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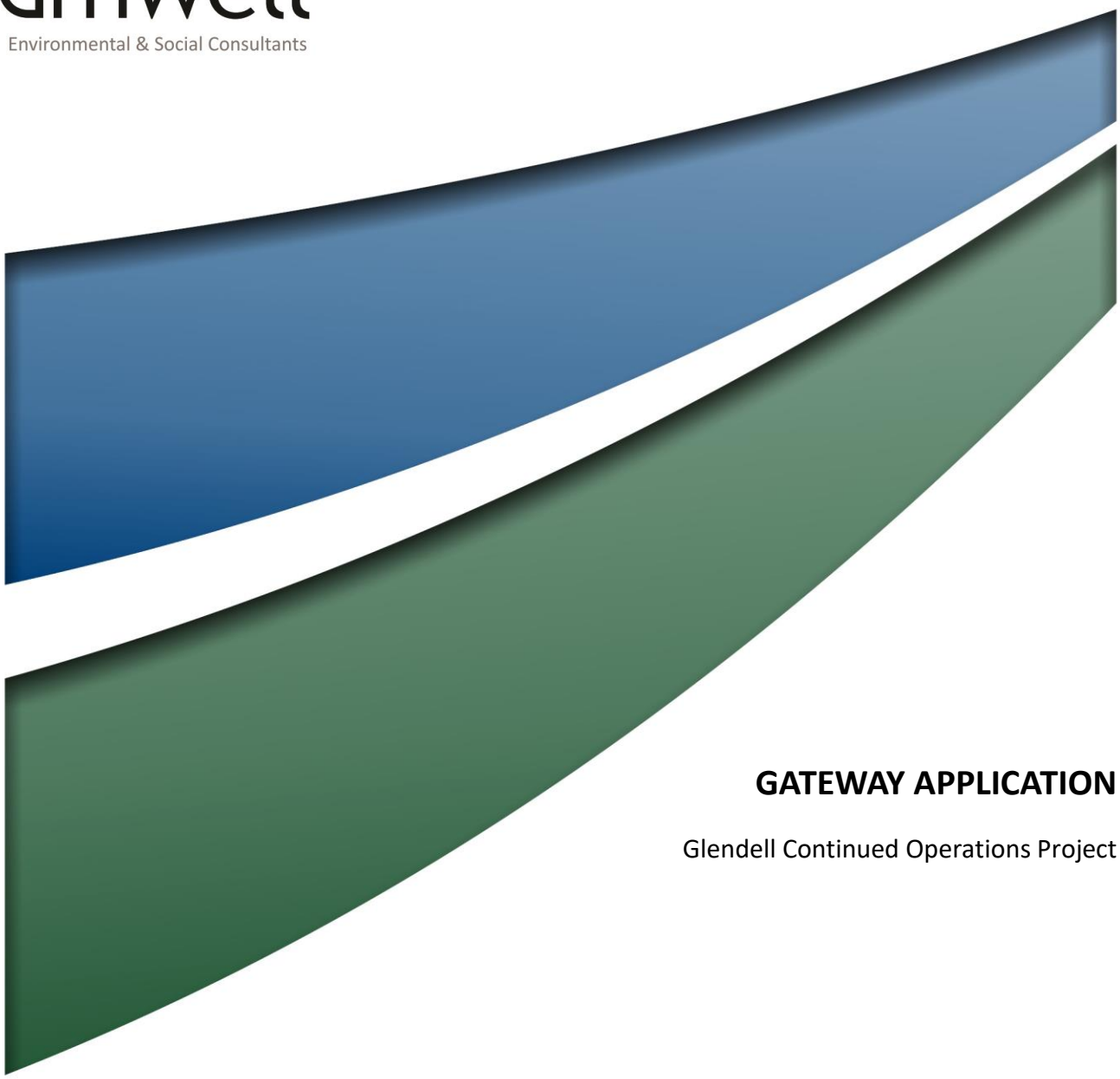

GATEWAY APPLICATION

Glendell Continued Operations Project

FINAL

April 2019

GATEWAY APPLICATION

Glendell Continued Operations Project

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Glendell Tenements Pty Limited

Project Director:	Bret Jenkins
Project Manager:	David Holmes
Report No.	R07
Date:	April 2019

Environmental & Social Consultants

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
Final	David Holmes	4 April 2019	Bret Jenkins	4 April 2019

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Appendix A BSAL Verification

1.0 Introduction

1.1 Project Context

The Glendell Mine forms part of the Mount Owen Complex located in the Upper Hunter Valley of New South Wales (NSW), approximately 20 kilometres (km) north-west of Singleton, 24 km south-east of Muswellbrook and to the north of Camberwell (refer to **Figure 1.1**).

In addition to the Glendell Mine, the Mount Owen Complex comprises mining operations at the Mount Owen Mine (North Pit) and Ravensworth East Mine (Bayswater North Pit). The Mount Owen Complex also includes a coal handling and preparation plant (CHPP) and transport infrastructure (refer to **Figure 1.2**).

Mt Owen Pty Limited (Mount Owen) operates the Bayswater North Pit and Glendell mining operations and the CHPP at the Mount Owen Complex with mining operations at the Mount Owen Mine North Pit operated by Thiess Pty Ltd pursuant to a contractual arrangement with Mount Owen. The Mount Owen Complex is adjacent to the Integra Underground, Liddell Coal Operations and Ravensworth Operations mines, which are also operations owned and operated by subsidiaries of Glencore Coal Assets Australia Pty Limited (Glencore) (and its joint venture partners as applicable). Glencore and its joint venture (JV) partners also hold a number of exploration licences surrounding the Mount Owen Complex.

The Glendell Mine currently operates under development consent DA 80/952 (Glendell Consent), originally granted on 2 May 1983. The current operations are undertaken in accordance with revised mine plans approved in a modification to the Glendell Consent in February 2008. The Glendell Consent was also modified in December 2016 to facilitate the realignment of a 2.7 km section of an existing 132 kV Ausgrid powerline and associated activities.

The Glendell Consent regulates the mining of coal from the Glendell Pit and the rehabilitation of the mining area. The processing of coal mined from the Glendell Pit is regulated by development consent SSD-5850 (Mount Owen Continued Operations Consent) which also regulates mining at the Mount Owen and Ravensworth East Mines, and associated activities. **Section 3.0** contains further details regarding the existing operations.

1.2 The Proposed Project

Glencore and its JV partners proposes to seek approval to extend open cut mining operations north from the existing Glendell Mine as shown on **Figure 1.3**. The Proponent for the development consent will be the Glencore subsidiary Glendell Tenements Pty Ltd.

Mining authorities in the area north of the approved Glendell Mine are held by a variety of different companies and in most areas are stratified. Glencore's interests in Liddell Coal Operations and the Mount Owen Complex has brought a number of these authorities into common ownership. In recent years, contractual arrangements with Glencore's JV partner, who also hold interests in some of these authorities, has enabled the investigation and development of mining options in this area which has identified further coal reserves to the north of the approved Glendell Mine. Glencore proposes to seek approval to extend open cut mining operations north from the existing Glendell Mine into these mining authority areas to extract these coal reserves (refer to **Figure 1.3**) (the Project).

This proposed extension of the current open cut mining operations at the Glendell Mine would extract an additional approximately 135 million tonnes (Mt), of run-of-mine (ROM) coal. This extension of the Glendell Pit is referred to as the Glendell Pit Extension. The Glendell Pit Extension will extract reserves

down to the Hebden Seam. The Project would extend the life of mining operations at Glendell to approximately 2044 and provide ongoing employment for its existing workforce and contractors. ROM coal from Glendell will continue to be processed by the Mount Owen CHPP and associated infrastructure and utilise the Mount Owen Rail Loop for coal transport.

