz 999
Depth to Free Water
Type: SPC
Tax Unit: Code
Map Unit: Type, Code
Photo Meas: East, North
Air Photos: Film No, Run No, Frame No
Obs Land Use
Obs Management Practices
Aspect
Inundation: Freq, Dur, Depth, ROV

Elevation: Eval, Elev
Drainage: Eval, Height
Rainforest: For Type, Sclero, Cmpx, FC, Ind, LS, TO, Distance, Conf
Depth: 070
Gr S, Str, Por, Sp F, Alt
Substrate: Calcareous substrate or subsoil?
Str, Lith ML?, Gen T, Text
Mass: Str, MDS, MC1, MC2
Location: WGS 84
Dat 3
Zone 55
Easting/Latitude 780922
Northing/Longitude 7332825
Conf
Australian Soil Classification: Ord, Sub Ord, GG/Or2, SG/SO2, F1 F2 F3 F4 F5: DEAA or CHAA.
PPF
GSG aff

Microrelief: No, Disturb, Surf Con, Type, Agent, Cmpt, Prop, VI, HI
Erosion: Type, State, Deg, GD
Surf Coarse Frags: Abun, Size, Shape, Lith, Str
Outcrop: Abun, Lith
Ref No
Community: Effectively ML. underlying profile.
Community 1 Details: No, Name, Strata, Form, Ht, Co, Height Cover, Species 1, Prop, Species 2, Prop, Species 3, Prop

Naturally treeless + grassed → 1 HZ negligible + non cracking (assume cracking in small patches black soil)
2
3 Small patch of Black CC 40m away but soil variability not yet gauged...
4
= very hardsetting

1 Effectively treeless – Very isolated shrubby
2
3
4

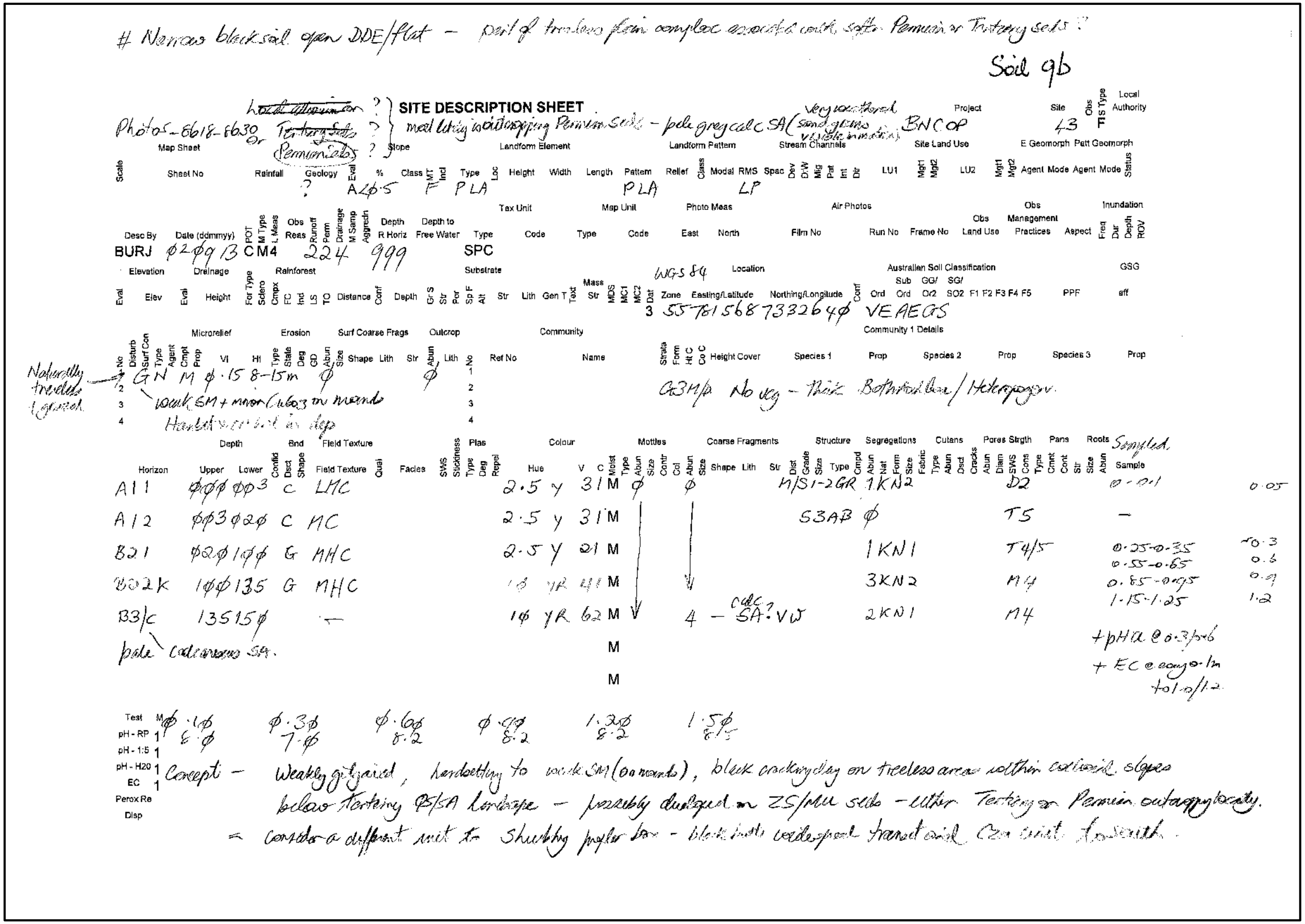
Horizon	Depth Upper	Depth Lower	Bnd Dsct	Field Texture	Facies	Colour Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations	Strgth	Sample
A1	000	020	C	CLFS → FSLC	SF = fine/med borderline	10 YR	33	M	0 ↓	0 ↓	M4AB	0	D5	0.0–0.1 0.05
B2	020	070	A	MC +		5 YR	43	M			M5LE M3AB	0	D6	0.25–0.35 0.3 0.55–0.65 0.6
BCk?	070	150		FSMC		7.5 YR +10 YR	54 54	M			S3/4PO	5KS4 N3 (prob 60–80% of subsoil matrix)	T4	0.85–0.95 0.9 1.15–1.25 1.2
								M						
								M						
								M						
								M						

Sampled
+ pH, Cl 0.3/0.6
+ EC @ 0.1m to 1.0 + 1.2.

Test	M	0.10	0.35	0.55	0.90	1.20	1.55
pH - RP	1	6.5	7.5	8.5	8.5	8.2	8.5
pH - 1:5	1						
pH - H20	1						
EC	1						
Perox Re							
Disp							

Concept – Hardsetting / red loamy surfaced, non cracking red noncracking clay over calcareous clay / marl substrate; assume Cza / local colluvial infill in closed basin; origin unidentified.

BNCOP 2013 Soil Investigation – Soil 9b
Representative Field Site – 43



Narrow blacksoil open DDE/flat – part of treeless plain complex associated with softer Permian or Tertiary seds ?

Soil 9b

SITE DESCRIPTION SHEET

Photos – 6618-6630

~~Local alluvium~~ ? / ~~Tertiary Seds~~ or Permian seds ? } mod likely weathering/outcropping Permian seds – pale grey calc SA (very weathered sand grains visible in matrix)

Project: BNCOP
Site: 43
Obs Type: F
Geology: ?
Slope: A 0·5
Landform Element Type: F PLA
Landform Pattern: PLA
Relief Modal: LP

Desc By: BURJ
Date (ddmmyy): 020913
POT: C
M Type: M
L Meas: 4
Runoff / Perm / Drainage: 2 2 4
Depth R Horiz: 999
Substrate Type: SPC

WGS 84
Dat: 3
Zone: 55
Easting/Latitude: 761568
Northing/Longitude: 7332640
Australian Soil Classification: VE AE GS

Naturally treeless (grazed) → GN M 0·15 8–15m 0 0
weak SM + minor CaCO3 on mounds
Hardsetting? ... in dep

Community 1 Details: G3M/p No veg – Thick Bothriochloa / Heteropogon.

Sampled.

Horizon	Upper	Lower	Bnd	Field Texture	Hue	V	C	Moist	Mottles	Coarse Fragments	Structure	Segregations	Strgth	Sample	
A11	000	003	C	LMC	2.5Y	3	1	M	0	0	M/S1-2GR	1KN2	D2	0 - 0.1	0.05
A12	003	020	C	MC	2.5Y	3	1	M			S3AB	0	T5	–	
B21	020	100	G	MHC	2.5Y	2	1	M				1KN1	T4/5	0.25-0.35 0.55-0.65	~0.3 0.6
B22K	100	135	G	MHC	10YR	4	1	M				3KN2	M4	0.85-0.95	0.9
B3/C	135	150	←		10YR	6	2	M		4 – calc SA? VW		2KN1	M4	1.15-1.25	1.2

pale calcareous SA.

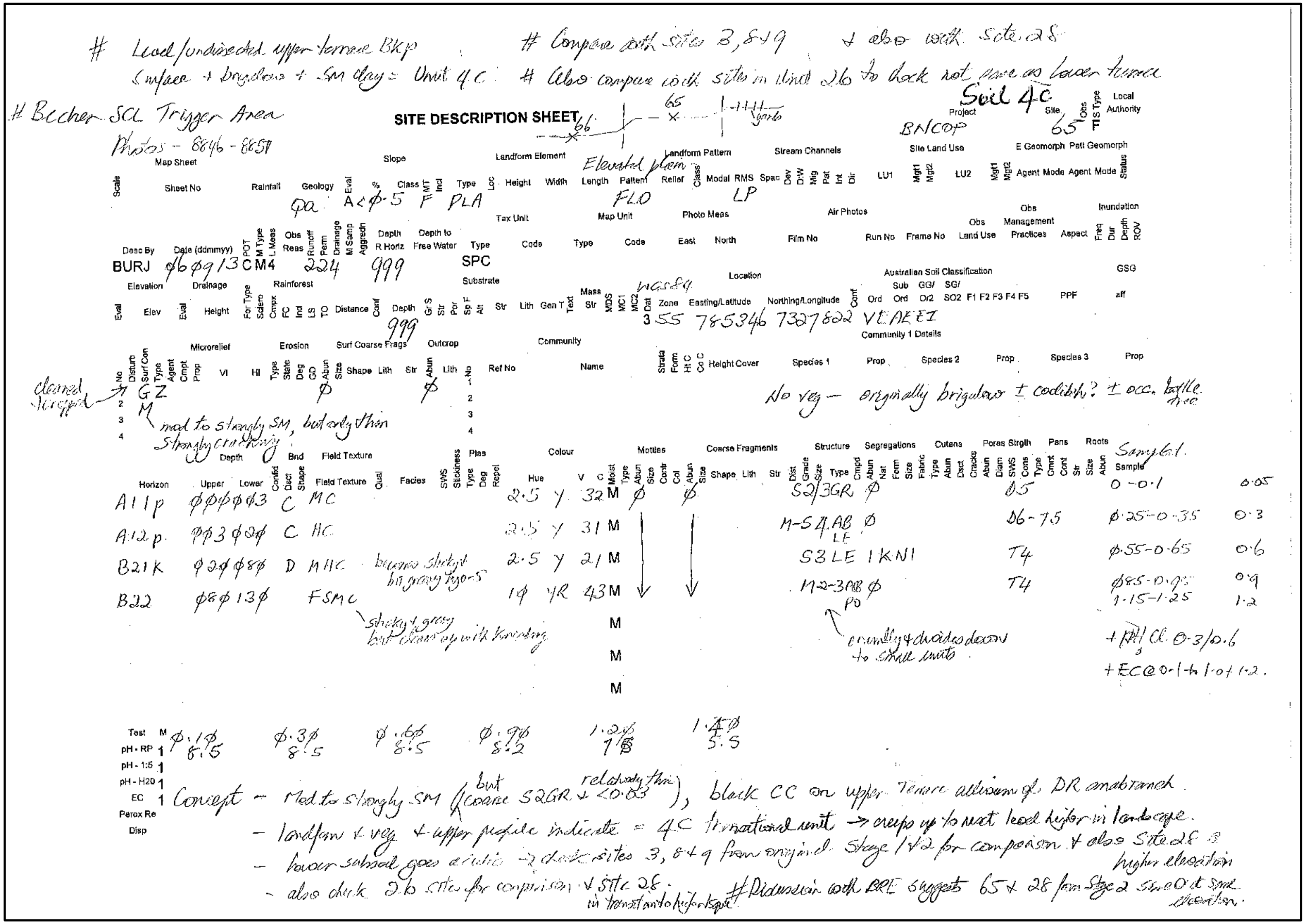
+pHa @ 0.3/0.6
+ EC @ every 0.1m to 1.0/1.2

Test	M					
	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP	8.0	7.0	8.2	8.2	8.2	8.5

Concept – Weakly gilgaied, hardsetting to weak SM (on mounds), black cracking clay on treeless areas within colluvial slopes below Tertiary QS/SA landscape – possibly developed on ZS/MU seds – either Tertiary or Permian outcropping locally.
= consider a different unit to Shrubby poplar box – black soils widespread transect with C2a unit to south.

Appendix 7 – Soil profile field data for detailed sites described and sampled within the SCL trigger area – BNCOP Disturbance Footprint.

BNCOP Disturbance Footprint – Soil 4c
SCL trigger area field site – 65



Lead/undissected upper terrace BkP (infaces + brigalow + SM clay = Unit 4C

Compare with sites 3, 8 + 9 + also with Site 28

Also compare with sites in Unit 2b to check not same as lower terrace

Becher SCL Trigger Area

Photos – 8846 – 8851

SITE DESCRIPTION SHEET

66 — 65 × — yards

Project BNCOP Soil 4C Site 65 Obs TIS Type F Local Authority

Map Sheet: Scale Sheet No Rainfall Geology Qa Slope: Eval A % <0.5 Class F MT Incl Type PLA Loc Landform Element: Height Width Length Pattern FLO (Elevated plain) Landform Pattern: Relief Class Modal RMS LP Spac Stream Channels: Dev D:W Mig Pat Int Dir Site Land Use: LU1 Mgt1 Mgt2 LU2 Mgt1 Mgt2 E Geomorph: Agent Mode Patt Geomorph: Agent Mode Status

Desc By BURJ Date (ddmmyy) 060913 POT C M Type M4 L Meas Obs Reas Runoff 2 Perm 2 Drainage 4 M Samp Aggredn Depth R Horiz 999 Depth to Free Water Tax Unit: Type SPC Code Map Unit: Type Code Photo Meas: East North Air Photos: Film No Run No Frame No Obs Land Use Obs Management Practices Aspect Inundation: Freq Dur Depth ROV

Elevation: Eval Elev Drainage: Eval Height Rainforest: For Type Sclero Cmpx FC Ind LS TO Distance Conf Substrate: Depth 999 Gr S Str Por Sp F Alt Str Lith Gen T Text Mass Str MDS MC1 MC2 Dat 3 Location: Zone 55 (WGS84) Easting/Latitude 785346 Northing/Longitude 7327822 Conf Australian Soil Classification: Ord VE Sub Ord AE GG/Or2 EI SG/SO2 F1 F2 F3 F4 F5 PPF GSG aff

Microrelief: No 1 Disturb G (cleared scraped) Surf Con Z, M Type Agent Cmpt Prop VI HI Erosion: Type State Deg GD Surf Coarse Frags: Abun 0 Size Shape Lith Str Outcrop: Abun 0 Lith Community: No 1 2 3 4 Ref No Name Strata Form Ht C Co C Height Cover Species 1 Prop Species 2 Prop Species 3 Prop Community 1 Details

No 2, 3, 4

mod to strongly SM, but only thin strongly cracking

No veg – originally brigalow ± codibh? ± occ. bottle tree

Horizon	Depth Upper	Depth Lower	Bnd Confid	Bnd Dsct	Bnd Shape	Field Texture	Qual	Facies	SWS	Stickiness	Plas Type	Plas Deg	Repel	Colour Hue	V	C	Moist	Mottles Type	Mottles Abun	Size	Contr	Col	Coarse Fragments Abun	Size	Shape	Lith	Str	Structure Dist	Grade	Size	Type	Cmpd	Segregations Abun	Nat	Form	Size	Fabric	Cutans Type	Abun	Dsct	Cracks	Pores Abun	Diam	Strgth SWS	Cons	Pans Type	Cmnt	Cont	Roots Str	Size	Abun	Sample	
A11p	000	003	C			MC								2.5	Y	32	M		0				0					S2/3GR					0											05								0 – 0.1	0.05
A12p	003	020	C			HC								2.5	Y	31	M		↓				↓					M-S4 AB LE					0											06 – 75								0.25 – 0.35	0.3
B21K	020	080	D			MHC (becomes sticky & bit gravy 1y0-5)								2.5	Y	21	M											S3 LE					1 K N 1											T4								0.55 – 0.65	0.6
B22	080	130				FSMC (sticky & gravy but clears up with kneading)								10	YR	43	M											M2-3 AB PO (crumbly & divides down to small units)					0											T4								0.85 – 0.95 1.15 – 1.25	0.9 1.2

Moist: M, M, M (further rows)

Sample 61.

+ pH Cl 0.3/0.6

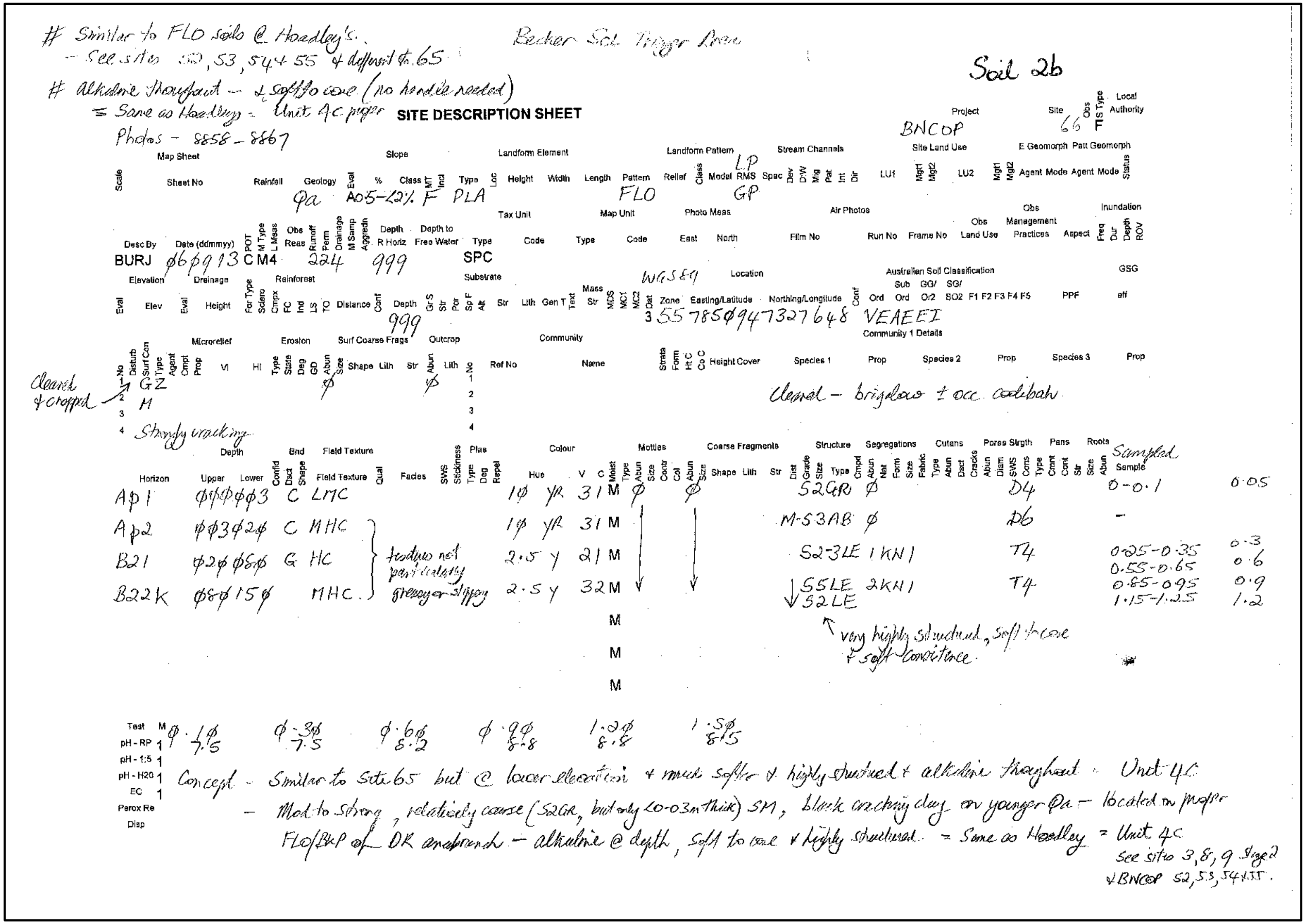
+ EC @ 0.1 to 1.0 + 1.2.

Test	M					
		0.10	0.30	0.60	0.90	1.20
pH - RP	1	8.5	8.5	8.5	8.2	7.5
pH - 1:5	1					
pH - H20	1					
EC	1					
Perox Re						
Disp						

1.40 — 5.5

Concept – Med to strongly SM (but coarse S2GR + relatively thin <0.03), black CC on upper Terrace alluvium of DR anabranch.
– landform + veg + upper profile indicate = 4C transitional unit → creeps up to next level higher in landscape.
– lower subsoil goes acidic → check sites 3, 8 + 9 from original Stage 1/2 for comparison + also Site 28 @ higher elevation
– also check 2b sites for comparison + Site 28 in transition to higher landscape. # Discussion with BRE suggests 65 + 28 from Stage 2 some 0 at same elevation.

BNCOP Disturbance Footprint – Soil 2b
SCL trigger area field site – 66



Similar to FLO soils @ Hoadley's.
– See sites 52, 53, 54 + 55 + different to 65

Alkaline throughout – + soft to core (no handle needed)
= Same as Hoadley – Unit 4C proper

Photos – 8858 – 8867

Becker SCL Trigger Area

Soil 2b

SITE DESCRIPTION SHEET

Project: BNCOP
Site: 66
Obs / TIS Type: F

Geology: Qa
Slope: Eval A, % 0.5–<2%, Class F
Landform Element Type: PLA
Landform Pattern: Pattern FLO, Modal LP, RMS GP

Desc By: BURJ
Date (ddmmyy): 060913
POT: C
M Type / L Meas: M4
Runoff / Perm / Drainage: 224
Depth R Horiz: 999
Tax Unit Type: SPC
Substrate Depth: 999

Location: WGS 84
Dat: 3 Zone: 55 Easting/Latitude: 785094 Northing/Longitude: 7327648
Australian Soil Classification: VEAEEI

Cleared + cropped
Disturb: 1 GZ, 2 M
Surf Coarse Frags Abun: 0
Outcrop Abun: 0
4 Strongly cracking

Community: Cleared – brigalow ± occ. coolibah

Sampled

Horizon	Depth Upper Lower	Bnd	Field Texture	Facies	Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations	Strgth	Sample	
Ap1	00003	C	LMC		10 YR	31	M	0	0	S2GR	0	D4	0-0.1	0.05
Ap2	003020	C	MHC	texture not particularly greasy or slippy	10 YR	31	M	↓	↓	M-S3AB	0	D6	–	
B21	020080	G	HC		2.5 Y	21	M			S2-3LE	1KN1	T4	0.25-0.35 0.55-0.65	0.3 0.6
B22K	080150		MHC.		2.5 Y	32	M			↓S5LE S2LE	2KN1	T4	0.85-0.95 1.15-1.25	0.9 1.2

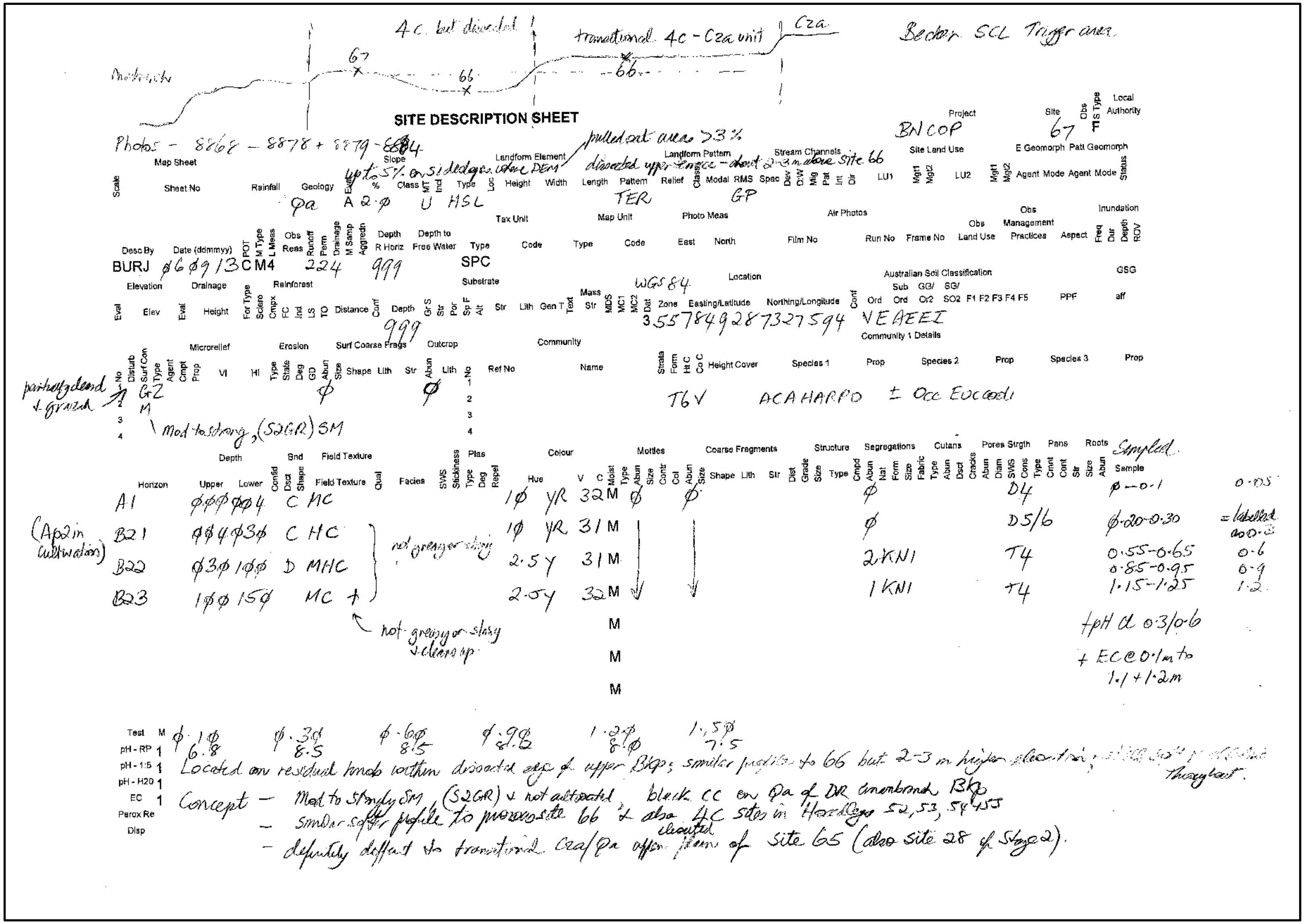
↑ very highly structured, soft to core + soft consistence.

Test M	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP 1	7.5	7.5	8.2	8.8	8.8	8.5

pH - 1:5 1
pH - H20 1
EC 1
Perox Re
Disp

Concept – Similar to Site 65 but @ lower elevation + much softer + highly structured + alkaline throughout. Unit 4C
– Mod to strong, relatively coarse (S2GR, but only <0-03m thick) SM, black cracking clay on younger Qa – located on major FLO/BkP of DK anabranch – alkaline @ depth, soft to core + highly structured. = Same as Hoadley = Unit 4C
See sites 3, 8, 9 Stage 2 + BNCOP 52, 53, 54 + 55.

BNCOP Disturbance Footprint – Soil 4c
SCL trigger area field site – 67



SITE DESCRIPTION SHEET

Photos - 8868 - 8878 + 8879-8884

Project: BNCOP
Site: 67

Slope: upto 5% on sidedges, above DEM
pulled out areas >3%
Landform Pattern: dissected upper terrace - about 2-3 m above site 66

Geology: Qa
Slope Eval: A
%: 2.0
MT: U
Type: HSL
Pattern: TER
Modal: GP

Desc By: BURJ
Date (ddmmyy): 060913
POT: C
M Type: M4
Runoff: 2
Perm: 2
Drainage: 4
Depth R Horiz: 999
Type: SPC
Substrate Depth: 999

Location: WGS 84
Dat: 3
Zone: 55
Easting/Latitude: 784928
Northing/Longitude: 7327594
Australian Soil Classification: VE AE EI

Disturb: partially cleared + grazed 7
Surf Con: GZ, M
Mod to strong, (S2GR) SM
Surf Coarse Frags Abun: 0
Outcrop Abun: 0

Community 1 Details: T6V ACA HARPO ± Occ EUC coodi

Sampled

Horizon	Upper	Lower	Bnd	Field Texture	Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Segregations Abun		Sample	
A1	000	004	C	MC	10YR	32	M	0	0	0	D4	0-0.1	0.05
B21	004	030	C	HC	10YR	31	M			0	D5/6	0.20-0.30	= labelled as 0.3
B22	030	100	D	MHC	2.5Y	31	M			2KNI	T4	0.55-0.65 0.85-0.95	0.6 0.9
B23	100	150		MC +	2.5Y	32	M			1KNI	T4	1.15-1.25	1.2
							M						
							M						
							M						

(Ap2 in cultivation)

not greasy or slaty

not greasy or slaty + cleans up

+pH Cl 0.3/0.6

+ EC @ 0.1 m to 1.1 + 1.2 m

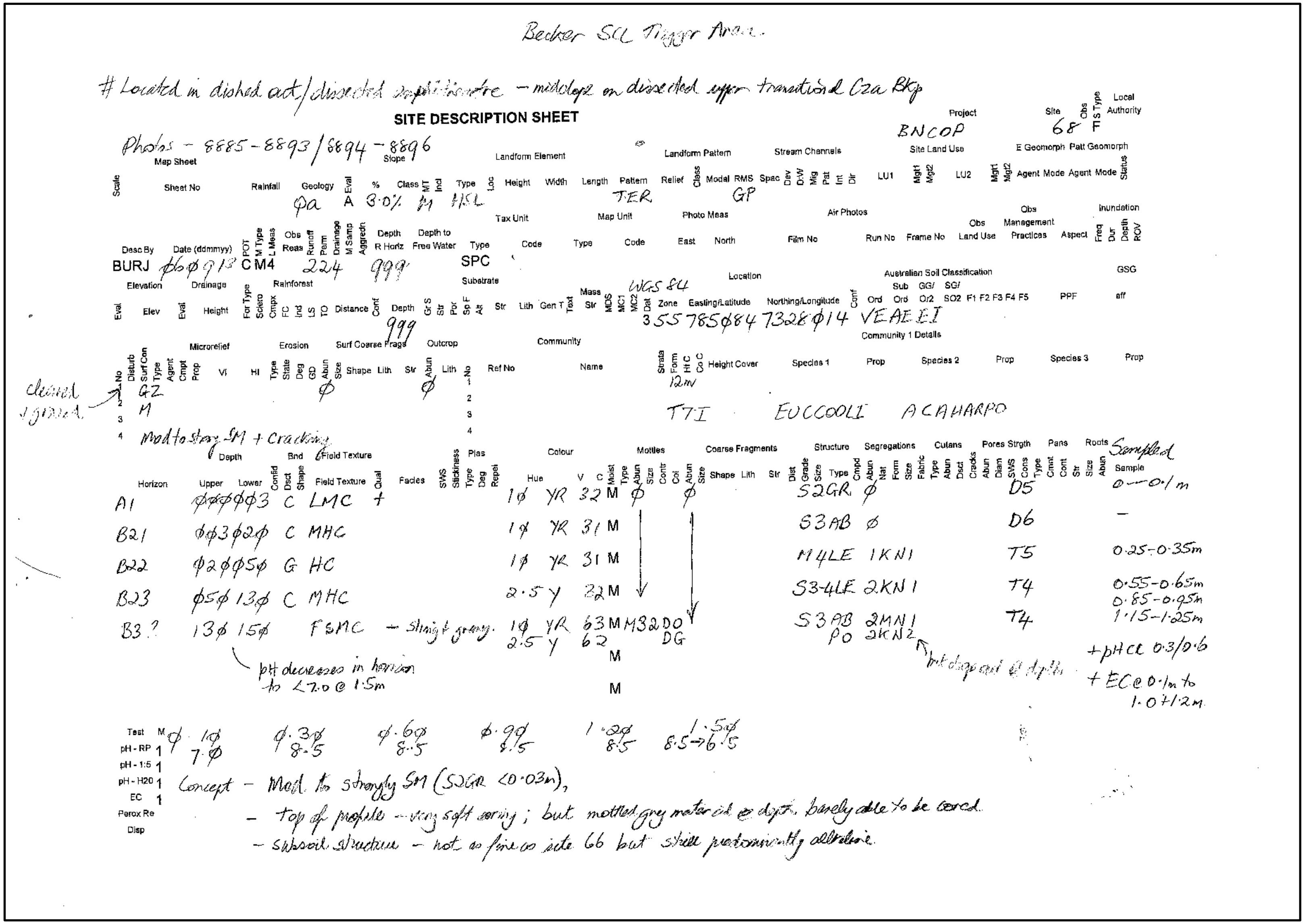
Test M	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP 1	6.8	8.5	8.5	8.8	8.0	7.5

pH - 1:5 1
pH - H20 1
EC 1
Perox Re
Disp

Located on residual knob within dissected edge of upper Bkp; similar profile to 66 but 2-3 m higher elevation; [illegible] throughout.

Concept - Mod to strongly SM (S2GR) + not attenuated, black CC on Qa of DR [illegible] Bkp
- similar softer profile to previous site 66 + also elevated 4C sites in Hardings 52, 53, 54 + 55
- definitely different to transitional Cza/Qa upper plain of site 65 (also site 28 of Stage 2).

BNCOP Disturbance Footprint – Soil 4c
SCL trigger area field site – 68



Becker SCL Trigger Area.

Located in dished act/dissected amphitheatre – midslope on dissected upper transitional Cza Bkp

SITE DESCRIPTION SHEET

Project BNCOP
Site 68 Obs F

Photos – 8885-8893/8894-8896

Geology 0a
Slope Eval A
% 3.0%
Class M
Type HSL
Landform Pattern Pattern TER
Model GP

Desc By BURJ
Date (ddmmyy) 060913
POT C
M Type M4
Obs Reas 224
Depth R Horiz 999
Type SPC

Distance 999
Datum WGS 84
Zone 3 55
Easting/Latitude 785084
Northing/Longitude 7328014
Australian Soil Classification VE AE EI

Strata Form H C 12m
T7I
Species 1 EUCCOOLI
Species 2 ACAHARPO

cleared / grazed
1 Disturb GZ
2 Surf Con M
Surf Coarse Frags Abun 0
Outcrop Abun 0
4 Mod to strong SM + cracking

Horizon	Upper	Lower	Bnd Dsct	Field Texture	Qual	Hue	V C	Moist	Mottles	Coarse Fragments Abun	Structure	Segregations	Strgth	Sample (Sampled)
A1	000	003	C	LMC	+	10 YR	32	M	0	0	S2GR	0	D5	0—0.1m
B21	003	020	C	MHC		10 YR	31	M			S3AB	0	D6	—
B22	020	050	G	HC		10 YR	31	M			M4LE	1KN1	T5	0.25–0.35m
B23	050	130	C	MHC		2.5 Y	22	M			S3-4LE	2KN1	T4	0.55–0.65m 0.85–0.95m
B3?	130	150		FSMC – slightly gravy.		10 YR 2.5 Y	63 62	M	M32D0 DG		S3AB PO	2MN1 2KN2	T4	1.15–1.25m
								M						
								M						

pH decreases in horizon to <7.0 @ 1.5m

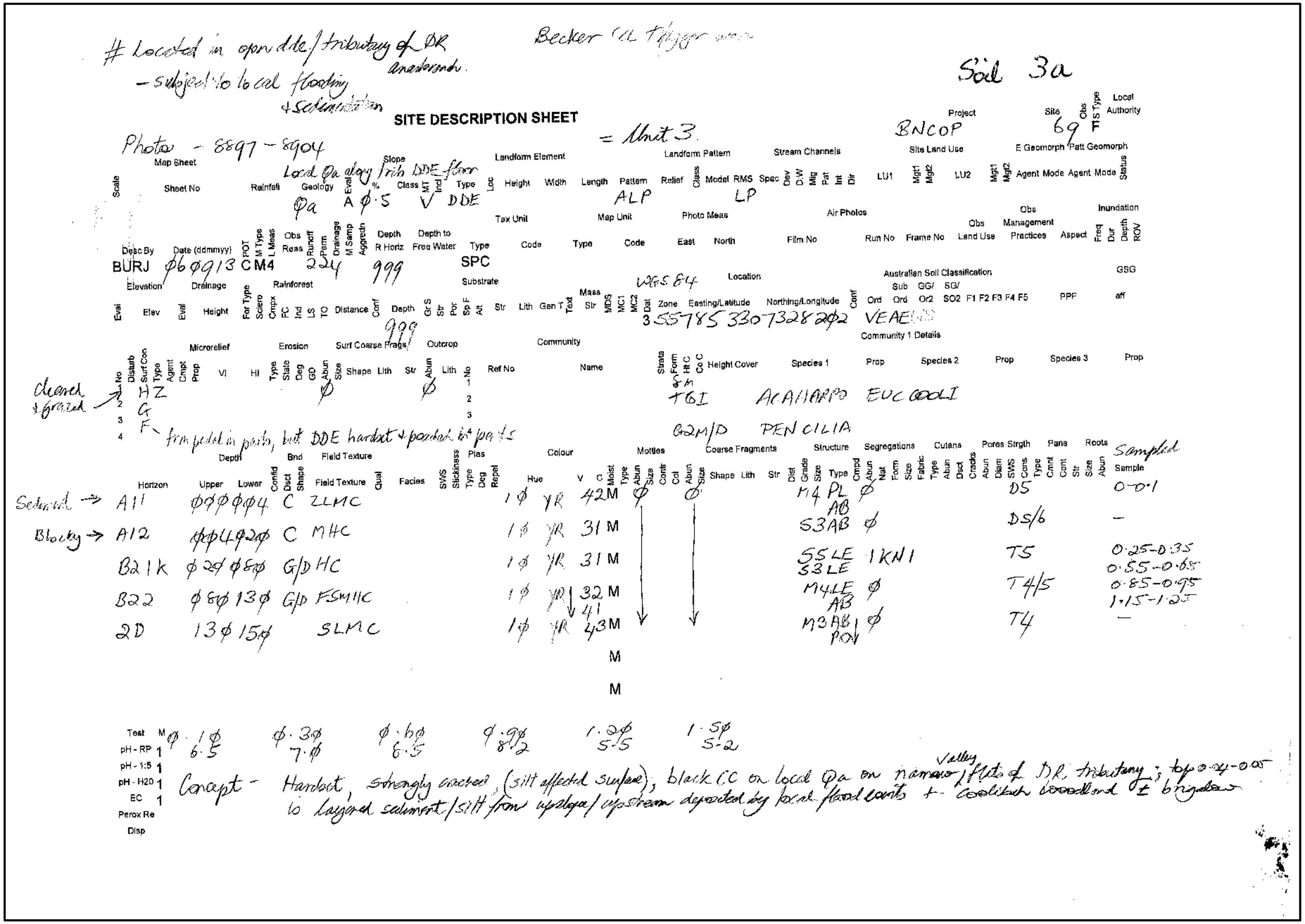
bit disp out @ depth

+pHCL 0.3/0.6
+EC @ 0.1m to 1.0+1.2m.

Test	M					
pH - RP 1	0.10 7.0	0.30 8.5	0.60 8.5	0.90 8.5	1.20 8.5	1.50 8.5→6.5
pH - 1:5 1						
pH - H20 1						
EC 1						
Perox Re						
Disp						

Concept – Mod. to strongly SM (S2GR <0.03m),
– top of profile – very soft coring; but mottled grey material @ depth barely able to be cored.
– subsoil structure – not as fine as site 66 but still predominantly alkaline.