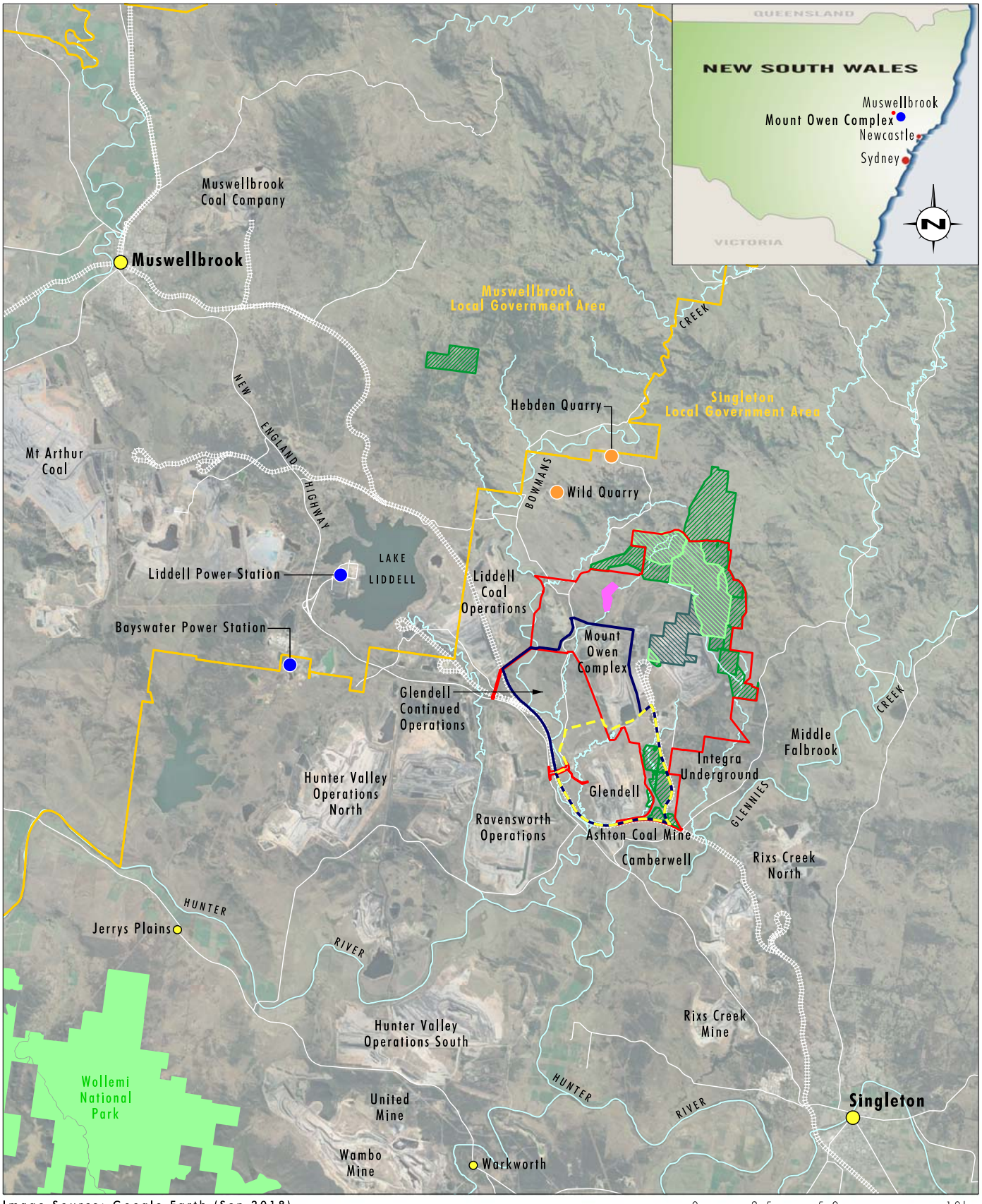

Image Source: Google Earth (Sep 2018)
Data Source: Glencore (2019), OEH (2013), Forest Corporation of NSW (2013)

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1:200 000

Legend

- Mount Owen Consent Boundary
- Project Area
- Glendell Consent Boundary (Current)
- Local Government Area Boundary
- Existing Mount Owen Complex Biodiversity Offset Area
- Ravensworth State Forest
- Ravensworth State Forest within Mount Owen Continued Operations Operational Area
- Yorks Creek Voluntary Conservation Area
- National Park
- Road
- Railway
- Drainage Line
- Towns
- Power Stations
- Quarry

FIGURE 1.1

Regional Locality Plan

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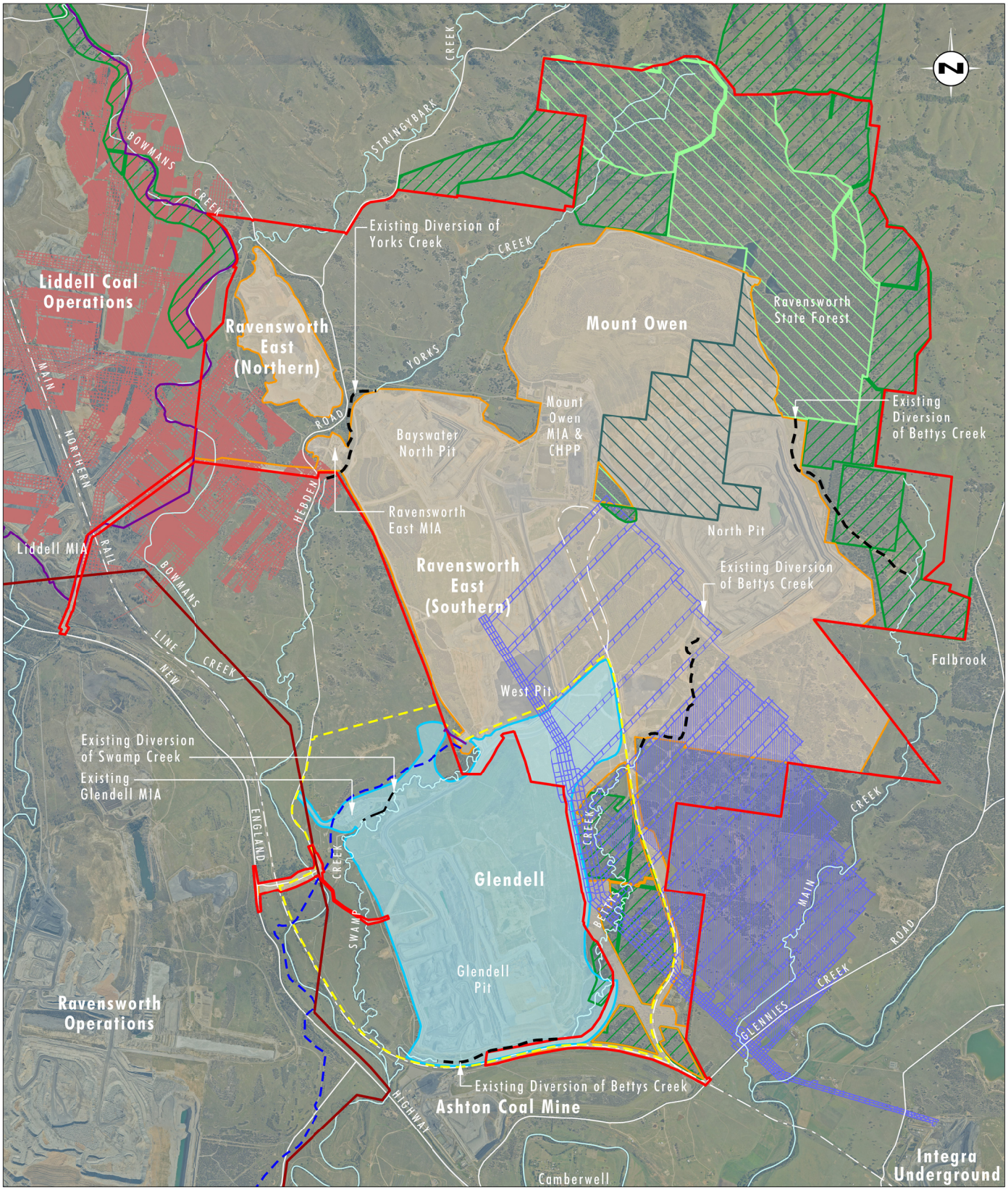

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

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1:60 000

Legend

- Glendell Consent Boundary (Current)
- Liddell Consent Boundary
- Mount Owen Consent Boundary
- Ravensworth Operations Consent Boundary
- Approved Mount Owen Continued Operations Operational Area
- Approved Glendell Disturbance Area
- Approved Link Pipeline
- Existing Creek Diversion
- Existing Narama Pipeline
- Approved Integra Underground Mining Area - Middle Liddell Seam Workings
- Integra Underground Workings Middle Liddell Seam as at May 2018
- Liddell Underground Mining Area
- Biodiversity Offset
- Ravensworth State Forest
- Ravensworth State Forest within Mount Owen Continued Operations Disturbance Area