BNCOP Disturbance Footprint – Soil 3a
SCL trigger area field site – 69



\# Located in open ddc / tributary of DR anastomosing
– subject to local flooding + sedimentation

Becker SCL trigger area

Soil 3a

SITE DESCRIPTION SHEET

= Unit 3.

Photo – 8897 – 8904

Project: BNCOP
Site: 69
Obs / TS Type: F
Local Authority

Map Sheet
Scale | Sheet No | Rainfall | Geology: Qa — Local Qa along trib DDE floor | Eval: A | Slope %: 0.5 | Class | MT | Incl | Type: V DDE | Loc
Landform Element: Height | Width | Length
Landform Pattern: Pattern: ALP | Relief | Class | Model RMS: LP | Spec
Stream Channels: Dev | D:W | Mig | Pat | Int | Dir
Site Land Use: LU1 | Mgt1 | Mgt2 | LU2 | Mgt1 | Mgt2
E Geomorph: Agent Mode | Patt Geomorph: Agent Mode | Status

Desc By: BURJ | Date (ddmmyy): 060913 | POT: C | M Type / L Meas: M4 | Obs Reas | Runoff: 2 | Perm: 2 | Drainage: 4 | M Samp | Aggredn | Depth R Horiz: 999 | Depth to Free Water | Type: SPC
Tax Unit: Code | Map Unit: Type | Code | Photo Meas: East | North | Air Photos: Film No | Run No | Frame No | Obs Land Use | Obs Management Practices | Aspect | Inundation: Freq | Dur | Depth | ROV

Elevation: Eval | Elev | Drainage: Eval | Height | Rainforest: For Type | Sclero | Cmpx | FC | Ind | LS | TO | Distance | Conf | Substrate: Depth: 999 | Gr S | Str | Por | Sp F | Alt | Str | Lith | Gen T | Text
Location: WGS 84 | Mass Str | MDS | MC1 | MC2 | Dat | Zone: 3 55 | Easting/Latitude: 785 330 | Northing/Longitude: 7328 202 | Conf
Australian Soil Classification: Ord: VE | Sub Ord: AE | GG/Or2 | SG/SO2 | F1 F2 F3 F4 F5 | PPF | GSG aff

Microrelief: No | Disturb | Surf Con | Type | Agent | Cmpt | Prop | VI | HI
Erosion: Type | State | Deg | GD
Surf Coarse Frags: Abun: 0 | Size | Shape | Lith | Str
Outcrop: Abun: 0 | Lith
Community: No | Ref No | Name
Community 1 Details: Strata | Form | Ht C | Co C | Height Cover | Species 1 | Prop | Species 2 | Prop | Species 3 | Prop

cleared + grazed → 1 HZ
2 G
3 F ← firm pedal in parts, but DDE hardset + pedal in parts
4

Sm
T6I ACAHARPO EUC COOLI
G2M/D PEN CILIA

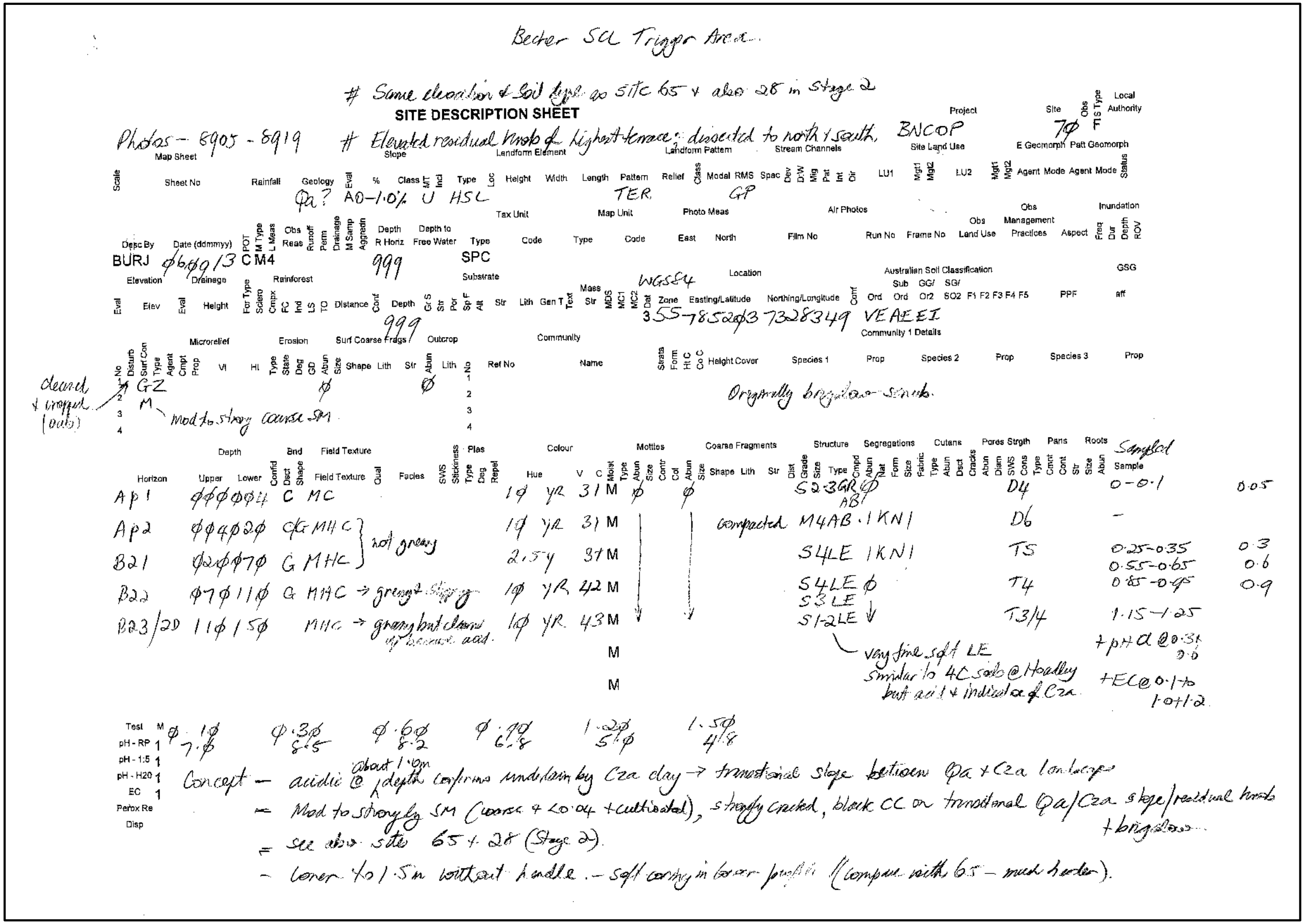
Sampled

	Horizon	Depth Upper	Depth Lower	Bnd	Field Texture	Colour Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations	Strgth	Sample
Sediment →	A11	000	004	C	ZLMC	10 YR	42	M	0 ↓	0 ↓	M4 PL AB	0	D5	0-0.1
Blocky →	A12	004	020	C	MHC	10 YR	31	M			S3AB	0	DS/6	–
	B21k	020	080	G/D	HC	10 YR	31	M			S5LE S3LE	1KN1	T5	0.25-0.35 0.55-0.65
	B22	080	130	G/D	FSMHC	10 YR ↓	32 41	M			M4LE AB	0	T4/5	0.85-0.95 1.15-1.25
	2D	130	150		SLMC	10 YR	43	M			M3AB POV	0	T4	–
								M						
								M						

Test	M	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP	1	6.5	7.0	6.5	8.2	5.5	5.2
pH - 1:5	1						
pH - H20	1						
EC	1						
Perox Re							
Disp							

Concept – Hardset, strongly cracked, (silt affected surface), black CC on local Qa on narrow valley flats of DR tributary; top 0.04-0.05 to layered sediment / silt from upslope / upstream deposited by local flood events + coolibah woodland ± brigalow

BNCOP Disturbance Footprint – Soil 4c
SCL trigger area field site – 70



Becker SCL Trigger Area.

Same elevation & soil type as site 65 + also 28 in Stage 2

SITE DESCRIPTION SHEET

Photos – 8905 - 8919

Elevated residual knob of highest terrace; dissected to north + south.

Project: BNCOP
Site: 70

Geology: Qa?
Slope: A0–1.0%
Landform Element: U HSL
Landform Pattern: TER
Relief / Modal: GP

Desc By: BURJ
Date (ddmmyy): 060913
POT / M Type: C M4
Depth R Horiz: 999
Type: SPC
Substrate Depth: 999
Location: WGS84
Zone / Easting/Latitude / Northing/Longitude: 3 55 785203 7328349
Australian Soil Classification: VE AE EI

Microrelief / Surf Con: GZ
2: M
cleared + cropped (oats)
Mod to strong coarse SM
Erosion Abun: 0
Surf Coarse Frags Abun: 0
Community: Originally brigalow scrub.

Horizon	Upper	Lower	Bnd	Field Texture		Colour Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun		Structure	Pores Strgth	Sampled	
Ap1	000	004	C	MC		10 YR	31	M	0	0		S2-3GR 0 AB	D4	0–0.1	0.05
Ap2	004	020	CG	MHC	not greasy	10 YR	31	M			compacted	M4AB 1KN1	D6	–	
B21	020	070	G	MHC		2.5Y	31	M				S4LE 1KN1	T5	0.25–0.35	0.3
B22	070	110	G	MHC	→ greasy + slippery	10 YR	42	M				S4LE 0 S3LE	T4	0.55–0.65 0.85–0.95	0.6 0.9
B23/2D	110	150		MHC	→ greasy but clear of because acid.	10 YR	43	M				S1-2LE	T3/4	1.15–1.25	
								M							
								M							

very fine soft LE
Similar to 4C soils @ Hoadley but acid + indicative of Cza

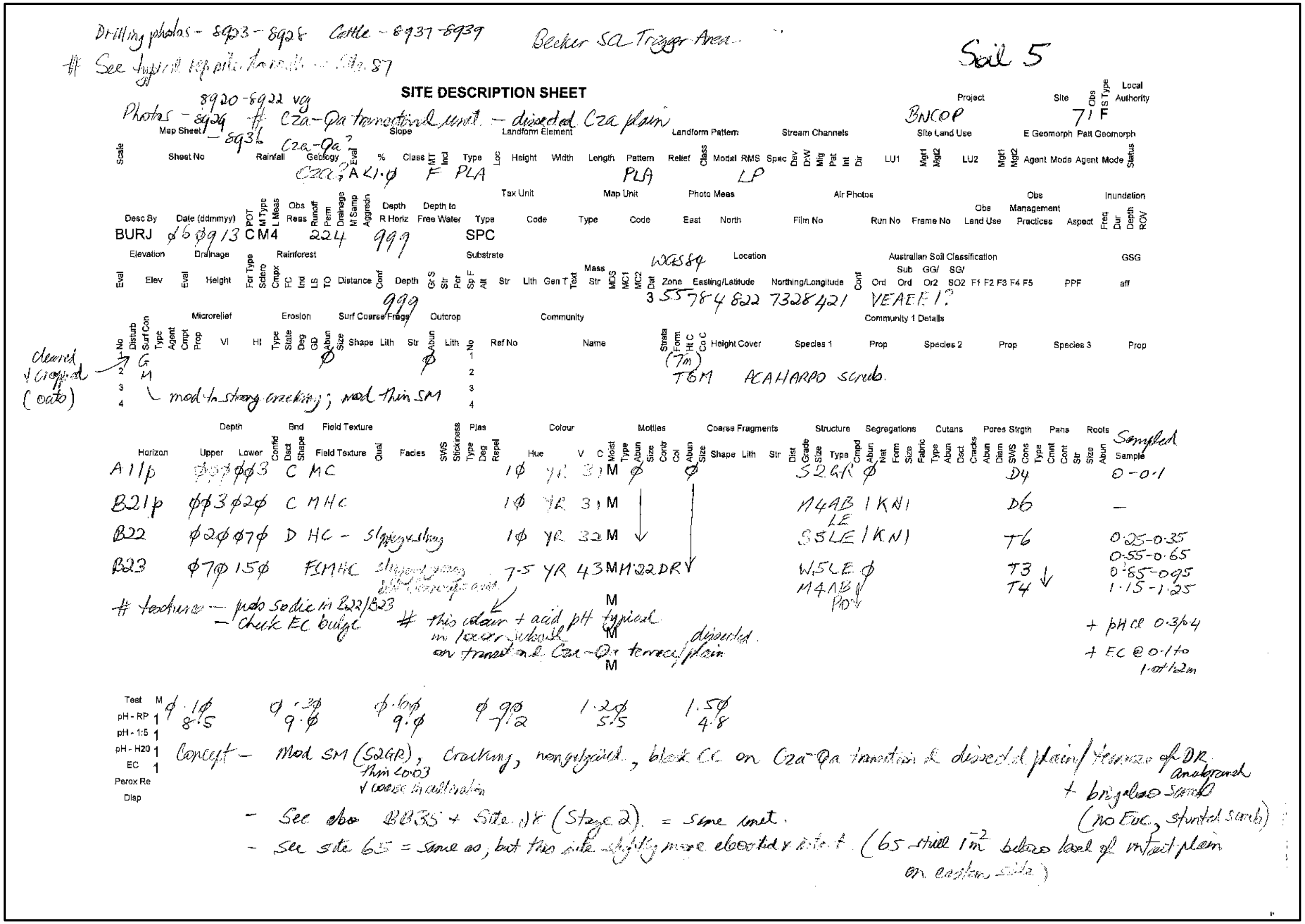
+ pH Cl @ 0.3 + 0.6
+ EC @ 0.1 to 1.0 + 1.2

Test	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP	7.0	8.5	8.2	6.8	5.0	4.8

pH - 1:5 1
pH - H20 1
EC 1
Perox Re
Disp

Concept – acidic @ about 1.0m depth confirms underlain by Cza clay → transitional slope between Qa + Cza landscape
– Mod to strongly SM (coarse + <0.04 + cultivated), strongly cracked, black CC on transitional Qa/Cza slope/residual knob + brigalow.
– see also sites 65 + 28 (Stage 2).
– Lower to 1.5m without handle. – soft coring in lower profile (compare with 65 – much harder).

BNCOP Disturbance Footprint – Soil 5
SCL trigger area field site – 71



Drilling photos - 8923 - 8928 Cattle - 8937-8939 Becker SCL Trigger Area

See typical rep site for soil - Site 87

Soil 5

SITE DESCRIPTION SHEET

Photos - 8920-8922 veg, 8924 - 8931

Cza-Qa transitional unit - dissected Cza plain

Project	Site	S Type
BNCOP	71	F

Geology: Cza-Qa? Cza? A

Slope %: <1.0 Class: F Type: PLA

Landform Pattern: PLA LP

Desc By	Date (ddmmyy)	POT	M Type	Obs Reas	Runoff	Perm	Drainage	Depth R Horiz	Depth to Free Water	Substrate Type
BURJ	060913	C	M4		2	2	4	999		SPC

Substrate Depth: 999

Location: WGS84 Zone 3 55 Easting 784822 Northing 7328421

Australian Soil Classification: VEAEE1?

Disturb: cleared √ cropped (oats) 1 G, 2 M

Erosion Abun: 0 Surf Coarse Frags Abun: 0

└ mod to strong cracking; mod thin SM

Community: (7m) T6M ACAHARPO scrub.

Horizon	Upper	Lower	Bnd	Field Texture	Hue	V C	Moist	Mottles	Coarse Fragments	Structure	Strgth	Sample
A11p	0.00	0.03	C	MC	10 YR	31	M	0	0	S2GR 0	D4	0-0.1
B21p	0.03	0.20	C	MHC	10 YR	31	M	↓	↓	M4AB 1KN1	D6	—
B22	0.20	0.70	D	HC - slippery/sticky	10 YR	32	M	↓	↓	S5LE 1KN1	T6	0.25-0.35
B23	0.70	1.50		FSMHC slippery/gritty	7.5 YR	43	M	M22DR	↓	W5LE 0 M4AB PO ↓	T3 T4 ↓	0.55-0.65 0.85-0.95 1.15-1.25

Sampled

texture - prob sodic in B22/B23 - check EC bulge

this colour + acid pH typical in lower subsoil on transitional Cza-Qa terrace/plain dissected.

+ pHCa 0.3/0.4

+ EC @ 0.1 to 1.0/1.2m

Test	M					
	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP 1	8.5	9.0	9.0	7.2	5.5	4.8

pH - 1:5 1

pH - H20 1

EC 1

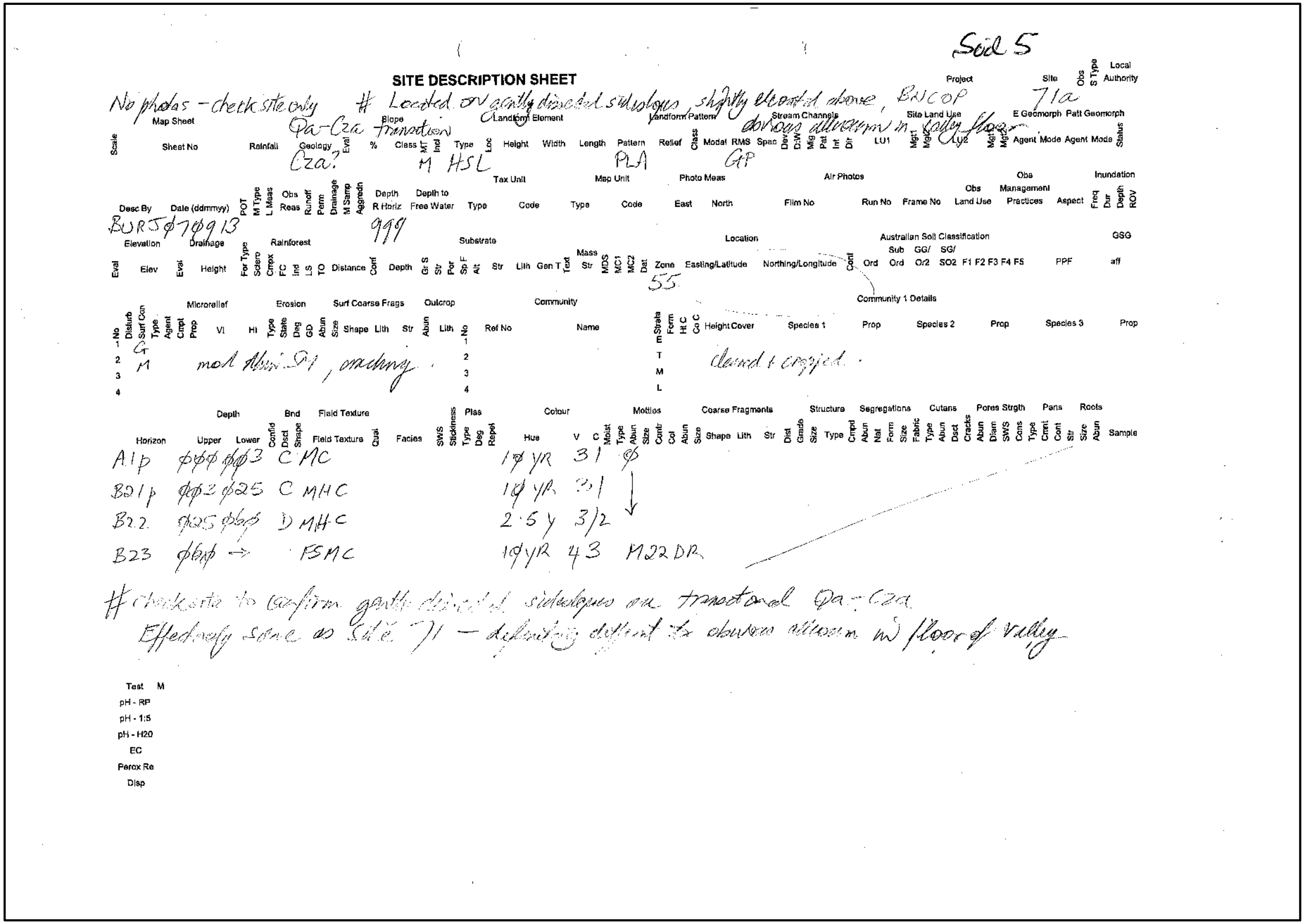
Perox Re

Disp

Concept - Mod SM (S2GR), thin <0.03 √ coarse in cultivation, cracking, nongilgaied, black CC on Cza-Qa transition & dissected plain/terrace of DR anabranch + brigalow scrub (no Euc, stunted scrub)

- See also BB35 + Site 18 (Stage 2). = same unit.
- See site 65 = same as, but this site slightly more elevated & intact. (65 still 1m-2 below level of intact plain on eastern side)

BNCOP Disturbance Footprint – Soil 5
SCL trigger area field site – 71a



Soil 5

SITE DESCRIPTION SHEET

No photos - check site only   # Located on gently directed sideslopes, slightly elevated above alluvium in valley floor.

Project: BNCOP   Site: 71a

Geology: Qa-Cza transition   Cza?

Slope Class / MT: M   Landform Element Type: HSL

Landform Pattern: PLA   Relief Modal Class: GP

Desc By: BURJ   Date (ddmmyy): 070913   Depth R Horiz: 999

Location Zone: 55

Microrelief / Disturb: G   Surf Con: M   mod Abun 91, cracking.

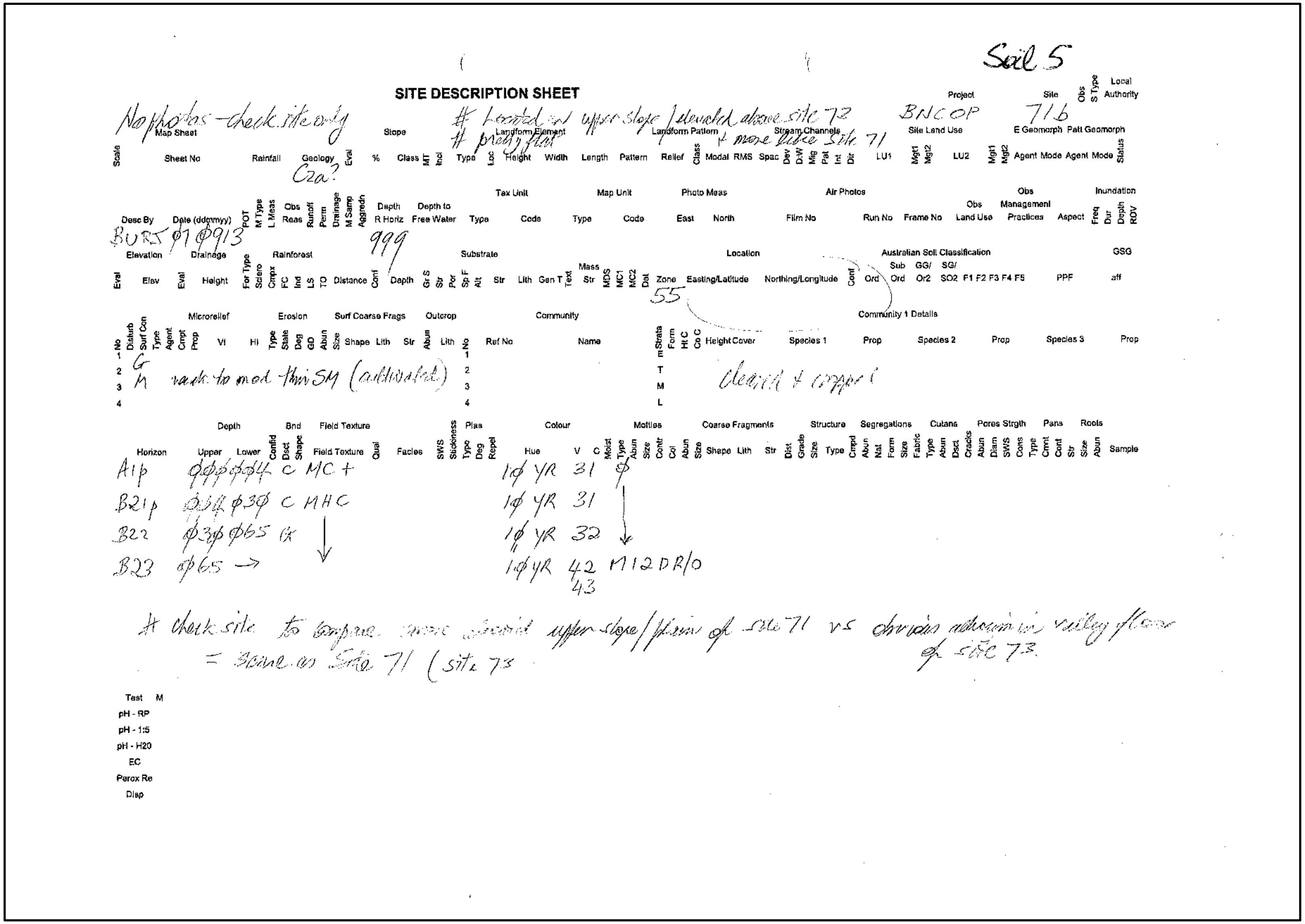
Community Strata: cleared + cropped.

Horizon	Depth Upper	Depth Lower	Bnd Dsct	Field Texture	Colour Hue	V C	Mottles
A1p	000	003	C	MC	10 YR	3 1	0
B21p	002	025	C	MHC	10 YR	3 1	↓
B22	025	060	D	MHC	2.5 Y	3/2	
B23	060	→		FSMC	10YR	4 3	M22DR

check site to confirm gently directed sideslopes on transitional Qa-Cza
Effectively same as Site 71 - definitely different to obvious alluvium in floor of valley

Test M
pH - RP
pH - 1:5
pH - H2O
EC
Perox Re
Disp

BNCOP Disturbance Footprint – Soil 5
SCL trigger area field site – 71b



Soil 5

SITE DESCRIPTION SHEET

No photos – check site only

Located on upper slope / elevated above site 72
pretty flat
+ more like Site 71

Project: BNCOP
Site: 71b
Obs S Type Local Authority

Map Sheet Slope Landform Element Landform Pattern Stream Channels Site Land Use E Geomorph Patt Geomorph

Scale Sheet No Rainfall Geology Eval % Class MT Incl Type Loc Height Width Length Pattern Relief Class Modal RMS Spac Dev D:W Mig Pat Int Dir LU1 Mgt1 Mgt2 LU2 Mgt1 Mgt2 Agent Mode Agent Mode Status

Geology: Cza?

Tax Unit Map Unit Photo Meas Air Photos Obs Inundation

Desc By Date (ddmmyy) POT M Type L Meas Obs Reas Runoff Perm Drainage M Samp Aggredn Depth R Horiz Depth to Free Water Type Code Type Code East North Film No Run No Frame No Obs Land Use Obs Management Practices Aspect Freq Dur Depth ROV

Desc By: BURS
Date (ddmmyy): 010913
Depth R Horiz: 999

Elevation Drainage Rainforest Substrate Location Australian Soil Classification GSG

Eval Elev Eval Height For Type Sclero Cmpx FC Ind LS TO Distance Conf Depth Gr S Str Por Sp F Alt Str Lith Gen T Text Mass Str MDS MC1 MC2 Dat Zone Easting/Latitude Northing/Longitude Conf Ord Sub Ord GG/ Or2 SG/ SO2 F1 F2 F3 F4 F5 PPF aff

Zone: 55

Microrelief Erosion Surf Coarse Frags Outcrop Community Community 1 Details

No Disturb Surf Con Type Agent Cmpt Prop VI HI Type State Deg GD Abun Size Shape Lith Str Abun Lith No Ref No Name Strata Form Ht C Co C Height Cover Species 1 Prop Species 2 Prop Species 3 Prop

1
2 G
3 M hard to mod thin SM (cultivated)
4

No: 1 2 3 4
Strata: m T M L

cleared + cropped

Depth Bnd Field Texture Plas Colour Mottles Coarse Fragments Structure Segregations Cutans Pores Strgth Pans Roots

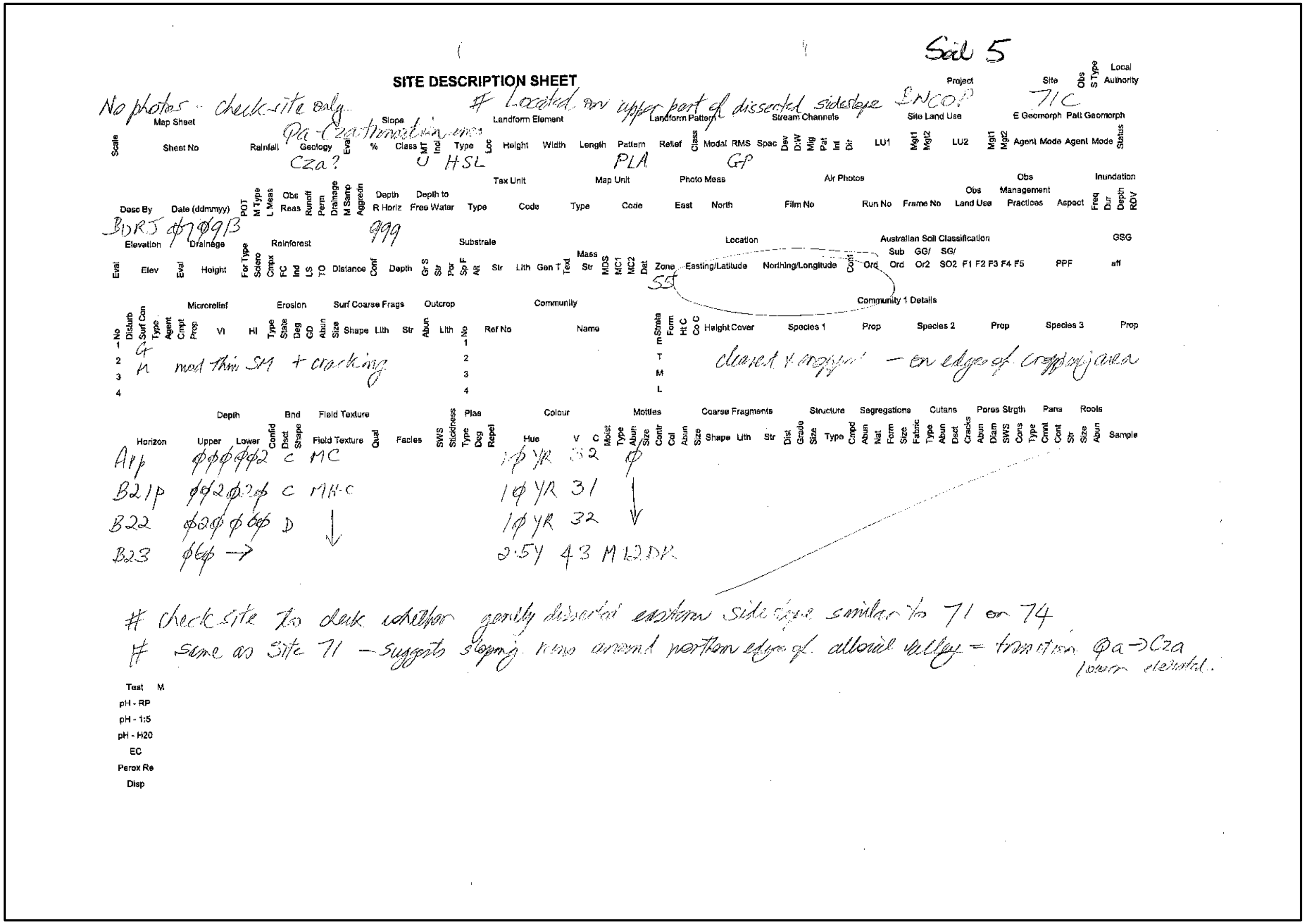
Horizon	Upper	Lower	Bnd Dsct	Field Texture	Hue	V C	Moist	Mottles
A1p	000	004	C	MC+	10YR	31	0	
B21p	004	030	C	MHC	10YR	31	↓	
B22	030	065	G	↓	10YR	32	↓	
B23	065	→			10YR	42 43		M12DR/0

Horizon Upper Lower Confid Dsct Shape Field Texture Qual Facies SWS Stickiness Type Deg Repel Hue V C Moist Type Abun Size Contr Col Abun Size Shape Lith Str Dist Grade Size Type Cmpd Abun Nat Form Size Fabric Type Abun Dsct Cracks Abun Diam SWS Cons Type Cmnt Cont Str Size Abun Sample

check site to compare more elevated upper slope/plain of site 71 vs [illegible] alluvium in valley floor of site 73.
= Same as Site 71 (site 73

Test M
pH - RP
pH - 1:5
pH - H20
EC
Perox Re
Disp

BNCOP Disturbance Footprint – Soil 5
SCL trigger area field site – 71c



Soil 5

SITE DESCRIPTION SHEET

Project: BNCOP Site: 71C

No photos - check-site only

Located on upper part of dissected sideslope

Map Sheet / Sheet No / Rainfall / Geology: Pa-Cza transition unit? Cza?

Slope % / Class: U / Type: HSL

Landform Pattern: PLA / Modal: GP

Desc By: BDRJ Date (ddmmyy): 070913

Depth R Horiz: 999

Location Zone: 55

Microrelief: G M mod thin SM + cracking

Community: cleared & cropped - on edge of cropping area

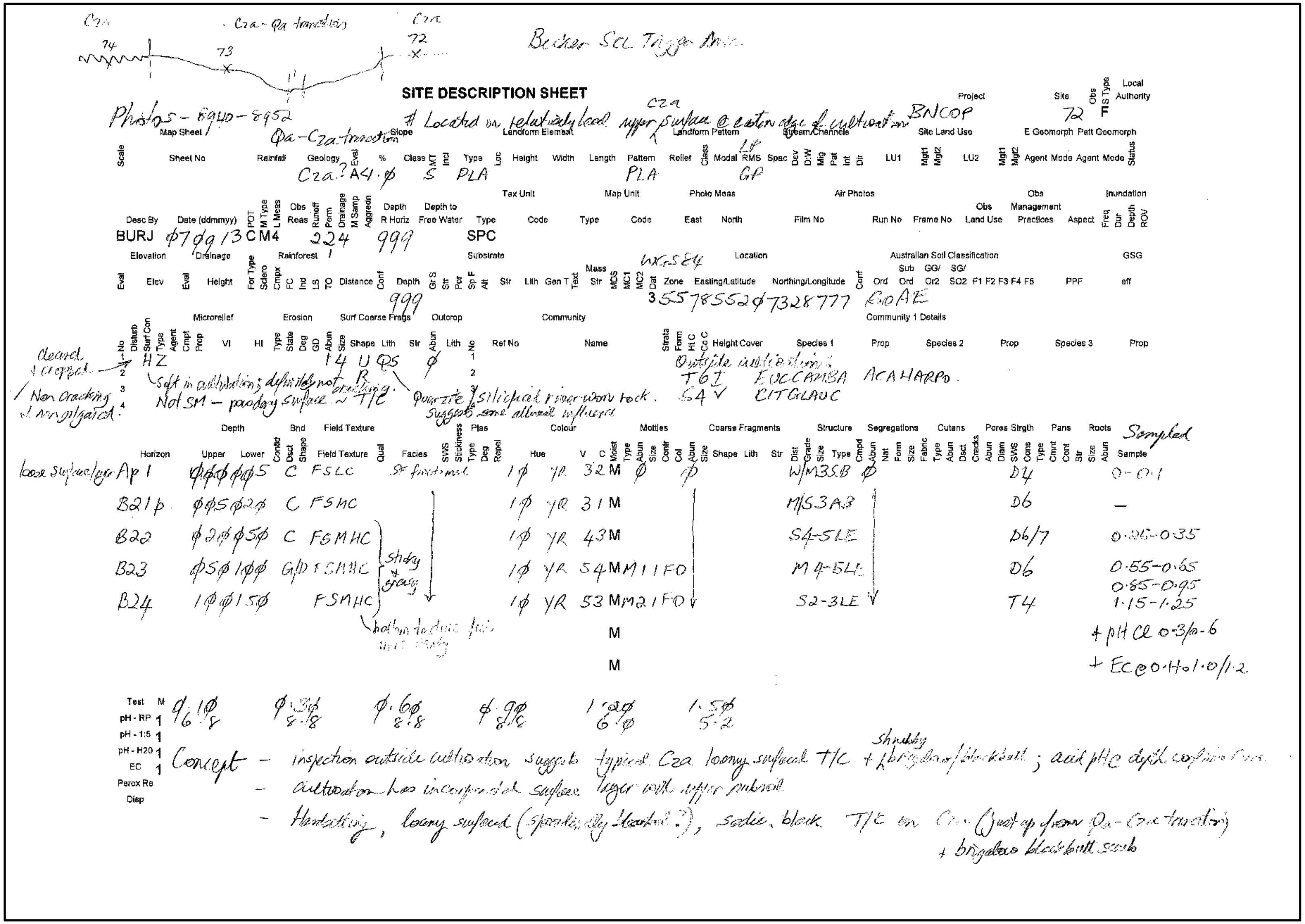
Horizon	Upper	Lower	Bnd Dsct	Field Texture	Hue	V	C	Mottles
A1p	000	002	C	MC	10YR	3	2	0
B21p	002	020	C	MH-C	10YR	3	1	↓
B22	020	060	D	↓	10YR	3	2	↓
B23	060	→			2.5Y	4	3	M 12DR

check site to check whether gently dissected eastern side slope similar to 71 or 74

same as site 71 - suggests sloping rises around northern edge of alluvial valley = transition 0a → Cza lower elevated.

Test M
pH - RP
pH - 1:5
pH - H20
EC
Perox Re
Disp

BNCOP Disturbance Footprint – Soil 7d
SCL trigger area field site – 72



Becker SCL Trigger Area

SITE DESCRIPTION SHEET

Photos – 8940 – 8952

Project: BNCOP

Site: 72

Obs / T/S Type / Local Authority

Map Sheet / Slope: Qa-Cza transition

Landform Element: # Located on relatively level upper surface @ eastern edge of cultivation on Cza

Landform Pattern / Stream/Channels / Site Land Use / E Geomorph / Patt Geomorph

Scale / Sheet No / Rainfall / Geology: Cza? / Eval / %: A4·0 / Class: S / MT / Incl / Type: PLA / Loc / Height / Width / Length / Pattern: PLA / Relief / Class / Modal / RMS: LP GP / Spac / Dev / D:W / Mig / Pat / Int / Dir / LU1 / Mgt1 / Mgt2 / LU2 / Mgt1 / Mgt2 / Agent Mode / Agent Mode / Status

Desc By: BURJ / Date (ddmmyy): 070913 / POT: C / M Type: M / L Meas: 4 / Obs Reas / Runoff: 2 / Perm: 2 / Drainage: 4 / M Samp / Aggredn / Depth R Horiz: 999 / Depth to Free Water / Tax Unit Type: SPC / Code / Map Unit Type / Code / Photo Meas East / North / Air Photos Film No / Run No / Frame No / Obs Land Use / Obs Management Practices / Aspect / Inundation Freq / Dur / Depth / ROV

Elevation Eval / Elev / Eval / Height / Drainage / Rainforest For Type / Sclero / Cmpx / FC / Ind / LS / TO / Distance / Conf / Substrate Depth: 999 / Gr S / Str / Por / Sp F / Alt / Str / Lith / Gen T / Text / Mass Str / MDS / MC1 / MC2 / Dat: WGS84 / Location Zone: 3 55 / Easting/Latitude: 785520 / Northing/Longitude: 7328777 / Conf / Australian Soil Classification Ord / Sub Ord / GG/ Or2 / SG/ SO2: GOAE / F1 F2 F3 F4 F5 / PPF / GSG aff

Microrelief No / Disturb / Surf Con / Type / Agent / Cmpt / Prop / VI / HI / Erosion Type / State / Deg / GD / Surf Coarse Frags Abun / Size / Shape / Lith / Str / Outcrop Abun / Lith / Community No / Ref No / Name / Strata / Form / Ht C / Co C / Community 1 Details Height Cover / Species 1 / Prop / Species 2 / Prop / Species 3 / Prop

cleared + cropped → 1 / Disturb: H / Surf Con: Z / Surf Coarse Frags: 1 4 U QS / Outcrop: 0

Soft in cultivation; definitely not cracking. R. Not SM – paradary surface ~ T/C

/ Non cracking + non gilgaied.