FIGURE 1.2

Existing Glendell Mine and Other Approved Operations

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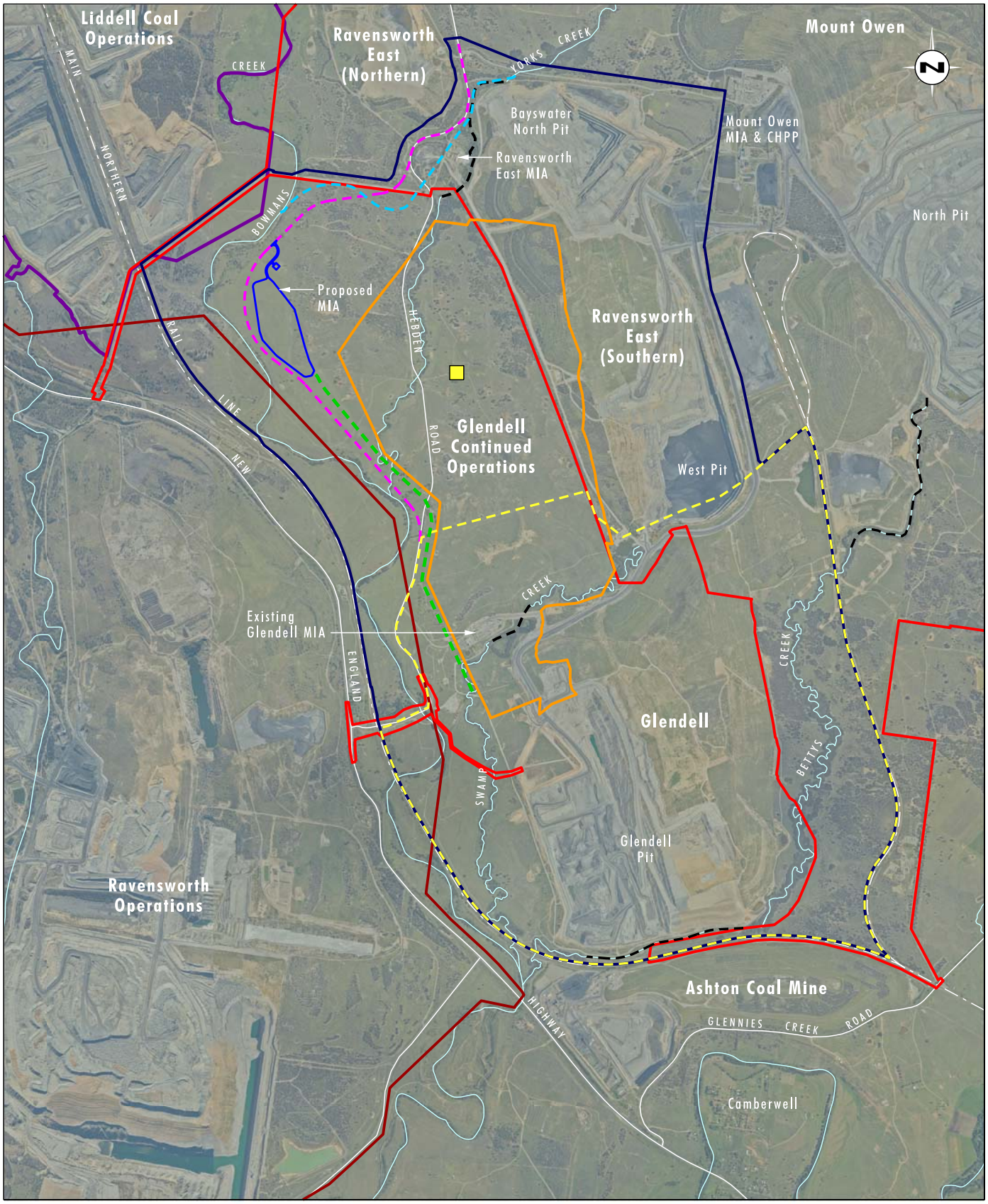

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)
Note: Ravensworth Homestead to be relocated

0 0.5 1.0 2.0km
1:45 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Glendell Consent Boundary (Current)
- Mount Owen Consent Boundary
- Liddell Consent Boundary
- Ravensworth Operations Consent Boundary
- Ravensworth Homestead
- Existing Creek Diversion

Project Features:

- Proposed MIA
- Proposed Heavy Vehicle Access Road
- Proposed Yorks Creek Realignment
- Proposed Hebden Road Realignment

FIGURE 1.3

Key Project Features

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The Project will also retain the ability to transport up to 2 million tonnes per annum (Mtpa) of coal to the Liddell CHPP and/or the Ravensworth Coal Terminal for processing and rail loading (which is already approved pursuant to the Mount Owen Continued Operations Consent). The Project will extend the operating life of the Mount Owen infrastructure to 2045[1].

The Project will necessitate the realignment of a section of Hebden Road, realignment of Yorks Creek and the relocation of Ravensworth Homestead.

The Project will also require the demolition/ relocation of the existing Glendell Mine Infrastructure Area (MIA) and construction of a new MIA. A heavy vehicle access road will also be required for accessing the new MIA.

Further details of the Project are contained in **Section 3.0**.

1.3 Approval requirements for Glendell Pit Extension and related works

The Project is State Significant Development (SSD) as defined under the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP) and will require development consent under the *Environmental Planning and Assessment Act 1979* (EP&A Act). The new development consent being sought for the Project will include the current approved mining operation (and associated rehabilitation requirements) relating to the Glendell Pit at the Glendell Mine and therefore the Glendell Consent will be surrendered should approval be granted for the Project. In accordance with section 4.63(3) of the EP&A Act, the consent authority is not required to re-assess the likely impact of continued development under the existing Glendell Consent.

In addition to the existing Glendell operations, this development consent would cover the Glendell Pit Extension and works directly associated with the pit extension including:

- rehabilitation of areas disturbed by mining activities, including overburden emplacement areas;
- the realignment of Hebden Road;
- the relocation of Ravensworth Homestead;
- the realignment of Yorks Creek;
- construction/use of MIA facilities and associated related infrastructure;
- construction/use of a heavy vehicle access road; and
- construction/ use of related ancillary infrastructure.

[1] A longer operating life for the Mount Owen CHPP and related infrastructure is required to account for the processing of coal material mined from the Glendell Pit Extension in the later stages of the 2044 calendar year.

As State Significant Development, the development application for the Project is required to be supported by an Environmental Impact Statement (EIS). The EIS prepared for the Project must address the matters contained in the environmental assessment requirements issued by the Secretary of the Department of Planning and Environment (DP&E) (SEARs). A Preliminary Environmental Assessment (PEA) of the Project was prepared to accompany the request for SEARs. The request for SEARs was lodged on 17 May 2018 and SEARs were issued on 11 July 2018.

1.4 Gateway Process Requirements

Part 4AA of the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) together with Clause 50A of the Environmental Planning and Assessment Regulation 2000 (EP&A Regulation) provides for the implementation of the NSW Government's Strategic Regional Land Use Plans (SRLUPs). The 'gateway process' applies to mining development located on Biophysical Strategic Agricultural Land (BSAL) and Critical Industry Cluster Land (CIC land) (as defined by the regional mapping presented in the Mining SEPP) if a new or additional mining lease/s is required to be obtained to carry out the development. A project that triggers the gateway process must obtain a Gateway Certificate. The Project includes areas which are inside existing mining lease areas; these aspects of the Project are not subject to the gateway process.

This report has been prepared in accordance with the 'Guideline for Gateway Applicants' (NSW Government, 2013). As the Project will only impact on BSAL and not CICs, this report only addresses the criteria relevant to BSAL. Detailed mine planning is still being undertaken and some impact assessment studies relevant to the assessment of BSAL criteria are still being undertaken. This application therefore only seeks a conditional gateway approval which identifies the issues to be assessed in detail in the Environmental Impact Statement being prepared for the Project. The focus of this report is those areas of the Project Area which will be impacted by the project and which are outside existing mining lease areas (but where a mining lease may be required to enable the development to be carried out); this area is referred to as the Verification Area in this report and aligns with the BSAL verification being lodged in relation to the Project. The Verification Area is discussed further in **Section 1.4.1** and the Verification Application is discussed further in **Section 2.0**. The areas within the Verification Area that are not currently approved for mining related disturbance are referred to in this report as the Gateway Disturbance Area. The Gateway Disturbance Area is discussed further in **Section 1.4.2**.