Quartzite / siliceous river worn rock. Suggests some alluvial influence

Outside cultivation: T6I EUCCAMBA ACAHARPO. S4 ✓ CITGLAUC

Horizon	Depth Upper	Depth Lower	Bnd	Field Texture	Facies	Colour Hue	V C	Moist	Mottles	Coarse Fragments	Structure	Pores Strgth	Sample
loose surface layer Ap1	0.00	0.05	C	FSLC	SF friable mat	10 YR	32	M	0	0	W/M3SB 0	D4	0-0.1
B21p	0.05	0.20	C	FSHC		10 YR	31	M			M/S3AB	D6	–
B22	0.20	0.50	C	FSMHC	shiny + greasy	10 YR	43	M			S4-5LE	D6/7	0.25-0.35
B23	0.50	1.00	G/D	FSMHC		10 YR	54	M	M11FO		M4-5LE	D6	0.55-0.65 0.85-0.95
B24	1.00	1.50		FSMHC		10 YR	53	M	M21FO		S2-3LE	T4	1.15-1.25
								M					+ pH CL 0-3/0-6
								M					+ EC @ 0·1/0·4/1·0/1·2.

both textures fairly [illegible]

Sampled

Test M						
pH - RP 1	9.6 / 10.8	0.30 / 8.8	0.60 / 8.8	0.90 / 8.8	1.20 / 6.0	1.50 / 5.2

pH - 1:5 1

pH - H20 1

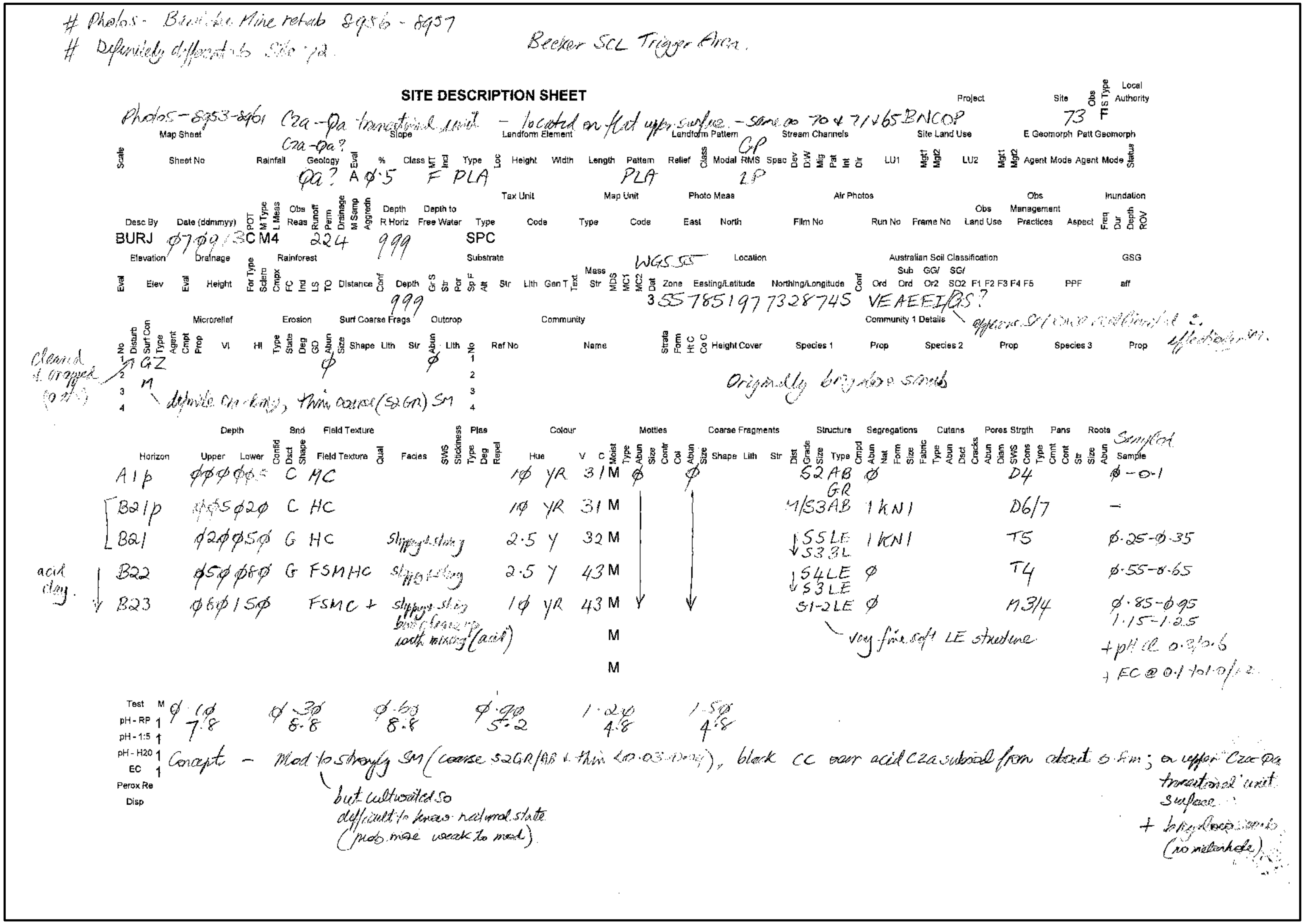
EC 1

Perox Re

Disp

Concept
- inspection outside cultivation suggests typical Cza loamy surfaced T/C + shrubby brigalow/blackbutt; acid pHC depth confirms Cza.
- cultivation has incorporated surface layer with upper subsoil
- Hardsetting, loamy surfaced (sporadically bleached?), sodic, black T/C on Cza (just up from Qa - Cza transition) + brigalow blackbutt scrub

BNCOP Disturbance Footprint – Soil 4c
SCL trigger area field site – 73



Photos - Baralaba Mine rehab 8956 - 8957
Definitely different to Site 72.

Becker SCL Trigger Area.

SITE DESCRIPTION SHEET

Photos - 8953-8961 Cza-Qa transitional unit - located on flat upper surface. - same as 70 & 71 & 65

Project: BNCOP
Site: 73
Obs Type: F

Geology: Cza-Qa?
Qa?

Eval: A
Slope %: 0.5
Landform Element Type: F PLA
Landform Pattern: PLA
Modal Slope Class: GP
Relief / RMS: 2P

Desc By: BURJ
Date (ddmmyy): 070913
POT: C
M Type: M4
Obs Reas / Runoff / Perm: 224
Depth R Horiz: 999
Depth to Free Water Type: SPC

Substrate Depth: 999

Location: WGS 55
Zone: 55
Easting/Latitude: 785197
Northing/Longitude: 7328745
Dat: 3

Australian Soil Classification: VE AE EI GS ?
Community 1 Details \ approx. 3/4 above natural state. effectively?

Microrelief / Disturb:
1 GZ
2 M
3
4

Cleared & cropped (now)

\ definite cracking, thin coarse (S2GR) SM

Surf Coarse Frags Abun: 0
Outcrop Abun: 0

Originally brigalow scrub

Sampled

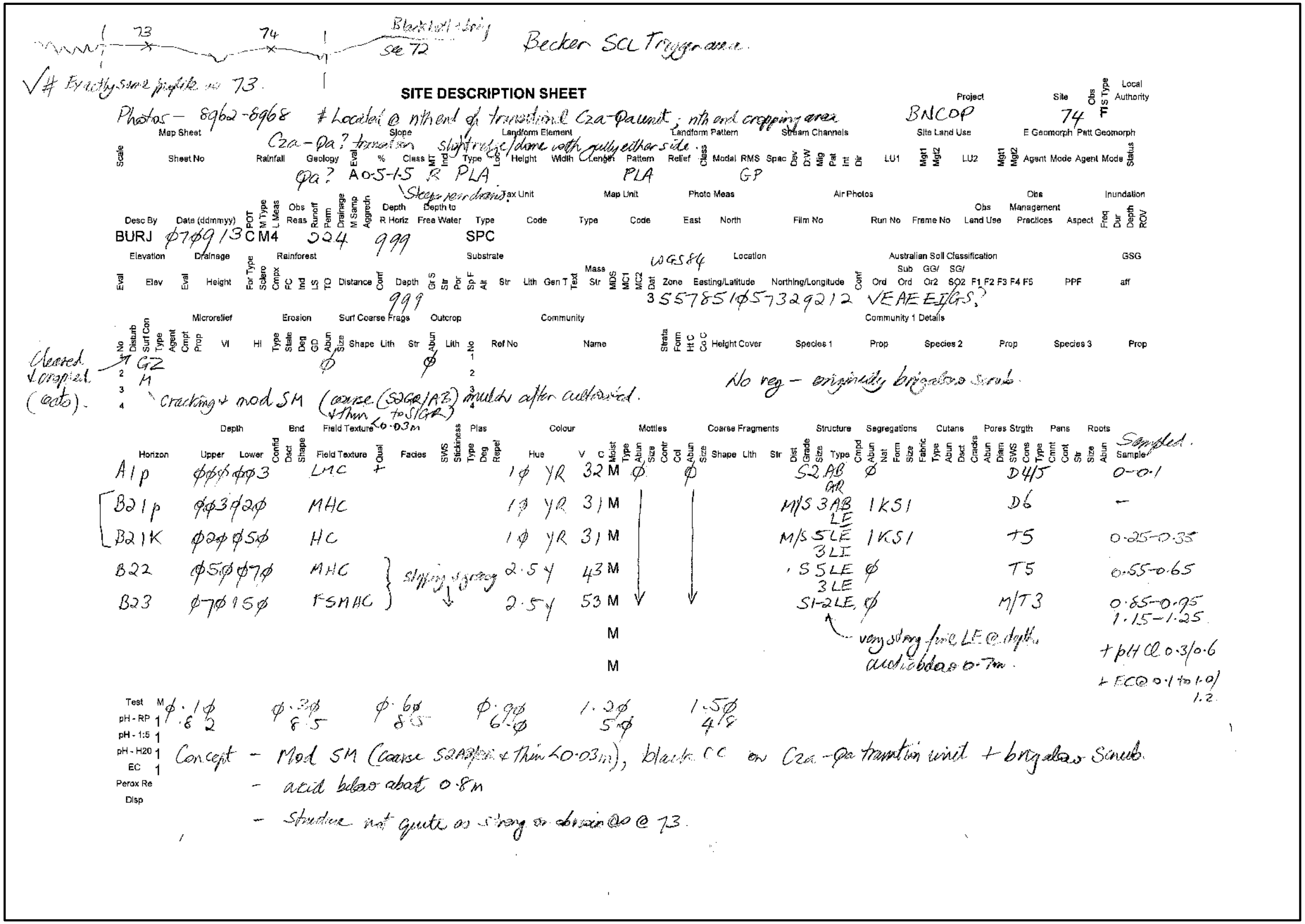
Horizon	Upper	Lower	Bnd	Field Texture	Facies	Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations	Strgth	Sample
A1p	000	005	C	MC		10 YR	31	M	0	0	S2AB GR	0	D4	0-0.1
[B21p	005	020	C	HC		10 YR	31	M	↓	↓	M/S3AB	1KN1	D6/7	–
B21	020	050	G	HC	slippy & shiny	2.5 Y	32	M			↓S5LE ↓S33L	1KN1	T5	0.25-0.35
acid clay. B22	050	080	G	FSMHC	slippy & shiny	2.5 Y	43	M			↓S4LE ↓S3LE	0	T4	0.55-0.65
↓ B23	080	150		FSMC +	slippy shiny but cleaner up with mixing (acid)	10 YR	43	M	↓	↓	S1-2LE \ very fine soft LE structure	0	M3/4	0.85-0.95 1.15-1.25 +pH @ 0.3/0.6 + EC @ 0.1 to 1.0/1.2
								M						
								M						

Test	M					
	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP 1	7.8	8.8	8.8	5.2	4.8	4.8
pH - 1:5 1						
pH - H20 1						
EC 1						
Perox Re						
Disp						

Concept - Mod to strongly SM (coarse S2GR/AB & thin <0.03 m), black CC over acid Cza subsoil from about 0.5 m; on upper Cza-Qa transitional unit surface + brigalow scrub (no melonhole).

\ but cultivated so difficult to know natural state (prob. more weak to mod).

BNCOP Disturbance Footprint – Soil 4c
SCL trigger area field site – 74



73 74 Blacksoil + brig see 72

Becker SCL Trigger area.

√# Exactly same profile as 73.

SITE DESCRIPTION SHEET

Photos – 8962-8968 # Located @ nth end of transitional Cza-Qa unit; nth end cropping area

Project: BNCOP
Site: 74

Geology: Cza – Qa? transition; Qa?
Slope: A 0.5-1.5
Landform Element: slight ridge/dome with gully either side.; R PLA \Steeper? [illegible]
Landform Pattern: PLA
RMS: GP

Desc By: BURJ
Date (ddmmyy): 070913
POT: C
M Type: M4
Runoff: 3
Perm: 2
Drainage: 4
Depth R Horiz: 999
Type: SPC
Depth (Substrate): 999
Dat: WGS84
Zone: 3 55
Easting/Latitude: 785105
Northing/Longitude: 7329212
Australian Soil Classification: VE AE EI GS?

Cleared & cropped (oats). Disturb: GZ; M
Surf Coarse Frags Abun: 0
Outcrop Abun: 0
Cracking + mod SM (coarse (S2GR/AB) + thin to S1GR) <0.03m mulch after cultivated.

No veg – originally brigalow scrub.

Sampled.

Horizon	Upper	Lower	Field Texture	Qual	Facies	Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations	Pores Strgth	Sample
A1p	000	003	LMC	+		10 YR	32	M	0	0	S2 AB GR	0	D4/5	0–0.1
B21p	003	020	MHC			10 YR	31	M	↓	↓	M/S 3 AB LE	1KS1	D6	–
B21K	020	050	HC			10 YR	31	M			M/S 5LE 3LI	1KS1	T5	0.25–0.35
B22	050	070	MHC		slipping strongly	2.5 Y	43	M			S 5LE 3LE	0	T5	0.55–0.65
B23	070	150	FSMHC		↓	2.5 Y	53	M			S1-2LE,	0	M/T3	0.65–0.95 1.15–1.25
								M						
								M						

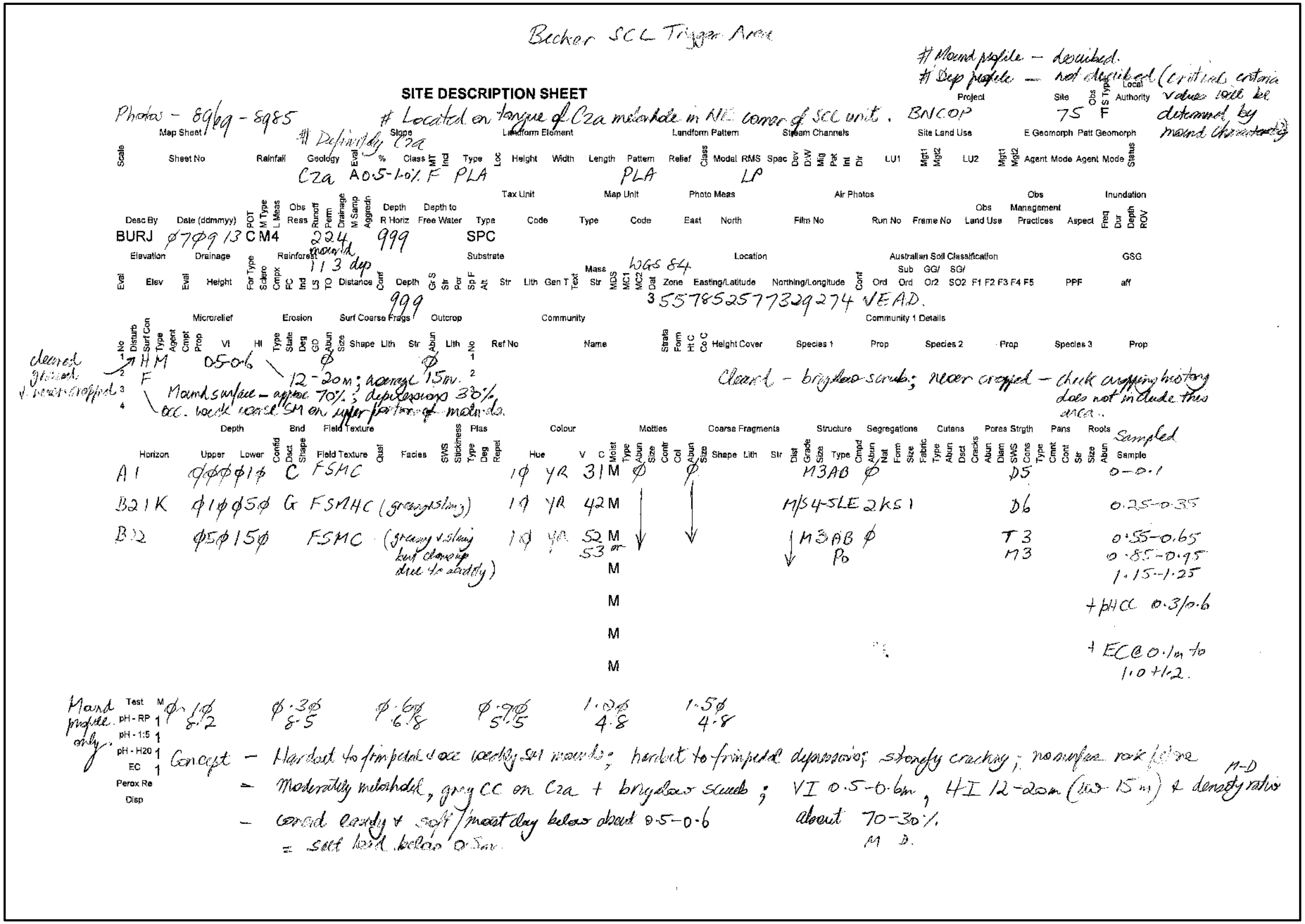
very strong fine LE @ depth. acid below 0.7m.

+ pH CL 0.3/0.6
+ EC @ 0.1 to 1.0/1.2

Test	M					
	0.10	0.30	0.60	0.90	1.20	1.50
pH - RP	1 8.2	8.5	8.5	6.0	5.0	4.8
pH - 1:5	1					
pH - H20	1					
EC	1					
Perox Re						
Disp						

Concept – Mod SM (coarse S2AB/GR + thin <0.03m), black CC on Cza-Qa transition unit + brigalow scrub.
– acid below about 0.8m
– Structure not quite as strong as observed @ 73.

BNCOP Disturbance Footprint – Soil 7a
SCL trigger area field site – 75



Becker SCL Trigger Area

Mound profile – described.
Dep profile – not described (critical criteria values will be determined by mound characteristics)

SITE DESCRIPTION SHEET

Photos – 8969 – 8985
Located on tongue of Cza melonhole in NE corner of SCL unit.
Definitely Cza

Project: BNCOP
Site: 75
Obs Type: F
Local Authority

Map Sheet: Scale, Sheet No
Rainfall
Geology: Cza
Slope: Eval A, % 0.5-1.0%, Class F
Landform Element: Type PLA
Landform Pattern: Pattern PLA, Modal Relief LP
Stream Channels
Site Land Use
E Geomorph, Patt Geomorph

Desc By: BURJ
Date (ddmmyy): 070913
POT: C
M Type: M4
Obs Reas: 224 mound, 113 dep
Depth R Horiz: 999
Type: SPC
Tax Unit, Map Unit, Photo Meas, Air Photos, Obs, Inundation

Elevation, Drainage, Rainforest
Substrate Depth: 999
Location: WGS 84
Zone: 3
Zone, Easting/Latitude, Northing/Longitude: 55785257732927
Australian Soil Classification: VEAD.
GSG

Microrelief:
1 HM 0.5-0.6 — 12 - 20m; average 15m.
2 F
3 Mound surface – approx 70%; depressions 30%
4 occ. weak linear SM on upper portion of mounds.

cleared grazed & never cropped

Erosion
Surf Coarse Frags: Abun 0
Outcrop: Abun 0

Community 1 Details: Cleared – brigalow scrub; never cropped – check cropping history does not include this area..

Sampled

Horizon	Depth Upper	Depth Lower	Bnd Dsct	Field Texture	Colour Hue	V C	Moist	Mottles Abun	Coarse Fragments Abun	Structure	Segregations Abun	Strgth	Sample
A1	0.00	0.10	C	FSMC	10 YR	31	M	0	0	M3AB	0	D5	0-0.1
B21K	0.10	0.50	G	FSMHC (greasy & slaking)	10 YR	42	M	↓	↓	M/S4-5LE	2KS1	D6	0.25-0.35
B22	0.50	1.50		FSMC (greasy & slaking but clears up due to acidity)	10 YR	52 or 53	M	↓	↓	↓ M3AB Po	0	T3 M3	0.55-0.65 0.85-0.95 1.15-1.25
							M						+ pHCC 0.3/0.6
							M						
							M						+ EC @ 0.1m to 1.0 + 1.2.
							M						

Mound profile only.

Test	M						
		0.10	0.30	0.60	0.90	1.00	1.50
pH - RP	1	8.2	8.5	6.8	5.5	4.8	4.8
pH - 1:5	1						
pH - H20	1						
EC	1						
Perox Re							
Disp							

Concept – Hardset to firmpedal & occ weakly SM mounds; hardset to firmpedal depressions; strongly cracking; no surface rock/stone
– Moderately melonholed, grey CC on Cza + brigalow scrub; VI 0.5-0.6m, HI 12-20m (av 15m) & density ratio M-D about 70-30%. M D.
– Cored easily & soft/moist day below about 0.5-0.6
= salt load below 0.5m

Appendix 8 – Assessment methodology used to determine pre-mining grazing suitability within the BNCOP Disturbance Footprint (QDME 1995).

Assessment criteria including explanation of limitations, attribute values and subclass suitability rules for grazing come directly from the "*Technical guidelines for Environmental Management of Exploration and Mining in Queensland"* (QDME 1995), in full and without change or addition.

Assessment methodology for determining pre-mining grazing suitability in Queensland (QDME 1995)

The land suitability assessment methodology described in the "*Technical guidelines for Environmental Management of Exploration and Mining in Queensland*" (QDME 1995) presents definitions, limitations, attribute values and subclass suitability rules for assessing the agricultural potential for both dryland cropping and grazing of lands within inland Queensland (particularly the semi-arid sub tropics/inland Central Queensland), but only the grazing suitability framework is presented here. The scheme uses a five class land suitability classification (Land Resources Branch Staff 1990, DNRM/DSITIA 2013a) with a common set of attributes/limitations, but separate decision rules for each land use. The scheme assesses the climatic or land based limitations to production that an area may be subject to and allocates land into one of five possible classes. Final suitability class is a measure of the potential of a particular soil or land area to attain optimum production with minimal long-term degradation, for the land use being considered.

The land suitability framework described below including explanation of limitations, attribute values and subclass suitability rules comes directly from the "*Land Suitability Assessment Techniques*" section within the "*Technical guidelines for Environmental Management of Exploration and Mining in Queensland"* (QDME 1995). Attribute values and suitability subclass rules for grazing have been reproduced directly from "*Attachment 2*" of the same document without change or addition.

Land suitability classification definitions

The five standard suitability classes for semi arid land uses in Queensland (namely dryland cropping and grazing) defined within the "*Technical guidelines for Environmental Management of Exploration and Mining in Queensland*" (QDME 1995) are presented below. Recent updated definitions released by DNRM/DSITIA (2013a, 2013b) remain essentially unchanged.

Class 1	**Suitable land with negligible limitations –** land which is well suited to a proposed use;
Class 2	**Suitable land with minor limitations –** land which is suited to a proposed use but which may require minor changes in management to sustain the use;
Class 3	**Suitable land with moderate limitations –** land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use;
Class 4	**Marginally suitable land with severe limitations –** land which is marginally suited for a proposed use and would require major inputs to ensure sustainability; often the inputs required may not be justified in terms of the benefits to be gained from using the land for a proposed use and the land is considered presently unsuitable for that use; and
Class 5	**Unsuitable land with extreme limitations –** land which is unsuited and cannot be sustainably used for a proposed use.

Land is considered less suitable as the severity of limitations for a particular land use increase. Increasing limitations may reflect either (a) reduced potential for production, and/or (b) increased inputs to achieve an acceptable level of production and/or (c) increased inputs required to prevent land degradation. Suitability **Classes 1 to 3** are considered suitable for a specified land use because the benefits from using the land (for that particular use) outweigh the inputs required to initiate and maintain production.

Typically, the benefits from using **Class 4** land are similar in magnitude to the level of inputs required to achieve production and its long-term suitability for the specified land use is doubtful. Class 4 is also used in situations where reducing the effect of a particular limitation may indicate production is possible, but additional studies are needed to determine the feasibility of such actions (e.g., levelling of melonholes may assist cultivation and wetness problems but subsoil salinity levels require investigation).

In contrast, there is no doubt regarding the long-term suitability of Class 1–3 lands or the unsuitability of Class 5 land. **Class 5** land has limitations that in aggregate are so severe that the benefits do not justify the inputs required to initiate and maintain production. It would require a major change in economics, technology or management expertise before the land could be considered suitable for the land use being considered. Many Class 5 lands have physical characteristics that totally preclude any form of development (e.g., mountains) and will always remain unsuitable for agriculture.

Grazing scheme

The **suitability classification for grazing** evaluates soils in terms of the potential to graze and finish cattle on improved pastures (QDME 1995, Shields and Williams 1991). Typically, grazing systems in inland Central Queensland aim to produce young, finished, grassfed, export quality cattle without inputs other than pasture development. Most production is based around improved pasture grass - legume pastures. Improved pasture development in many areas is dominated by buffel grass, although Rhodes grass, introduced bluegrasses (Indian bluegrass, creeping bluegrass), purple pigeon grass and panic species all have a role in certain situations. Legume establishment and species vary significantly depending on soil characteristics and climate. Commonly used legumes include shrubby stylos species, Desmanthus species, Wynn cassia (sandy), butterfly pea (clay), siratro, medics and leucaena (cropping soils).

Class 1 and 2 land is considered suitable for grazing improved pastures and is capable of attaining maximum grazing productivity (QDME 1995, Shields and Williams 1991). In inland Central Queensland this can be defined as the production of young, finished, grassfed, export quality cattle in most seasons, and such country is termed 'fattening country'. **Class 3** land is suitable for grazing improved pastures but is generally less productive than Classes 1 and 2 and encompasses a range in productivity. Land in this class is often termed 'growing country' and is defined as country on which younger cattle perform well but may be difficult to finish at a young age, depending on seasonal conditions (i.e. cattle on Class 3 land may take longer to achieve the desired weight class or finished grade than equivalent cattle on Classes 1 and 2).

Class 4 land is considered marginal for grazing improved pastures, but is generally considered suitable for grazing native pastures of varying quality all year round, depending on soil characteristics, (QDME 1995, Shields and Williams 1991). In inland Central Queensland such country is typically termed 'breeding country'. It encompasses a range in productivity from the lower end of Class 3 'growing country' through to the poorer end of Class 4 'breeding country'. Shields and Williams (1991) suggest 3 possible subclasses exist within Class 4:

- land with native pasture of low productivity, which while physically capable of being developed to improved pasture, is subject to low soil fertility and doubtful long term productivity;
- land with high quality native pasture (typically black soil downs) on which improved pasture establishment is marginal because of unfavourable soil characteristics and limited species; and
- land with native pasture of low productivity, which has physical limitations that preclude full improved pasture development, but allow oversowing of legumes such as shrubby stylo.

Class 5 land is unsuitable for any form of pasture improvement, and land use is limited to extensive grazing of native pastures of low productivity. In many cases, lands are of such poor quality they are considered marginal as 'breeding country' and may be destocked in the winter/dry season, unless grazed in conjunction with better quality country. Land in this class is mostly used, as 'breeding country' during the summer/wet season when planes of nutrition are higher.

Land use requirements, limitations and soil and land attributes

A set of land use requirements for plant growth, machinery use, land preparation, irrigation and the prevention of land degradation has been defined for agricultural land uses in Queensland (Land Resources Branch Staff 1990, QDME 1995). To assess the suitability of any parcel of land for a particular use, it is necessary that each of the relevant land use requirements be considered. Attributes of land which cause it to have less than optimal conditions for a particular use are known as limitations. Management is concerned with overcoming or reducing the effects of such limitations.

In inland Central Queensland, where dryland cropping and grazing are the predominant land uses, a total of 13 land use requirements and associated limitations have been identified as important by the "*Technical guidelines for Environmental Management of Exploration and Mining in Queensland*" (QDME 1995). These are listed below and are described more fully in the sections that follow.

Land use requirements	Limitations	Soil and land attributes used to assess each limitation
1. Adequate water supply	water availability (M)	PAWC, ERD (including effects of subsoil sodicity and inherent salinity), deep drainage losses, infiltration rate, crop modelling,
2. Adequate nutrient supply	nutrient deficiency (Nd)	surface soil (0.1 m) levels of Bicarb P (ppm) and Total N (%)
3. Ease of seedbed preparation and plant establishment	surface condition (Ps)	surface soil structure, surface condition, surface soil texture
4. Salinity free root zone	root zone salinity (Sa)	Average salinity within the root zone (ERD)
5. Rock-free	rockiness (R)	size and content (%) of coarse fragments, % rock outcrop
6. Level land surface	microrelief (Tm)	size and frequency of microrelief

Land use requirements	Limitations	Soil and land attributes used to assess each limitation
7. Adequate soil aeration	wetness (W)	field based soil drainage and permeability classes
8. Trafficable, stable land surface	topography (Tg)	size, depth and frequency of gullies
9. Minimum soil loss from erosion	water erosion (E)	slope/soil stability group combinations
10. Absence of damaging floods	flooding (F)	frequency of flooding based on average recurrence interval (ARI)
11. Absence of undesirable vegetation	vegetation (V)	vegetation type, regrowth potential, potential for shrubby thickening
12. Desirable surface soil pH	surface soil pH (0.1m)	1:5 soil water pH
13. Absence of dispersive behaviour in the soil surface	surface soil dispersive potential (0.1m)	ESP

Limitations listed do not necessarily apply to all land uses or to all soils. The importance of each limitation and the soil and land attributes used in its assessment, as well as the limitation subclasses used in the assessment of final suitability ratings for each soil and land use are discussed more fully below. All explanation, terminology and abbreviations used come directly from or are consistent with the "*Technical guidelines for Environmental Management of Exploration and Mining in Queensland*" (QDME 1995) and the *Guidelines for Agricultural Land Evaluation in Queensland* (Land Resources Branch Staff 1990, DNRM/DSITIA 2013a, 2013b), as well as Mckenzie *et al* (2008), the National Committee on Soil and Terrain (2009) and Isbell (1996).

Water availability (M)

Attribute	Level	Description of attribute	Subclasses ratings
Grazing		QDME (1995) specify max. ERD (in the absence of rock or salinity >800ppm Cl) be set at 0.6m for pastures. PAWC sub-class values listed below are calculated accordingly as 60% of the 1.0m soil depth values listed in Table 2.2 of the QDME scheme (1995).	
M	1	PAWC >75mm/0.6m soil (60% of PAWC >125mm/1.0m; see Table 2.2 QDME (1995))	1
M	2	PAWC 60-75mm/0.6m soil (60% of PAWC 100-125mm/1.0m; see Table 2.2 QDME (1995))	2
M	3	PAWC 45-60mm/0.6m soil (60% of PAWC 75-100mm/1.0m; see Table 2.2 QDME (1995))	3
M	4	PAWC 30-45mm/0.6m soil (60% of PAWC 50-75mm/1.0m; see Table 2.2 QDME (1995))	4
M	5	PAWC <30mm/0.6m soil (60% of PAWC ≤50mm/1.0m; see Table 2.2 QDME (1995))	5

The plant available water capacity (PAWC) of a soil is defined as the amount of stored water a soil is capable of retaining against drainage that is available for plant growth. It represents the total amount of moisture a soil can hold at any given time after free drainage and is calculated as the difference between the water in a soil when fully wet compared with that at wilting point. It is largely dependent on particle size distribution (particularly clay content and mineralogy), structure and pore space within a soil and is calculated as the sum of stored moisture within the effective rooting depth (ERD) of the soil, as determined by the presence or absence of subsoil constraints (i.e. depth to which plant roots can grow and function effectively). PAWC is normally quoted as a measure of equivalent depth of water in the soil in mm.

Stored soil moisture is less critical for grazing than it is for cropping because it grazing productivity is more dependent on continuous vegetative leaf production and harvest rather than maximizing flowering or grain filling potential at set times. Because of this, PAWC limits for each grazing subclass are set at lower levels expected for cropping (QDME 1995).

Nutrient deficiency (Nd)

Attribute	Level	Description of attribute	Subclasses ratings
Grazing		**Bicarb. P (ppm)**	
Nd	1	Brigalow or softwood scrub soils >10ppm	1
Nd	2	Eucalypt soils or open downs >10ppm	2
Nd	3	Other soils 5-10ppm; except deep sands/loams >0.75m; shallow sands/loams on rock	3
Nd	4	Deep sands/loams >0.75m or shallow sands/loams on rock - 5-10ppm; other soils ≤4ppm	4
Nd	5	na	5

The inorganic nutrients phosphorus, potassium and calcium are the dominant nutrients controlling grazing productivity in inland Central Queensland (as defined by the QDME (1995) scheme) and combined levels of these three nutrients provide a useful framework for evaluating overall nutrient availability. Phosphorus, potassium and calcium are the nutrients required in the largest quantities by plants. They are also critical for both plant and animal growth and metabolism, and are deficient in a number of Central Queensland soils. In general, the inorganic fertility, particularly the level of phosphorus, of a soil reflects the history of soil and landscape development, particularly the interactions between climate, geology, topography, vegetation and fire history over time.

Soil physical factors – surface condition (Ps)

Attribute	Level	Description of attribute	Subclasses ratings
Grazing			
Ps	1	Cracking clays with very fine SM (<2mm); or rigid soils with loose, soft or firm surface	1
Ps	2	Cracking clays with fine SM (2-10mm); or rigid soils with hardsetting surface	2
Ps	3	Cracking clays with coarse peds at the surface (>10mm); or subject to crusting behaviour	3
Ps	4	na	4
Ps	5	na	5

Seedling emergence and establishment are affected by adverse physical conditions in the surface soil including hard setting, crusting or coarse self-mulching behaviour. Such conditions can reduce plant establishment either by failing to maintain adequate seed - soil contact or by providing a barrier to seedling emergence. High evaporation rates in the Bowen Basin mean it is critical for crop seeds to have adequate seed – soil contact (with moist soil) following planting to ensure desiccation during germination does not occur. In general, soil physical conditions associated with seedling germination and emergence are far less critical for grazing than for the establishment of crops.

Root zone salinity (Sa)

Attribute	Level	Description of attribute	Subclasses ratings
Grazing			
Sa	1	Rootzone EC <0.15ds/m; or Rootzone Cl <300ppm	1
Sa	2	Rootzone EC 0.15 – 0.3ds/m; or Rootzone Cl 300 - 600ppm	2
Sa	3	Rootzone EC 0.3 – 0.9ds/m; or Rootzone Cl 600 - 900ppm	3
Sa	4	Rootzone EC 0.9 – 1.2ds/m; or Rootzone Cl 900 - 1500ppm	4
Sa	5	Rootzone EC >1.2ds/m; or Rootzone Cl >1500ppm	5

The salinity attribute provides a measure of the presence of soluble salts in the soil profile. Within inland Central Queensland inherent salt loads typically exist at some depth within the upper 2 m of many soil landscapes. Salt loads originate either from the weathering of underlying substrates; or from long term accumulations of cyclic salt (windblown ocean salt) that has built up within the catchments due to the combination of limited rainfall (<650 mm) and slowly drained, relatively low relief landscapes. Soluble salts affect plants through a number of mechanisms:

- osmotic effects that limit water uptake;
- toxicity effects caused by specific ions, principally sodium chloride; and
- restrictions to root development down the profile.

Leaching processes in soils often lead to a concentration of soluble salts in the upper 1-2m of soil landscapes because of subsoil drainage or permeability restrictions. These subsoil concentrations are often termed a salt bulge and provide an indication of the long term, maximum depth to which water typically moves through the soil mass. The depth to any significant salt bulge (>0.8dS/m or Cl >800ppm) is often used as a surrogate for determining effective rooting depth (QDME 1995).

Where significant levels of soluble salts are present within the rootzone (i.e. in the soil material sitting above the effective rooting depth) then effects on plant growth may limit production. Because plant response to soil salinity and effect on crop yield are species specific, comparisons of average or water uptake weighted root zone salinity values against yield reduction data (SalCon 1997) have not been considered as part of this limitation in the QDME (1995) scheme. Instead, a mean profile salinity value (dS/m) averaged across recorded $EC_{1:5}$ values at 0.1 m increments down the profile to the effective rooting depth (ERD) for each soil has been used to define Sa attribute levels (QDME 1995).

Rockiness (R)

Attribute	Level	Description of attribute	Subclasses ratings
Grazing			
R	1	<20% coarse gravel (<6cm)/rock outcrop	1
R	2	20 – 50% coarse gravel (<6cm)/rock outcrop	2
R	3	50 – 90% cobble (6-20cm)/rock outcrop	3
R	4	>90% cobble (6-20cm)/rock outcrop	4
R	5	100% gravel, cobble (6-20cm),stone, boulders or rock outcrop	5

The rockiness limitation assesses the effect rock outcrop and coarse fragments within the plough zone may have on cultivation and machinery damage. Severity of the rockiness limitation is directly related to the size, quantity and hardness of coarse fragments within the plough zone. Attribute levels record the size and abundance of all coarse fragments (National Committee on Soil and Terrain 2009) described in the field. Coarse gravel refers to fragments that are 20 to 60 mm in size (average maximum dimension) and cobble/stone refers to fragments that are 60 to 600 mm in size. In situations where cultivation and seedbed preparation are required, QDME (1995) subclass criteria are based largely on the subclass limits documented by Shields and Williams (1991).

The presence of rock outcrop, boulders, stone, cobble or gravel has far less effect on grazing than for cropping. Significant rock within a paddock can however physically limit the area of land surface capable of growing pasture and may impact indirectly on the carrying capacity of the land in very rocky situations. In general, subclass criteria for grazing are determined more by the overall % of rock present and are less concerned with the actual size of the material.

Topography – microrelief (Tm)

Attribute	Level	Description of attribute	Subclasses ratings
Grazing			
Tm	1	Melonholes (VI >0.3m) cover <20%	1
Tm	2	Melonholes (VI 0.3-0.6m) cover 20-50%	2
Tm	3	Melonholes (VI >0.6m) cover 20-50%	3
Tm	4	na	na
Tm	5	na	na

Microrelief refers to local relief of up to a few metres about the plane of the land surface (National Committee on Soil and Terrain 2009). Gilgai or melonhole microrelief are common on clay soils in inland Central Queensland and cause problems with uneven cultivation, reduced trafficability and detrimental effects to plant growth including high salinity loads at shallow depths in gilgai mounds, coarse self-mulching surface conditions and ponding in depressions. Normal, linear and lattice gilgai have a vertical interval of approximately 0.3 m or less and present only a negligible limitation to the use of machinery. Melonhole gilgai however, have a vertical interval greater than 0.3 m and can impede cultivation and trafficability significantly. The degree of limitation associated with melonhole gilgai depends upon the % of the land surface affected, as well as the amplitude (vertical interval (m)) and the relative proportion of mounds, depressions and flat areas. As such, attribute levels are based on a combination of microrelief type and vertical interval (m), as well as an estimate of the spatial extent and variability within a soil.

Microrelief impacts in grazing situations are only seen on severely melonholed soils. In such cases, ponding in depressions and scalding on mounds can result in reduced potential pasture yield and theoretical carrying capacity after significant rainfall events.

Wetness (W)

Attribute	Level	Description of attribute	Subclasses ratings
Grazing			
W	1	Undulating terrain or elevated plains	1
W	2	Low lying level plains; or rigid soil with strongly sodic subsoil (ESP >15) <0.6m or non-sodic rigid soil with coarse grey/yellow mottling <0.5m	2
W	3	Shallow seasonal and permanent swamps	3
W	4	na	na
W	5	Permanent lakes and deep swamps	5

Wetness refers to excess water both on the soil surface and in the profile, as a direct result of rainfall or run on from adjacent land. Excess water can occur due to poor soil permeability, restricted surface drainage or a combination of both. This limitation does not however, consider excess water associated with overbank stream flow, which is normally considered as part of the flooding limitation. Waterlogged soils reduce plant growth and crop yield and delay effective machinery operation after rain. Excess water in the soil impedes oxygen supply to plant roots and promotes plant disease.