1.4.1 Verification Area

The parts of the Project Area that will be newly disturbed by the Project and where new mining leases may be required for the activities proposed are referred to in this report as the Verification Area[2]. The location of mining tenements in and around the Project Area are shown in **Figure 1.4.** A number of tenements are located within the Verification Area, namely CCL 708, EL 6594, EL 8184 and ML 1629. The only current mining lease applying to the surface within the Verification Area is ML 1629 which is for mining purposes only and does not authorise the mining of coal in this area. Underlying ML 1629 is CCL 708 which permits the extraction of coal but excludes the surface; therefore a new mining lease will be required for the depth of surface exception to enable mining in the areas covered by ML 1629, as well as areas covered by EL 8184 and EL 6594. The extent of the Verification Area is shown in **Figure 1.5**. The Verification Area is approximately 700 hectares (ha) and includes areas which are currently approved for disturbance under the Glendell Consent and Mount Owen Continued Operations Consent.

[2] Mining leases are only required for mining and designated ancillary mining activities (refer to Sections 5 and 6 of the *Mining Act 1992*). Mining leases will not be required over the whole of the Verification Area.

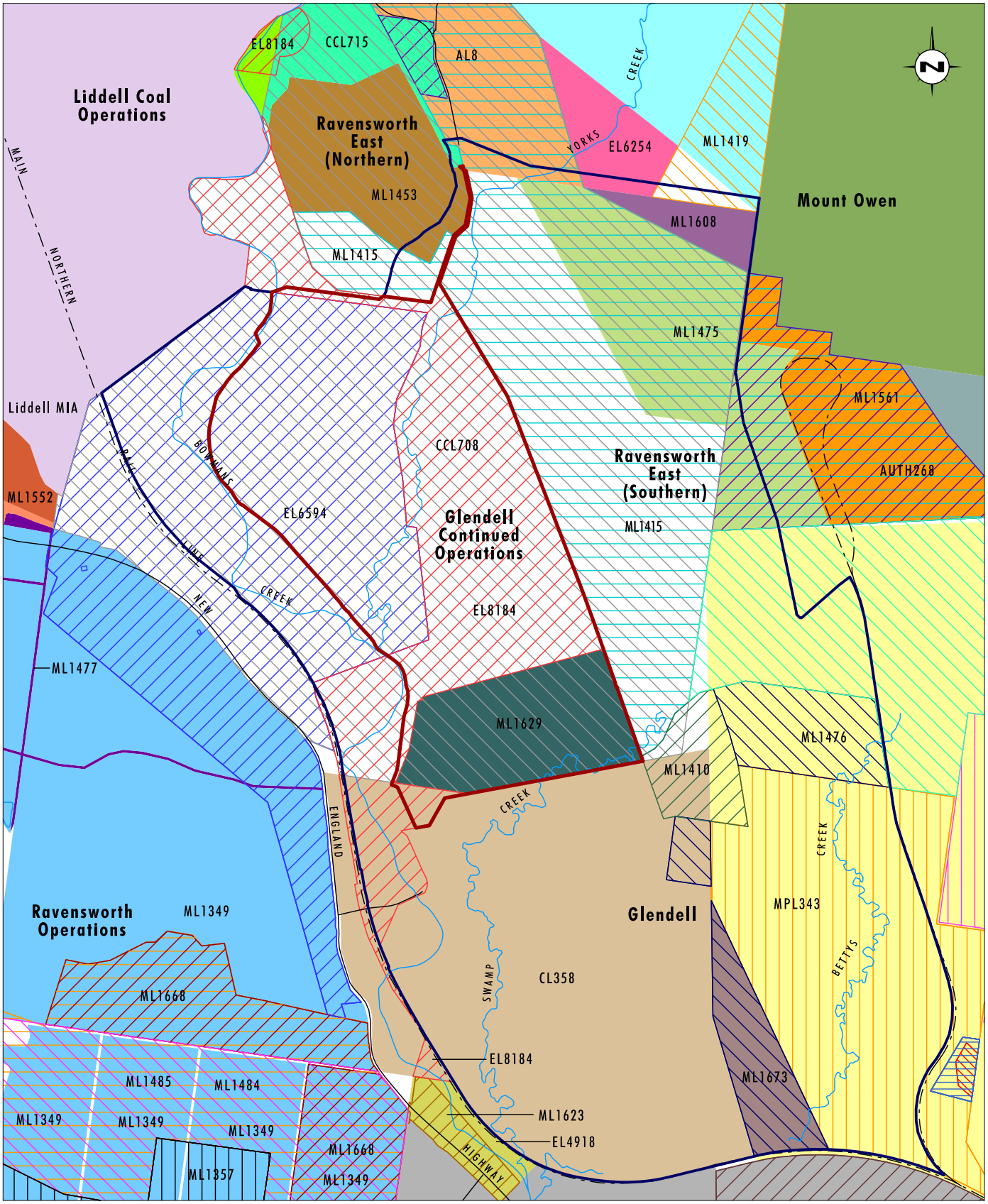
The Verification Area includes land identified by the relevant maps in the Upper Hunter SRLUP as BSAL. Fieldwork undertaken in accordance with the Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land (NSW Government, 2013) (Interim Protocol) has identified that the area of BSAL within the Verification Area is less than is mapped in the Upper Hunter SRLUP. **Appendix A** contains the Biophysical Strategical Agricultural Land Verification Assessment for the Verification Area. The location of the BSAL mapped under the SRLUP and the BSAL verified by fieldwork is shown in **Figure 1.6** and is discussed in further detail in **Section 2**. Approximately 34 ha of identified BSAL is located within the Verification Area.

No land is identified as being a CIC within the Project Area and the nearest CIC is located approximately 15 km from the Project Area (refer to **Figure 1.7)**.

Due to the potential for the Project to involve components that will require a new mining lease which could cover areas of verified BSAL, this Gateway Application has been prepared in relation to the Verification Area (refer to **Figure 1.5**).

1.4.2 Gateway Disturbance Area

The Project will involve the additional disturbance of approximately 850 ha of land not currently approved for disturbance however not all of this is located within the Verification Area. The areas of land that may be impacted by the Project that are within the Verification Area but are not currently approved for mining related disturbance are referred to in this Gateway Application as the Gateway Disturbance Area (refer to **Figure 1.8**). The Gateway Disturbance Area is approximately 670 ha. The disturbance area associated with the Project will be further refined throughout the EIS process and will be defined in the EIS.



Data Source: Glencore (2018), Minview (2018)

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1:40 000

Legend

Project Area	CL358	ML1398	ML1485	ML1629/ELA5736
Verification Area	CL382	ML1410	ML1525	ML1668
AL8	CL383	ML1415	ML1529	ML1673
AUTH268	CCL708	ML1419	ML1533	ML1676
AUTH423	CCL715	ML1453	ML1552	ML1694
EL4918	ML1313	ML1475	ML1561	MPL343
EL6254	ML1349	ML1476	ML1597	
EL6594	ML1355	ML1477	ML1608	
EL8184	ML1357	ML1484	ML1623	