Excess water occurs intermittently in most clay soils in inland Central Queensland. In general, it is only a short-term problem but can result in denitrification due to anaerobic soil conditions, particularly with unseasonal winter rainfall when evaporation rates are low. Temporary waterlogging also occurs in the surface soil of all sodic texture contrast soils, due to problems with subsoil permeability. Bleached A2 horizons are indicative, and 'spewy' (i.e., boggy) conditions are common following rainfall due to super saturation of the surface soil. Frequent and prolonged wetness occurs in enclosed seasonal swamps and slowly drained alluvial backplains, and also on level (<1%), gilgaied clay plains. Melonholed clay plains (with microrelief between 0.6–>1.5 m deep) are normally relatively low-lying and very slowly drained compared with adjacent landscapes. Ponded surface water is often retained within deeper melonholes (>0.6 m) for periods of 3 months or more, particularly in Autumn. As such, QDME (1995) attribute levels for wetness are based largely on field observations of land surface terrain, presence of melonholes, subsoil sodicity and the presence of significant mottling. Landscape wetness is far less critical in grazing situations than for cropping and subclass criteria reflect this accordingly.

Topography – complex slopes/gullies (Tg)

Attribute	**Level**	**Description of attribute**	**Subclasses ratings**
Grazing			
Tg	1	na	na
Tg	2	na	na
Tg	3	na	na
Tg	4	Many deep gullies make cultivation for pasture improvement impractical; or slopes >15% prevent contour cultivation	4
Tg	5	Strongly dissected terrain over >75% of area makes herd management difficult	5

This limitation only applies in severe or extreme situations where landscape dissection directly affects pasture establishment and/or carrying capacity/grazing productivity.

Water erosion (E)

Attribute	**Level**	**Description of attribute**	**Subclasses ratings**
Grazing			
E	1	• Slopes <1% on sodic rigid soils • Slopes <3% on all other soils	1
E	2	• Slopes 1-3% on sodic rigid soils • Slopes 3-6% on all cracking clays • Slopes 3-12% on non-sodic rigid soils	2
E	3	• Slopes 3-6% on sodic rigid soils • Slopes 6-9% on all cracking clays • Slopes 12-20% on non-sodic rigid soils	3
E	4	• Slopes 6-12% on sodic rigid soils • Slopes 9-15% on all cracking clays • Slopes 20-45% on non-sodic rigid soils	4
E	5	• Slopes >45%	5

Factors affecting soil erosion are complex and depend on the interaction between rainfall amount, distribution and intensity, slope gradient and length, soil erodibility, infiltration and runoff, vegetative cover and management practices. Because variation in rainfall intensity across inland Central Queensland is relatively minor, and cover levels and management practices are temporal factors outside the scope of a suitability classification, assessment of erosion potential within the QDME (1995) classification considers only inherent soil profile characteristics (profile type, sodicity, surface texture) and slope (%).

Provided grazing lands are well managed, erosion presents only a negligible to moderate limitation (subclasses 1-3) on soil landscapes at slopes <6%; while grazing of any soil type at slopes >45% is unsuitable. Suitability for grazing at slopes between 6-45% is soil type dependent (QDME 1995).

Flooding (F)

Attribute	Level	Description of attribute	Subclasses ratings
Grazing			
F	1	No flooding	1
F	2	Periodic flooding (includes only during abnormal 1 in 50-100 year events to whenever stream flows occur)	2
F	3	na	na
F	4	na	na
F	5	na	na

Land periodically inundated by water from over bank stream flow is defined as having a flooding limitation. Flooding can cause plant death or reduced growth due to submergence, high water temperatures, anaerobic soil conditions and silt deposition. In addition, severe soil erosion and infrastructure damage may result from high velocity, erosive flooding. The severity of flooding as a limitation for grazing depends largely on the frequency of flooding (rare, infrequent, occasional and regular), although duration, depth and velocity of the floodwaters are also important.

The effects of flooding on grazing are typically negligible to minor, except on major floodplains such as the lower Dawson, Comet, Nogoa, Isaac, Mackenzie and Fitzroy Rivers where inundation for periods of several weeks or more can occur. In these situations stock losses and lost grazing production are significant issues, but are managed effectively through strategic destocking (November to March/April). Even in these situations, subclass 3 would be the maximum limitation subclass recorded.

Vegetation (V) - regrowth management

Attribute	Level	Description of attribute	Subclasses ratings
Grazing			
V	1	• Softwood, brigalow, gidgee or blackwood scrub without melonholes • Queensland bluegrass grasslands • Mountain coolabah, bloodwood and ironbark open woodlands	1
V	2	• Brigalow, gidgee or blackwood scrub with melonholes • Box and ironbark woodlands without wattle understorey • Coolabah woodlands on flooded country	2
V	3	na	3
V	4	• Eucalypt woodlands with wattle understorey • Broad-leaved teatree woodlands	4
V	5	na	5

Surface soil (0.1m) pH $_{1:5}$

Attribute	Level	Description of attribute	Subclasses ratings
Grazing			
pH $_{1:5}$	1	5.6-6.6	1
pH $_{1:5}$	2	5.0-5.6 6.6-8.0	2
pH $_{1:5}$	3	4.5-5.0 8.0-9.0	3
pH $_{1:5}$	4	4.0-4.5 9.0-10.0	4
pH $_{1:5}$	5	<4.0 >10.0	5

Surface soil (0.1m) dispersive potential (ESP)

Attribute	Level	Description of attribute	Subclasses ratings
Grazing			
ESP (0.1m)	1	<5	1

Attribute	Level	Description of attribute	Subclasses ratings
ESP (0.1m)	2	5-10	2
ESP (0.1m)	3	10-15	3
ESP (0.1m)	4	15-30	4
ESP (0.1m)	5	>30	5

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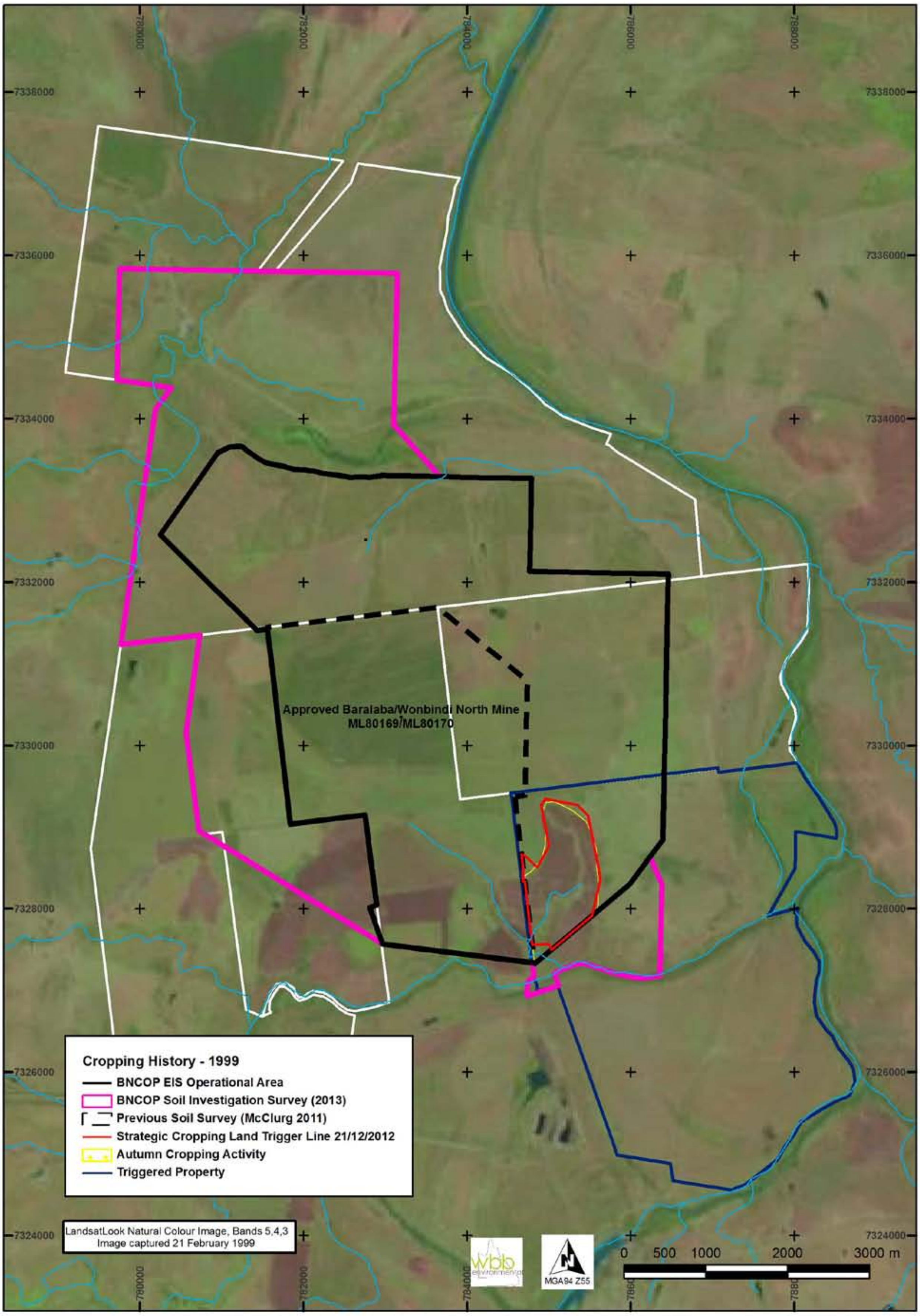
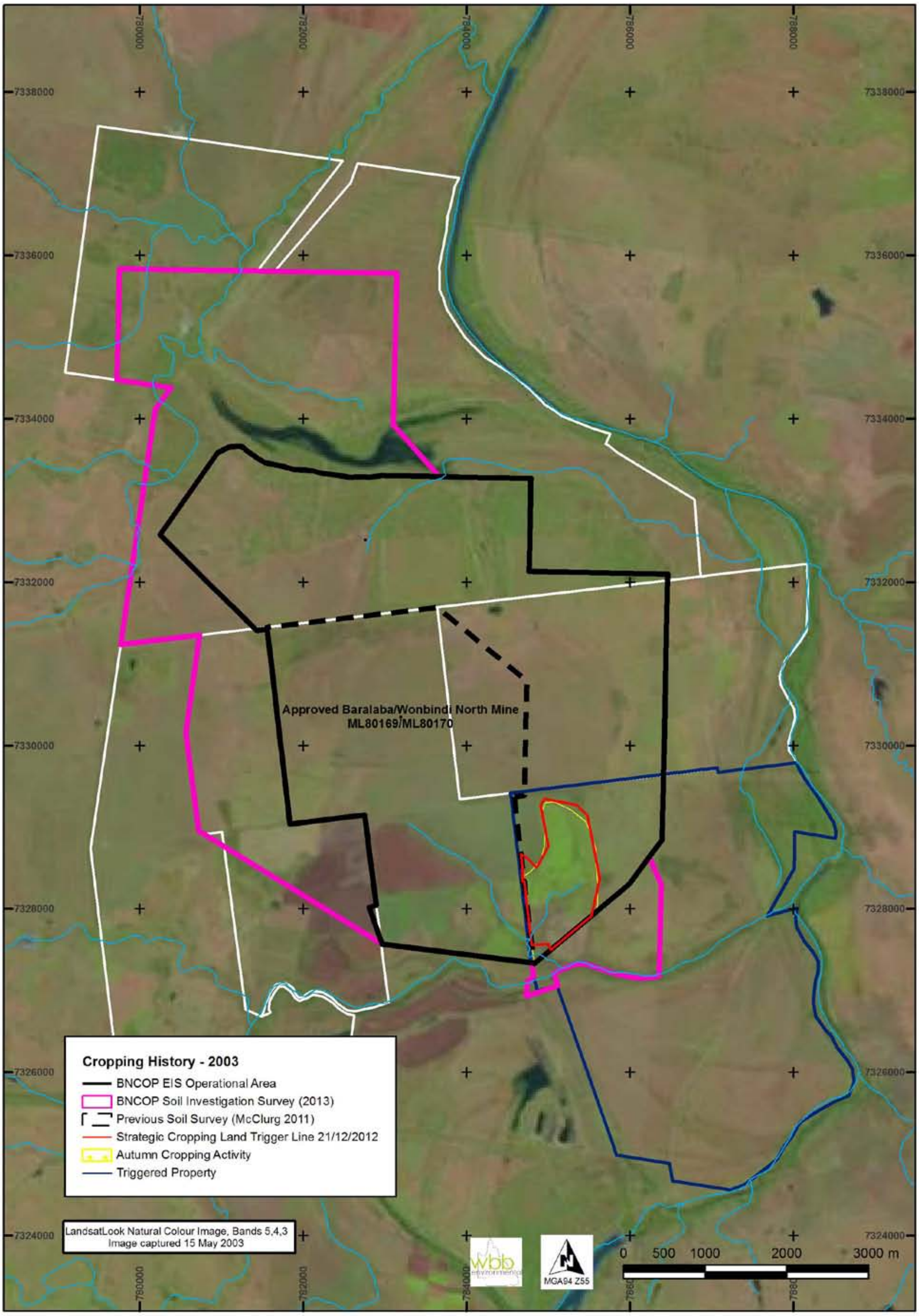
Appendix 9 – Raw Landsat imagery used to establish cropping history status within properties triggered for SCL assessment by the BNCOP Disturbance Footprint.


Approved Baralaba/Wonbindi North Mine
ML80169/ML80170
Cropping History - 1999
BNCOP EIS Operational Area
BNCOP Soil Investigation Survey (2013)
Previous Soil Survey (McClurg 2011)
Strategic Cropping Land Trigger Line 21/12/2012
Autumn Cropping Activity
Triggered Property
LandsatLook Natural Colour Image, Bands 5,4,3
Image captured 21 February 1999
MGA94 Z55
0
500
1000
2000
3000 m
780000
782000
784000
786000
788000
7338000
7336000
7334000
7332000
7330000
7328000
7326000
7324000


Approved Baralaba/Wonbindi North Mine
ML80169/ML80170
Cropping History - 2003
BNCOP EIS Operational Area
BNCOP Soil Investigation Survey (2013)
Previous Soil Survey (McClurg 2011)
Strategic Cropping Land Trigger Line 21/12/2012
Autumn Cropping Activity
Triggered Property
LandsatLook Natural Colour Image, Bands 5,4,3
Image captured 15 May 2003
MGA94 Z55
0
500
1000
2000
3000 m
780000
782000
784000
786000
788000
7338000
7336000
7334000
7332000
7330000
7328000
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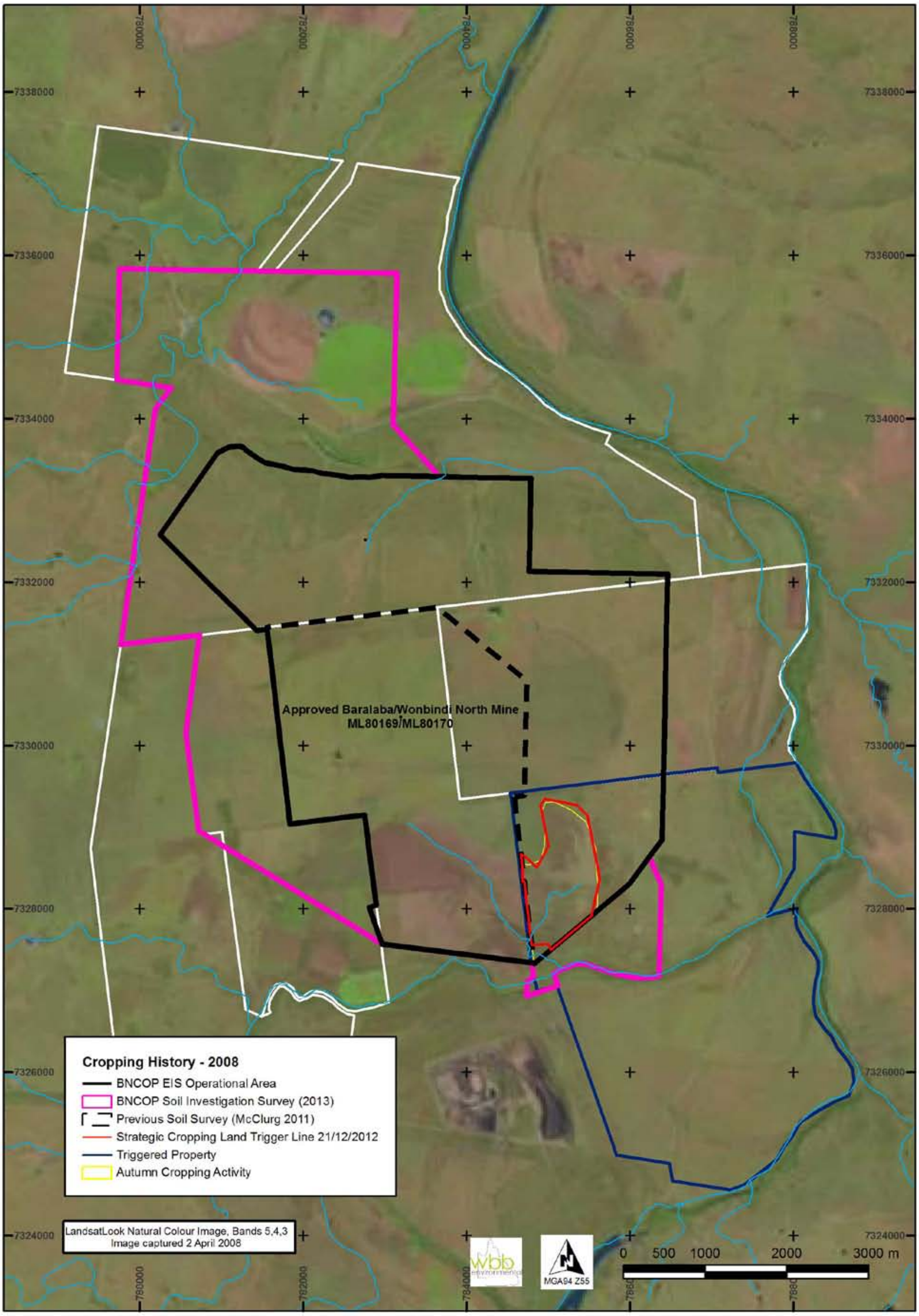
Cropping History - 2008
BNCOP EIS Operational Area
BNCOP Soil Investigation Survey (2013)
Previous Soil Survey (McClurg 2011)
Strategic Cropping Land Trigger Line 21/12/2012
Triggered Property
Autumn Cropping Activity
Approved Baralaba/Wonbindi North Mine
ML80169/ML80170
LandsatLook Natural Colour Image, Bands 5,4,3
Image captured 2 April 2008
wbb environmental
MGA94 Z55
0
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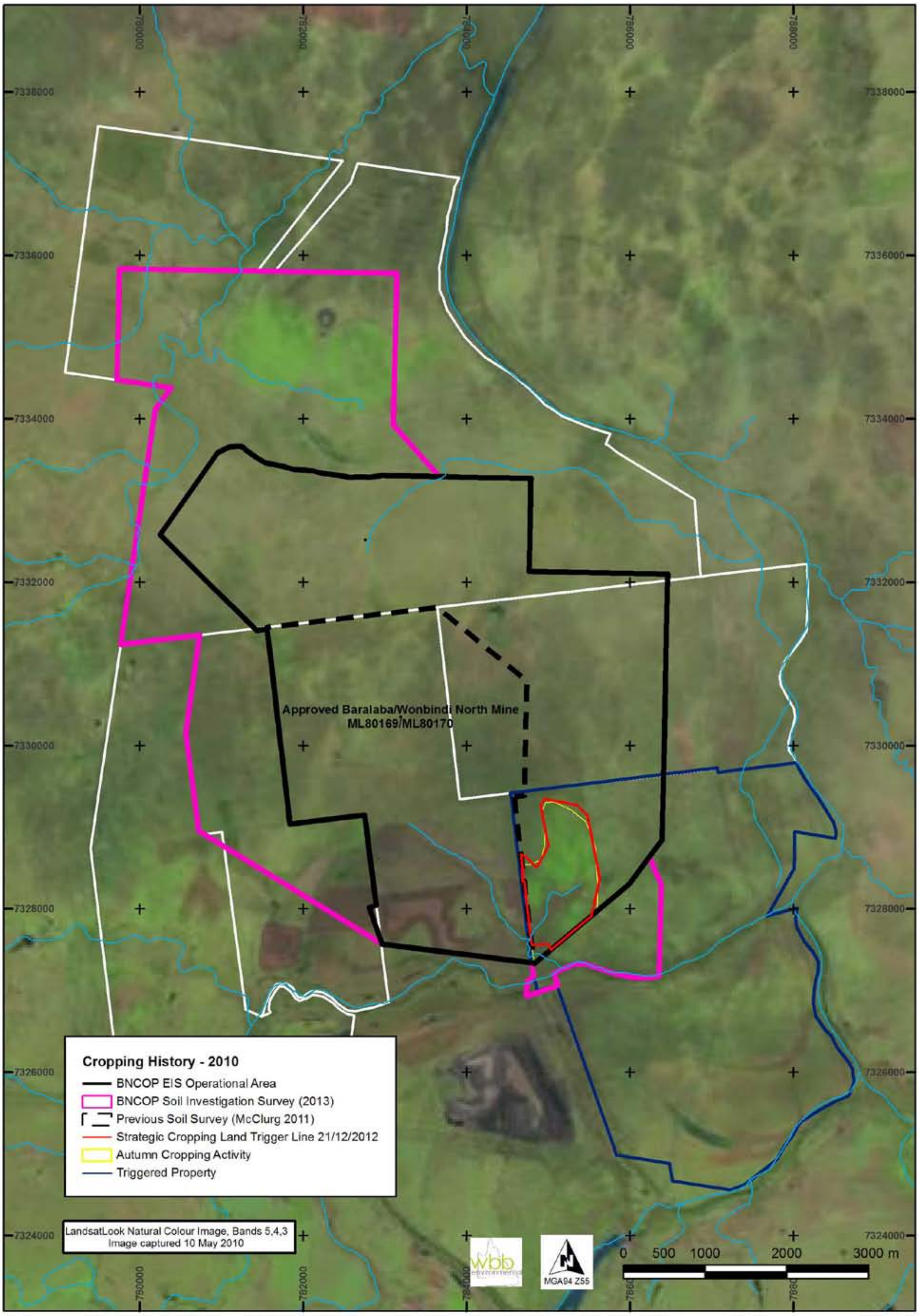
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Approved Baralaba/Wonbindi North Mine
ML80169/ML80170
Cropping History - 2010
BNCOP EIS Operational Area
BNCOP Soil Investigation Survey (2013)
Previous Soil Survey (McClurg 2011)
Strategic Cropping Land Trigger Line 21/12/2012
Autumn Cropping Activity
Triggered Property
LandsatLook Natural Colour Image, Bands 5,4,3
Image captured 10 May 2010
wbb
MGA94 Z55
0
500
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2000
3000 m

Appendix C – Protection Decision

Queensland
Government

Department of
Natural Resources and Mines

Information notice

Strategic Cropping Land Act 2011

Protection decision SCLRD2013/000161

This information notice is issued under s. 102 of the Strategic Cropping Land Act 2011 (SCL Act) to advise of a protection decision under s. 99 of the SCL Act.

Baralaba Coal Pty Ltd
PO Box 1823
Newcastle NSW 2300

Your reference: Application for a SCL Protection Decision - Baralaba North – Replacing SCL Protection Decisions SCLRD2012/000085 and SCLRD2012/000089

Our reference: SCLRD2013/000161

Attention: Bradly Sneddon
Ph: 0448 014 544 Email: bsnedden@cockatoocoal.com.au

Re: Application for a strategic cropping land protection decision by Baralaba Coal Pty Ltd for EPML00617113 and EPML00223213 in relation to coal mining and associated infrastructure (ML 80169, ML80170 and MDL 184) – Replacing SCL protection decisions SCLRD2012/000085 and SCLRD2012/000089.

The administering authority received your application for an SCL Protection Decision on 04/02/14 and is advising you of the following decision for **SCLRD2013/000161** which relates only to activities authorised by Environmental Authorities EPML00617113 and EPML00223213, that are the subject of the SCL application.

The maximum extents of permanent and temporary impacts on SCL or potential SCL as a result of resource activities carried out under Environmental Authorities EPML00617113 and EPML00223213 must be confined as follows.

Permanent impacts on SCL or potential SCL	**Extent of impact permissible**	**Unit**
Introduction of impediments to cropping or alterations to predevelopment condition of the land associated with the areas of disturbance for mining and associated infrastructure.	137 (ML 80170) 112 (ML 80169) 2 (MDL 184)	ha

Temporary impacts on SCL or potential SCL	**Extent of impact permissible**	**Unit**
Introduction of impediments to cropping or temporary alterations to predevelopment condition of the land associated with the areas of disturbance for mining and associated infrastructure.	26 (ML 80170) 10 (ML 80169)	ha

Please note, that the extent of impact permissible identified for permanent and temporary impacts has incorporated that previously authorised under SCL protection decisions SCLRD2012/000085 and SCLRD2012/000089. This decision replaces these previous SCL decisions.

Further SCL protection conditions have been imposed on Environmental Authorities EPML00617113 and EPML00223213. Refer to the attached schedule of *Protection Conditions*.

Financial assurance

Financial assurance attributable for any SCL protection or SCL restoration measures that are beyond the scope of the land rehabilitation and decommissioning requirements imposed under the *Environmental Protection Act 1994* must be submitted to the administering authority prior to commencement of works on SCL or potential SCL. This amount must include any additional financial assurances calculated for restoring areas to their predevelopment condition or that are associated with the costs of works and restoration measures instructed by the conditions of this protection decision.

Any financial assurance—regarding the *Strategic Cropping Land Act 2011*, provided to the administering authority must be accompanied with additional supporting information detailing the nature of the financial assurance being provided and the particular restoration activities that it is attributable for.

Financial assurance and supporting information must be sent to:

The Chief Executive, administering the *Strategic Cropping Land Act 2011*
C/- SCL South
Department of Natural Resources and Mines
PO Box 318
TOOWOOMBA QLD 4350

AND

Email: SCLSouth@nrm.qld.gov.au

Mitigation

Where permanent impacts are proposed on SCL or potential SCL, it is taken to be a condition of the authority that its holder must comply with the mitigation requirement. It is an offence to carry out development without prior mitigation.

You must provide mitigation for **251 Ha** (214 Ha of which has already been provided) of identified permanently impacted land in the Western Cropping Zone (Central Highlands Isaac). The number of hectares of permanently impacted land has been rounded up to the nearest whole hectare, in accordance with section 139 of the SCL Act.

The mitigation rate for the Western Cropping Zone (Central Highlands Isaac) is $4750/ha, as per section 10 of the *Strategic Cropping Land Regulation 2011*.

The mitigation value of the permanently impacted land is determined by multiplying each hectare of the area of identified permanently impacted land by the prescribed rate for the mitigation zone or sub-zone in the *Strategic Cropping Land Regulation 2011*.

The total mitigation value required for SCLRD2013/000161 is $1 192 250. It is recognised that regarding SCLRD2012/000085 and SCLRD2012/000089, mitigation payments have already been made to the Department of Agriculture, Fisheries and Forestry for $408 500 and $608 000 respectively. As such, the mitigation value required additional to that already paid is **$175 750.**

Please contact the Department of Agriculture, Fisheries and Forestry at sclmitigation@daff.qld.gov.au or telephone 13 25 23 for more information on how to meet your mitigation requirements.

Rights of Appeal

Details of your right to appeal against this decision to the Land Court are found in the SCL Act Chapter 3, Part 4, Division 6 and Chapter 8, Part 7.

If you have any questions about this notice, please contact Andrew McLaughlin, Senior Natural Resource Management Officer, on the telephone number listed below.

	5 February 2014
Signature	Date

Michael Watson

Project Manager
Natural Resource Assessment
Delegate of the Chief Executive administering the
Strategic Cropping Land Act 2011
Department of Natural Resources and Mines

Enquiries:
Andrew McLaughlin
Senior Natural Resource Management Officer
PO Box 383 Gympie Qld 4570
Phone: 07 5480 5336
Email: andrew.mclaughlin@dnrm.qld.gov.au

Queensland
Government

Department of
Natural Resources and Mines

Protection conditions

Strategic Cropping Land Act 2011

Protection Decision SCLRD2013/0000161

Holder(s)	Address
Baralaba Coal Pty Ltd	PO Box 1823 Newcastle NSW 2300

Resource activities	Environmental authority	Location(s)
Activity that may impact on SCL or potential SCL: • Coal mining and associated infrastructure (ML 80169, ML80170 and MDL 184)	EPML00617113 and EPML00223213	ML 80170 ML 80169 MDL 184

The following protection conditions are taken to be imposed on Environmental Authorities EPML00617113 and EPML00223213 pursuant to ss. 99 and 103 of the *Strategic Cropping Land Act 2011* and only apply to resource activities conducted within areas of SCL or potential SCL. Particular terms highlighted in bold font have a specific meaning described in the list of definitions provided at the end of this schedule.

1. Conditions – Replacement of SCL protection decisions SCLRD2012/000085 and SCLRD2012/000089.

1.1. This SCL protection decision replaces existing SCL protection decisions SCLRD2012/000085 and SCLRD2012/000089. As such, any conditions specified in SCLRD2012/000085 and SCLRD2012/000089 will no longer have any effect.

2. Conditions – Location and confinement of impacts on SCL or potential SCL

2.1. **Temporary impacts** on SCL or potential SCL associated with mining activities and associated infrastructure on ML 80169 must be limited to the areas identified as *Temporary Impact* in *Figure 2 ML 80169 Permanent and temporary SCL impact*, provided within the SCL application.

2.2. **Temporary impacts** on SCL or potential SCL associated with mining activities and associated infrastructure on ML 80170 must be limited to the areas identified as *Temporary Impact* in *Figure 1 80170 SCL Permanent and Temporary Impacted SCL*, provided within the SCL application.

2.3. **Permanent impacts** on SCL or potential SCL associated with mining activities and associated infrastructure on ML 80169 must be limited to the areas identified as *Permanent Impact* in *Figure 2 ML 80169 Permanent and temporary SCL impact*, provided within the SCL application.

2.4. **Permanent impacts** on SCL or potential SCL associated with mining activities and associated infrastructure on ML 80170 must be limited to the areas identified as *Permanent Impact* in *Figure 1 80170 SCL Permanent and Temporary Impacted SCL*, provided within the SCL application.

2.5. **Permanent impacts** on SCL or potential SCL associated with mining activities and associated infrastructure on MDL 184 must be limited to the areas identified as *Permanent Impact* in *Figure 3 Area of permanently impacted SCL on MDL184*, provided within the SCL application.

2.6. The extent of permanent impact on SCL within ML 80169, ML 80170 and MDL 184 must not exceed the figures identified in the information notice SCLRD2013/000161.

3. Conditions – Ensuring minimisation and restoration of areas subject to temporary impacts on SCL or potential SCL.

3.1. Conditions 3.2 to 3.13 below relate to areas referred to in conditions 2.1 and 2.2 above.

3.2. Areas of SCL or potential SCL subject to temporary impacts must be restored to its predevelopment condition.

3.3. Within areas of SCL or potential SCL, impacts caused from mining and associated infrastructure must not inhibit cropping outside 50 years from the impact commencing.

3.4. The extent of temporary impact on SCL or potential SCL within ML 80169, ML 80170 and MDL 184 must not exceed the figures identified in the information notice SCLRD2013/000161.

3.5 All excavated soils must be returned to their place of origin in a manner that ensures that the **soil horizons** of the returned soil are consistent with the horizons in adjacent undisturbed soil and the land surface is re-contoured to levels consistent to that of the surrounding undisturbed soil.

3.6 Respreading and cultivation of repatriated soil horizons must ensure that there is no mixing of the replaced **soil horizons.**

3.7 Following subsoil and topsoil reinstatement, if the land is not immediately being returned to cropping use, all temporary impacted areas must be sown with a mix of annual and perennial plant species that are able to become self sustaining within the **restoration period**. Perennial vegetation cover of at least 50% must be achieved and sustained within one year following repatriation of topsoils.

3.8 Cultivation may only be undertaken when soil moisture levels are sufficient to avoid degradation of the soil structure as a result of pulverising the aggregate structure of soils that are too dry or smearing of soils that are too wet.

3.9 Any surplus subsoil, rock and other material obtained from the trenching or construction wastes must not be stored or disposed of on SCL or potential SCL or disposed of in any location where they may contribute to impacts on SCL or potential SCL.

3.10 Any decommissioned infrastructure that is to be left permanently buried must be rendered inert, structurally sound and not contain contaminants that have potential to leach into the surrounding soil or groundwater environment.

3.11 Financial assurance attributable for any SCL protection or SCL restoration measures that are beyond the scope of the land rehabilitation and decommissioning requirements imposed under the *Environmental Protection Act 1994*, must be submitted to the administering authority prior to commencement of resource activities on SCL or potential SCL. This amount must include any additional financial assurances calculated for restoring areas of disturbance to their predevelopment condition or that are associated with the additional cost of SCL protection and restoration measures instructed by any of the conditions within this schedule.

3.12 Any financial assurance, beyond that imposed under the *Environmental Protection Act 1994*, provided to the administering authority must be accompanied with additional supporting information detailing the nature of the financial assurance being provided and the particular restoration activities that it is attributable for.

3.13 Baralaba Coal Pty Ltd must monitor and maintain the amount of financial assurance lodged with the SCL administering authority that is attributable for activities required to protect and restore SCL or potential SCL in accordance with this protection decision.

3.14 Any rehabilitation of all areas impacted must ensure that declared or priority weed species are not permitted to colonise the area during the rehabilitation period and that long term stabilisation of the land surface by perennial vegetation cover is achieved except where the land is returned to cropping use or a farm access track.

4 Conditions – Soil disturbance and stockpiling

4.1 Prior to any topsoil stripping or bulk excavation occurring, the characteristics of the soil profile must first be determined. Key soil profile characteristics to be identified include the depth of the soil **A horizon** and the depth of any upper **B horizon** (upper subsoil) which has favourable characteristics for plant root growth as determined by the absence of a **soil physico/chemical limitation** to plant growth.

4.2 At each site of planned soil disturbance the process and depth of soil stripping and conservation is to be governed by: the depth of an identifiable **soil physico/chemical limitation** to plant growth; the need to ensure that soil striping does not expose or extend to a depth below the depth of an identifiable **soil physico/chemical limitation**; and the need to ensure that there is no mixing between soils that have different physical or chemical properties.

4.3 Areas that will be subjected to vehicular traffic, compaction or disturbance during construction and placement of buried infrastructure must first be stripped of **A Horizon** soil to a depth determined in accordance with condition 4.1 and 4.2.

4.4 In areas that will be subjected to trenching, the soil upper **B horizon** must also be removed to an appropriate depth as determined within conditions 4.1 and 4.2 and stockpiled.

4.5 Any additional subsoil or rock material removed from below the depth of an identifiable **soil physico/chemical limitation** must be handled, stored and managed in a way that ensures that the material does not contaminate or mix with soils of the A horizon or upper B horizon that have either been stockpiled or left in situ within the construction workspace.

4.6 Stripped **A horizon** and upper **B horizon** soils are to be stockpiled separately and in a way that prevents mixing of the two soil horizons and also prevents mixing with any other excavated soil or stored materials.

4.7 Stockpiles of **A horizon** and upper **B horizon** soils must remain uncompacted and less than 2.5 metres in height.

4.8 Soil stockpiles must not be located in any discernable drainage feature or waterway or in any area susceptible to ponding water.

4.9 Soil stockpiles must be located where they will not be disturbed by vehicle and human traffic or other resource activities and must not be located against woody vegetation, fences or any other built infrastructure.

4.10 Location and arrangement of soil stockpiles must not contribute to the concentration of surface runoff to the extent that it causes loss of soil from a stockpile or erosion in the landscape surrounding a stockpile.

4.11 Measures must be employed to avoid soil loss from stockpiles due to wind erosion.

4.12 Measures must be employed to prevent livestock and pest mammals other than rodents from accessing and disturbing soil stockpiles.

4.13 Weed management and control measures must be employed to prevent the establishment of any declared or priority weed species on soil stockpiles or surrounding areas of disturbance.

4.14 Soil stockpiles that are to be retained for a period longer than 1 month must be protected and stabilised by establishing on them a self sustaining vegetation cover of at least 70% coverage or by applying hydro-mulch or soil binding agents that are to be maintained over the duration of the stockpile existence.

4.15 Stockpiles of **A horizon** and upper **B horizon** soils must be constructed and managed to maintain the soils uncompacted state and maintain the soils biological activity, structural characteristics and productivity over the duration of the stockpile's existence.

5 Conditions – Regarding areas of temporary impact on SCL or potential SCL, benchmarking the predevelopment site condition, monitoring impacts and monitoring restoration of those impacts on areas of additional disturbance authorised by Environmental Authorities EPML00617113 and EPML00223213

5.1 Conditions 5.2 to 5.9 below relate to areas referred to in conditions 2.1 and 2.2 above.

5.2 In the first 24 months after restoration commencement, monitoring is to be conducted on at least a 3 monthly basis until all temporary impacted areas are fully restored to their predevelopment condition.

5.3 Where monitoring inspections identify any incidence of soil subsidence, erosion, weed proliferation, failure of vegetation re establishment or any other decline in soil or land condition within the temporary impacted areas, corrective actions must be implemented immediately to restore and maintain the integrity and productivity of the soil profile and land surface.

5.4 A fixed point digital photographic monitoring record of all temporary impacted areas of SCL or potential SCL must be maintained as record of the area's pre development, post construction and post restoration condition and be made available to the administering authority upon request.

5.5 Each digital photograph within the monitoring record must be supported by the date, time, MGA 94 geographic location and the compass bearing at which the camera is facing when taking the photograph.

5.6 In areas of linear disturbance for buried infrastructure, photographs must be taken in either direction along the lineament at fixed intervals of no more than 100m apart.

5.7 Successive photographs of the area's pre development, post construction and post restoration conditions over time must be taken from the same position and in the same direction as the former photograph with the horizon in view and no more than 1/5 of the field of view occupied by sky.

5.8 Photographic records are to be stored and presented in a format that easily enables temporal comparison between successive photographs and also enables, by way of an accompanying plan, easy reference to the location of the fixed positions from which photographs have been taken and the temporary impacted areas on which they are focussed.

5.9 Up to date records of site condition and restoration progress must be provided to the administering authority upon request.

6 Conditions – Mitigation

6.1 Prior to a permanent impact occurring on SCL or potential SCL, the holder of the authority must comply with the relevant mitigation requirement. Total requirements for mitigation are outlined in the information notice SCLRD2013/000161.

Definitions

A Horizon

As defined in National Committee on Soil and Terrain (NCST) (2009) *Australian soil and land survey field handbook*, third edition. CSIRO Publishing.

B Horizon

As defined in National Committee on Soil and Terrain (NCST) (2009) *Australian soil and land survey field handbook*, third edition. CSIRO Publishing.

Footprint

of the development, means the proportion of the land covered by—

(a) buildings or structures measured to their outermost projection; and
(b) any of the following relating to the buildings or structures or the development—
  (i) asphalt, concrete or another hard built surface;
  (ii) a carpark;
  (iii) a road or access track;
  (iv) an area used for vehicle movement or parking;
  (v) an area used or that may be used for storage.

Restoration period

refers to the period of time taken to restore an area of land, that is disturbed by a resource activity, to its pre development condition.

Sealed

Bitumen, concrete or similar hardened and impervious material applied to the land surface.

Soil horizon/s

As defined in National Committee on Soil and Terrain (NCST) (2009) Australian soil and land survey field handbook, third edition. CSIRO Publishing.

Soil physico/chemical limitation

As defined in section 18 of Schedule 1 within the *Strategic Cropping Land Act 2011*

Temporary

relating to activities that have a "temporary impact" on SCL or potential SCL as described in section 14(4) of the *Strategic Cropping Land Act 2011*.

	5 February 2014
Signature	Date

Michael Watson

Project Manager
Natural Resource Assessment
Delegate of the Chief Executive administering the
Strategic Cropping Land Act 2011
Department of Natural Resources and Mines

Enquiries:
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