FIGURE 1.4

Mining Lease Authorities in the Project Area

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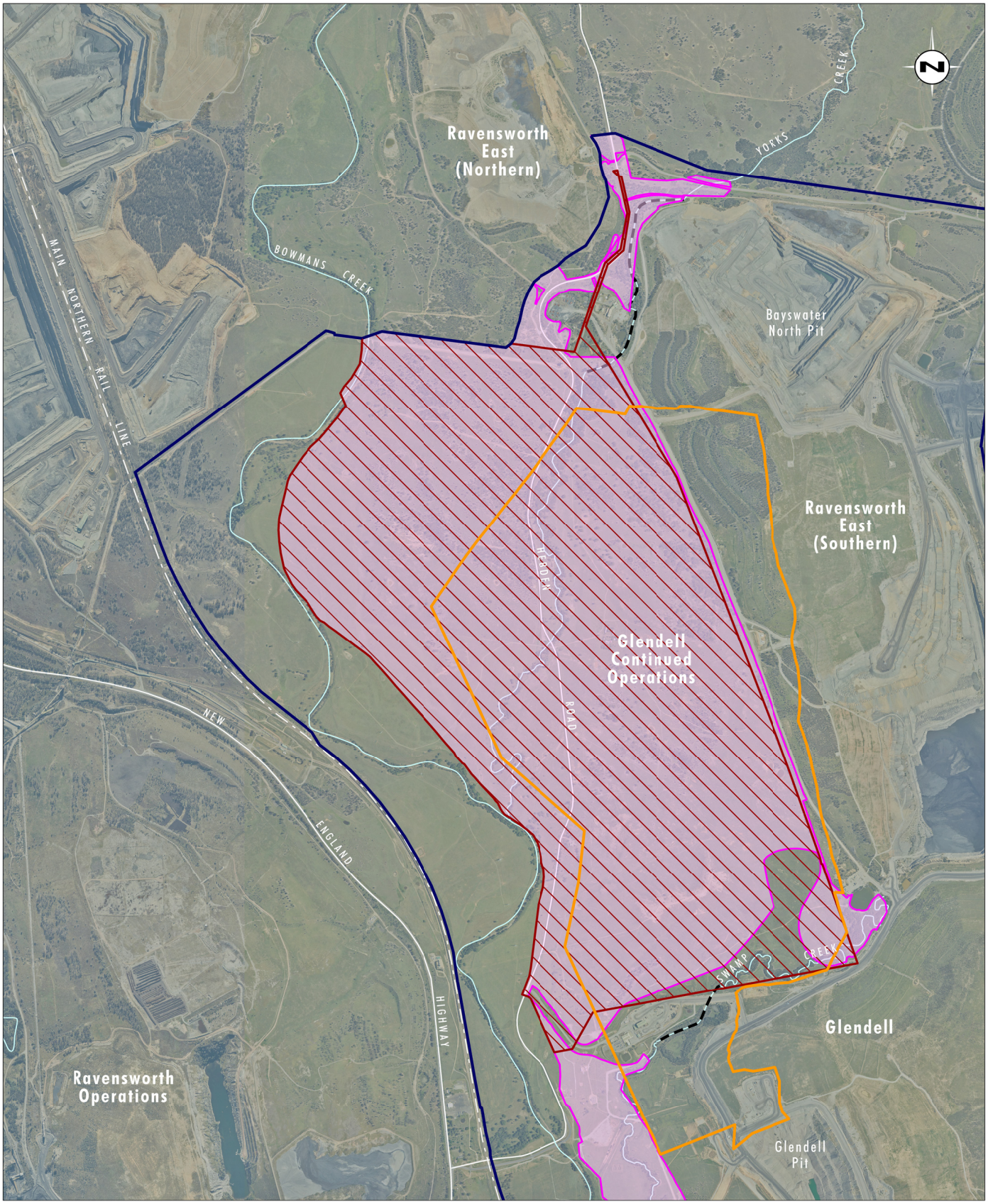

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 0.5 1.0 1.5km
1:30 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Additional Disturbance Area
- Verification Area
- Existing Creek Diversion

FIGURE 1.5

Verification Area

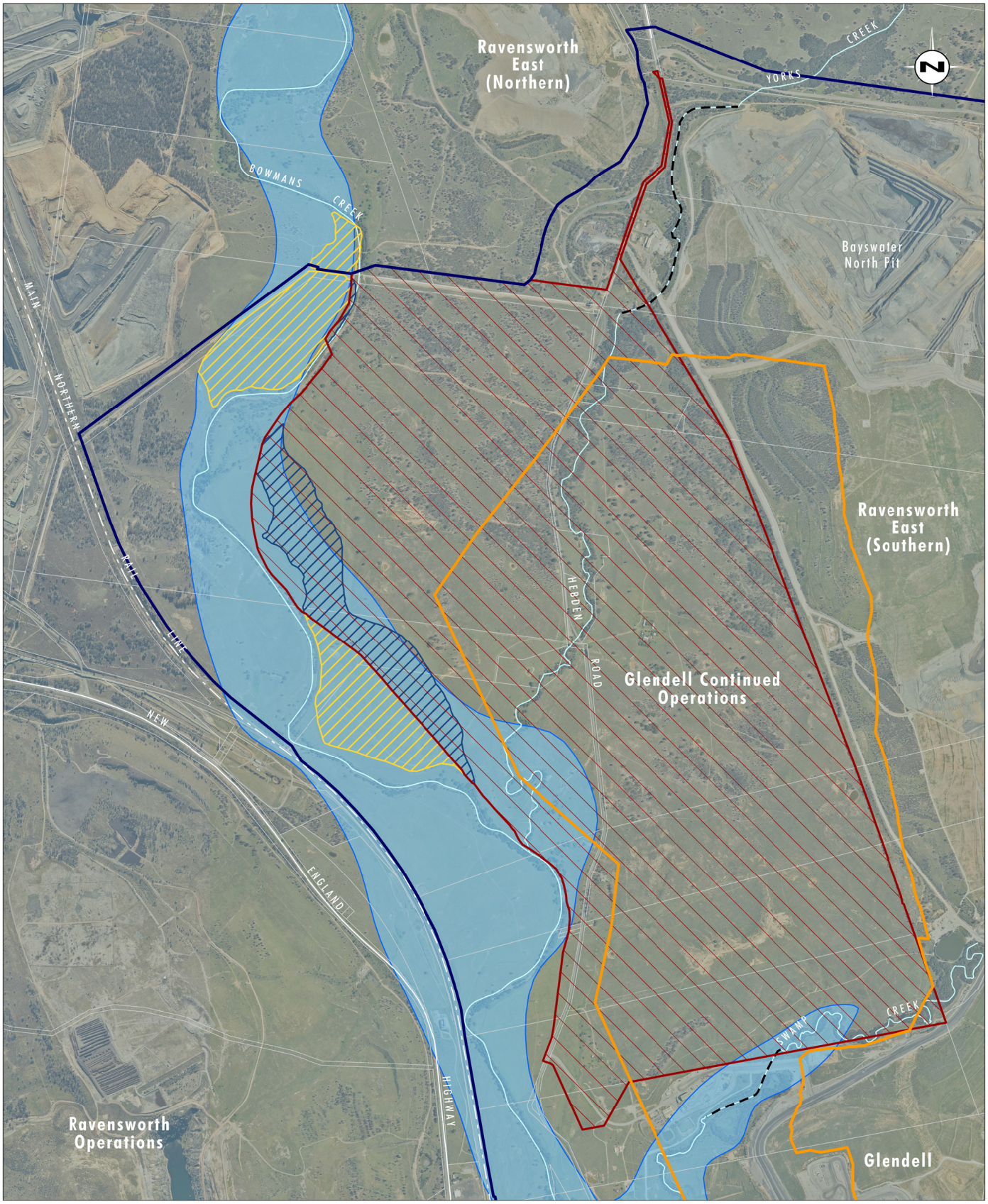

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), NSW Department of Planning and Infrastructure (2013)

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1:25 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Verification Area
- Mapped BSAL (Upper Hunter SRLUP, 2013)
- Verified BSAL within Verification Area
- Contiguous BSAL (Extrapolated from Verification Area)
- Existing Creek Diversion

FIGURE 1.6

Upper Hunter SRLUP BSAL mapping and Verified BSAL in Verification Area

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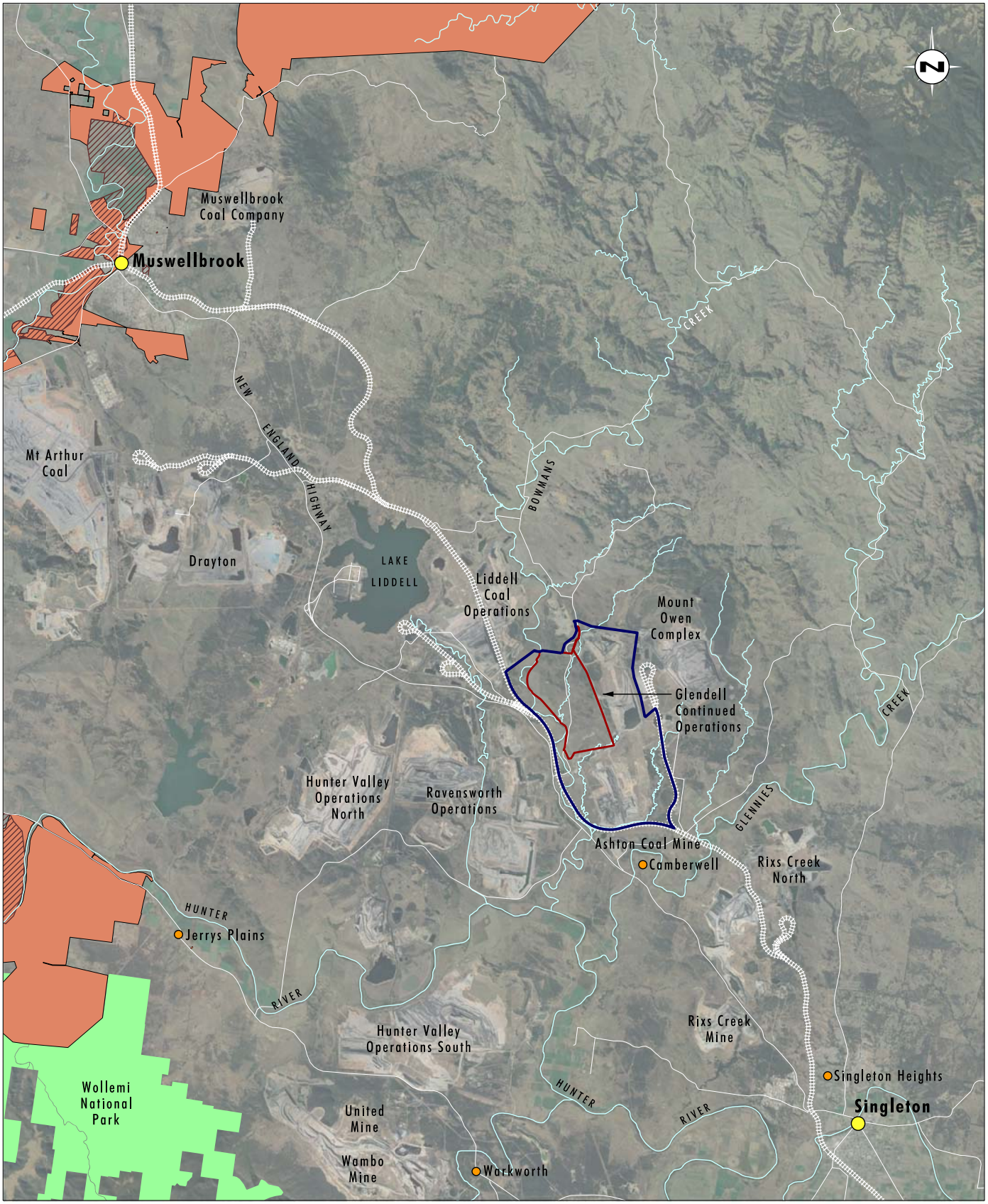

Image Source: Google Earth (Sep 2018)
Data Source: Glencore (2019), OEH (2013)

0 2.5 5.0 10km
1:200 000

Legend

- Project Area
- Verification Area
- Critical Industry Cluster - Equine
- Critical Industry Cluster - Viticulture
- National Park
- Road
- Railway
- Creek/River
- Towns
- Localities

FIGURE 1.7

Critical Industry Clusters

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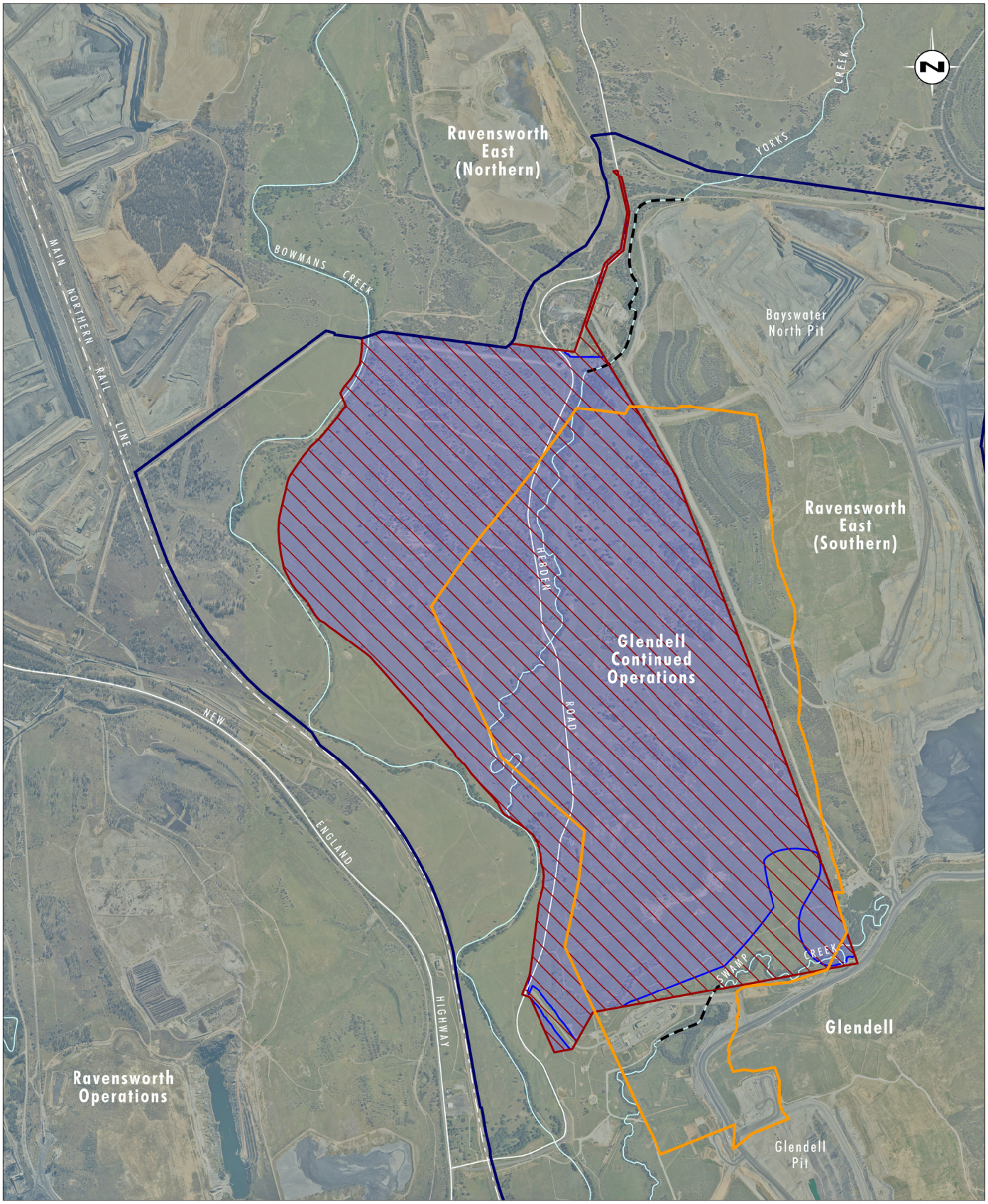

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 0.5 1.0 1.5km
1:30 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Gateway Disturbance Area
- Verification Area
- Existing Creek Diversion

FIGURE 1.8

Gateway Disturbance Area

2.0 BSAL Verification

The Verification Area includes land identified by the relevant maps in the Upper Hunter SRLUP as BSAL (refer to **Figure 1.7)**. No land within the Project Area is identified as being a CIC and the nearest CIC is located approximately 15 km from the Project Area (refer to **Figure 1.8**).

Fieldwork undertaken in accordance with the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (NSW Government, 2013) (Interim Protocol) has identified that the area of BSAL within the Verification Area is less than is mapped in the Upper Hunter SRLUP. The BSAL Verification Assessment is contained as **Appendix A** to this Report. The location of the BSAL mapped under the SRLUP and the BSAL verified by fieldwork is shown in **Figure 1.7**. Approximately 34 ha of identified BSAL is located within the Verification Area.

As can be seen on **Figure 2.1,** the proposed new MIA is located on the area of verified BSAL, as is the heavy vehicle access road to the new MIA. The existing conveyor between Ravensworth East and Liddell Coal Operations also passes over the area of verified BSAL. Adjustments to the existing conveyor alignment and/or alternate transport arrangements for ROM coal and crushed rock from Mount Owen Complex to Liddell Coal Operations may be required as a result of the proposed Yorks Creek realignment; works associated with alternative transport arrangements may also pass over verified BSAL. These components of the Project have potential to trigger the requirement for a mining lease under sections 5 or 6 of the *Mining Act 1992*. Due to the potential for the Project to involve components that will require a new mining lease over land which could include areas of identified BSAL, the Gateway process applies to those aspects of the Project in the Verification Area.

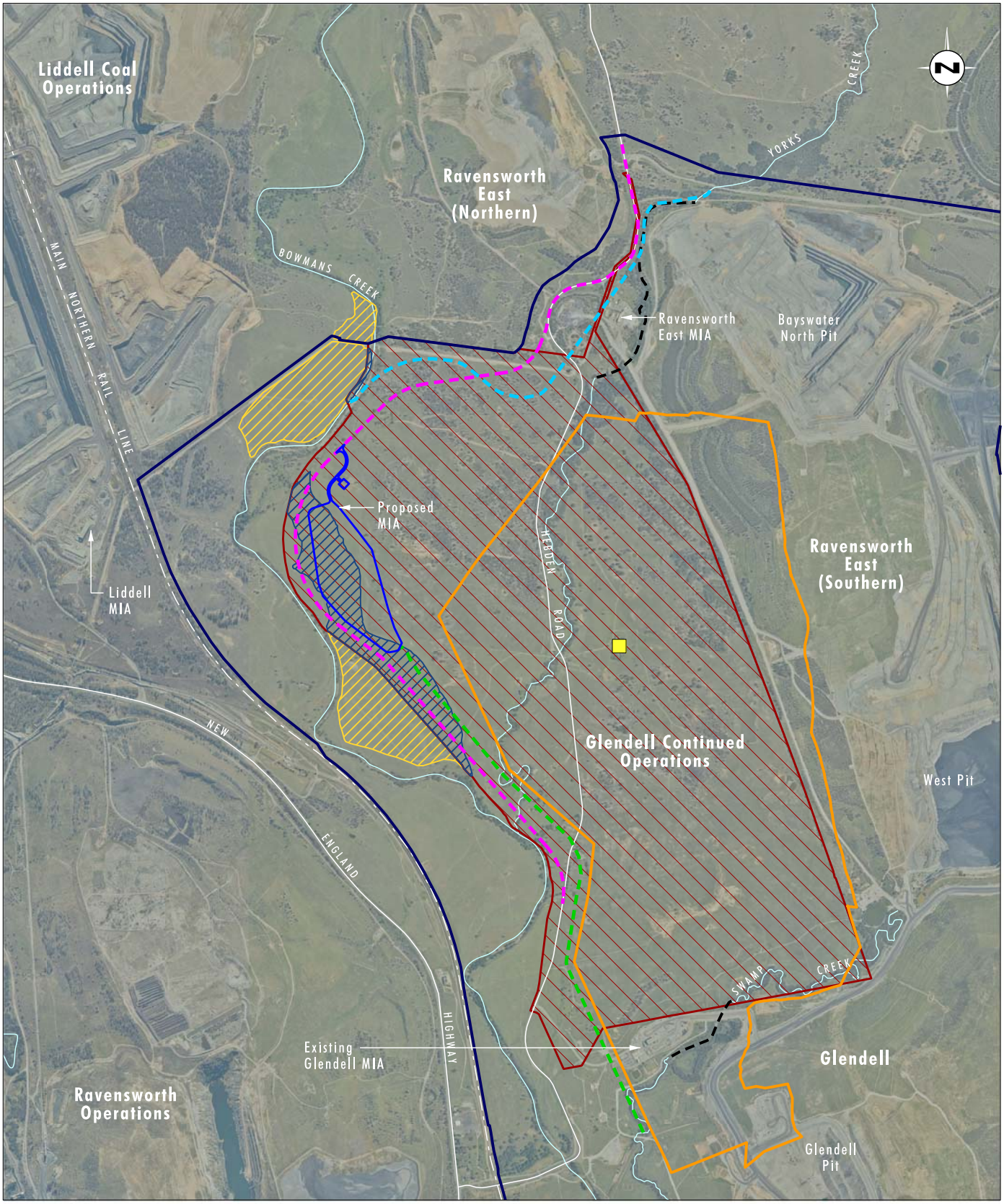

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)
Note: Ravensworth Homestead to be relocated

0 0.5 1.0 1.5km
1:30 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Ravensworth Homestead
- Existing Creek Diversion
- Verification Area
- Verified BSAL within Verification Area
- Contiguous BSAL (Extrapolated from Verification Area)

Project Features:

- Proposed MIA
- Proposed Heavy Vehicle Access Road
- Proposed Yorks Creek Diversion
- Proposed Hebden Road Realignment

FIGURE 2.1

Project Impacts on BSAL

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20190129 9.13

3.0 Existing Operations

3.1 Summary of Approved Mining Operations at Mount Owen Complex

Mining operations at the Mount Owen Complex commenced at the Ravensworth East Mine (previously known as Swamp Creek Mine) and date back to the early 1960s.

Ravensworth East Mine has been subject to various modifications including:

- integration with the Mount Owen and Glendell Mines in 2008 to allow efficient processing and haulage of coal to the Mount Owen CHPP and
- the emplacement of tailings within the Ravensworth East voids from the Mount Owen CHPP.

Mining in the Ravensworth East Mine is currently limited to the Bayswater North Pit and tailings emplacement in the West Pit void; these activities are regulated by the Mount Owen Continued Operations Consent.

Mining operations within the Mount Owen Mine (North Pit) commenced in 1993 under the management of Hunter Valley Coal Corporation Pty Limited (HVCC). Glencore (formerly Xstrata) has managed Mount Owen Mine, Ravensworth East and Glendell Mines as the Mount Owen Complex since 2004.

The Glendell Consent was granted on 2 May 1983. A modification of the Glendell Consent granted in February 2008 approved the integration of the Glendell Mine with the broader Mount Owen Complex. This modification removed the duplication of coal processing, handling and transport infrastructure and enabled integrated water and tailings management at the operations forming the Mount Owen Complex.

The Mount Owen Continued Operations Consent (SSD-5850), granted in 2016, brought the Mount Owen and Ravensworth East Mines under a single development consent with the former consents for these operations surrendered. The Mount Owen Continued Operations Modification 2 Project was lodged in July 2018 and seeks to extend the mine life of mining in the North Pit by 6 years. The application is currently being assessed by the Department of Planning and Environment.

As discussed in **Section 1.0**, the Glendell Mine forms part of the broader Mount Owen Complex with integrated coal handling and processing facilities, product transport, tailings disposal and water management systems. ROM coal extracted from the Glendell Pit is transported to the Mount Owen CHPP for processing. The Mount Owen CHPP is currently approved for up to 17 Mtpa ROM coal throughput. Product coal is approved for transportation from the Mount Owen Complex using the Mount Owen Rail Loop or to the Liddell or Bayswater power stations by conveyor. Up to 2 Mtpa ROM coal and/or crushed gravel can also be transported by conveyor from the Mount Owen Complex to the Liddell Coal Operations and/or Ravensworth Coal Terminal.

Glendell Mine and Mount Owen Mine both operate 7 days per week, 24 hours per day.

The integration of water management and tailings disposal systems between the other Glencore operated mines of Integra Underground, Liddell Coal Operations and Ravensworth Operations is also approved under the various development consents and project approvals for each operation. This integrated water and tailings management system is known as the Greater Ravensworth Area Water and Tailings Scheme (GRAWTS) and enables water and tailings to be transferred between sites to optimise water use and management at these operations, to minimise the need to discharge surplus water to the Hunter River and provide for more efficient management of fine tailings from CHPPs.

Thiess Pty Ltd currently operates the Mount Owen Mine (excluding the CHPP and associated infrastructure) under a contractual agreement with Mount Owen. Mount Owen operates the Mount Owen CHPP and associated infrastructure, and the Ravensworth East Mine (Bayswater North Pit) and the Glendell Mine (Glendell Pit).

Key operational aspects at the current Mount Owen Complex are provided in **Table 3.1**. Key features of existing approved developments and development consent boundaries are shown on **Figure 1.2.**

Table 3.1 Key Operational Aspects of Mount Owen Complex

Operational Aspect	Mount Owen Continued Operations Consent (SSD-5850)	Glendell Consent (DA 80/952)
Mining Area	North Pit Bayswater North Pit	Glendell Pit
Production Limits	North Pit – up to 10 Mtpa Bayswater North Pit – up to 4 Mtpa	Glendell Pit – up to 4.5 Mtpa
Mining Method	North Pit – Open Cut (Truck and excavator) Bayswater North Pit – Open Cut (Truck and excavator)	Glendell Pit – Open Cut (Truck and excavator)
Approved Mine Life	North Pit – to 31 December 2031 Mount Owen Continued Operations Project Modification 2 is seeking an extension to the mining operations in North Pit which would extend the mine life and operation of the Mount Owen CHPP to approximately 2037 Bayswater North Pit – to approximately 2022	Glendell Pit – to 30 June 2024
Previously mined areas	Eastern Rail Pit (ERP), Tailings Pit 1 (TP1), Tailings Pit 2 (TP2), RW Pit, North Void Stage 1 (NVS1), North Void Stage 2 (NVS2), West Pit, Swamp Creek Mine	N/A – Glendell Pit currently being mined
Tailings Emplacement	West Pit Former tailings disposal areas include: TP1, RW Pit, NVS1 and NVS2 Approved transfer and receipt of tailings with other operations as part of the GRAWTS	N/A – Tailings generated by processing of coal at the Mount Owen CHPP and regulated under the Mount Owen Continued Operations Consent.
Overburden Emplacement	In-pit emplacement (Bayswater North Pit and North Pit) Out-of-pit emplacement at western out-of-pit (WOOP) emplacement area, and parts of Ravensworth East emplacement area Tailings capping of former tailings facilities and West Pit	In-pit emplacement and out-of-pit emplacement adjacent to Glendell Pit

Operational Aspect	Mount Owen Continued Operations Consent (SSD-5850)	Glendell Consent (DA 80/952)
Approved final voids	Bayswater North Pit North Pit	Glendell Pit
Coal Processing	Mount Owen CHPP (up to 17 Mtpa) and Liddell CHPP (up to 2 Mtpa ROM)	N/A - Mount Owen CHPP
Coal Transportation	Mount Owen Rail Loop and M series conveyor to Liddell Coal Operations and/or Ravensworth Coal Terminal	N/A – Mount Owen Rail Loop
Mine Infrastructure Area (MIA)	Mount Owen MIA and Ravensworth East MIA	Glendell MIA
Workforce	Up to approximately 920 full time equivalent (FTE) positions	Up to approximately 300 FTE positions
Creek Diversions	Upper reaches of Bettys Creek into Main Creek Diversion of section of Bettys Creek to the south of WOOP emplacement area Yorks Creek diverted as part of former Swamp Creek Mine around current Ravensworth East MIA (refer to **Figure 1.2**)	Bettys Creek diverted around southern extent of Glendell Pit (refer to **Figure 1.2**) Swamp Creek diverted adjacent to Glendell MIA

3.2 Water Management System

The Glendell Mine Water Management System (WMS) is an integrated component of the Mount Owen Complex WMS. In addition, the Mount Owen Complex is an integral part of the GRAWTS and is connected to the water management systems of Liddell Coal Operations, Ravensworth Operations and Integra Underground. The GRAWTS allows greater flexibility in mine water management by the Mount Owen Complex by allowing water to be transferred from sites with excess water to sites with storage capacity and/or higher usage demands or discharge opportunities.

Water management at the Mount Owen Complex considers three (3) categories of water, each with different potential to cause environmental harm. The target design criteria for each of the three (3) categories of water are summarised in **Table 3.2**.

Table 3.2 Design Criteria for components of Mount Owen Complex WMS

Water Category	Water Description	Target Design Criteria
Clean	Runoff from undisturbed or rehabilitated areas and selected hard surface areas where coal and fuel/oil contamination risks are low.	Release, where practicable, to downstream environment.
Dirty	Runoff from disturbed areas (does not include water captured in mining pit areas, runoff from coal processing areas and workshops).	Managed in line with the Blue Book (*Managing Urban Stormwater: Soils and Construction Volumes 1* and *2E*) (Landcom (2004), DECC (2008)). Designed to manage runoff from the 5 day, 95th percentile rainfall event. Water captured in sediment dams is pumped to storage dams where it is used for operational purposes.

Water Category	Water Description	Target Design Criteria
Mine	Runoff from active mining areas and areas exposed to coal or water used in coal processing or from coal stockpile areas.	Contained for events up to and including the 1% annual exceedance probability (AEP) 24 hour storm event.

3.3 Historical and Approved Impacts on Creeks

3.3.1 Yorks Creek

Yorks Creek is a tributary of Bowmans Creek. An approximately 1.5 km section of Yorks Creek has previously been diverted around the Ravensworth East MIA as part of the former Swamp Creek Mine/Ravensworth East mining operations. The upper catchment of Yorks Creek above the Glendell Pit Extension has been significantly modified due to approved mining at Ravensworth East and Mount Owen. As these areas are rehabilitated, runoff will be progressively returned into the Yorks Creek catchment. This progressive increase in the size of the upper catchment will occur during the life of the Project.

3.3.2 Swamp Creek

The upper reaches of Swamp Creek have been diverted around the North Pit emplacement area and now form part of the Yorks Creek catchment. The middle reaches of Swamp Creek are located within the existing approved disturbance area for Mount Owen Mine and Ravensworth East Mine. This former catchment of Swamp Creek is located entirely within the approved Mount Owen and Glendell disturbance areas and is managed as part of the Mount Owen Complex WMS. This catchment is broadly approved to be redirected towards Swamp Creek as part of the conceptual final landform once rehabilitated. A section of Swamp Creek adjacent to the existing Glendell MIA has also previously been diverted (refer to **Figure 1.2**).

3.3.3 Bettys Creek

Bettys Creek is located to the east and south of the current Glendell operations and has previously been diverted around the southern end of the Glendell Pit mining area, as approved under the Glendell Consent. The remnant upper reaches of Bettys Creek catchment to the north of the Mount Owen Complex have previously been diverted towards Main Creek as part of the approved Mount Owen operations (refer to **Figure 1.2**). Parts of the former Bettys Creek catchment are also located within the approved disturbance area for the Mount Owen Complex and are managed as part of the Mount Owen Complex WMS. The conceptual final landform for the Mount Owen Continued Operations Project retains the diversion of the upper catchment of Bettys Creek towards Main Creek. Part of the former Bettys Creek catchment is also located within the approved final void catchment for North Pit.

3.4 Existing Approvals

3.4.1 Planning Approvals

Table 3.3 summarises the development consents for the operations at the Mount Owen Complex and existing modifications of these consents.

Table 3.3 Mount Owen Complex Development Consents

Development Consent Reference	Title	Description	Approval Granted	Expiry
Glendell Consent				
DA 80/952	Glendell Mine	Initial approval of Glendell Mine operations Dragline and truck and shovel mining methods Production Rate of 3.6 Mtpa	2/5/1983	2/5/2013
DA 80/952 Modification No.1	Glendell Open Cut	Approval to use the Swamp Creek Mine South Void for overburden emplacement and extension of mining area	1997	30/6/2013
DA 80/952 Modification No.2	Glendell Mine Operations	Modification of mining footprint and integration with Mount Owen Complex coal handling, processing and transport facilities. Increase in production rate to 4.5 Mtpa Extended approved mining operations to 30 June 2024	25/2/2008	30/6/2024
DA 80/952 Modification No.3	Powerline Relocation	Realignment of a 2.7 km section of an existing 132 kV Ausgrid powerline and associated activities	1/12/2016	30/6/2024
DA 80/952 Modification No. 4	Minor Extension	Minor extension of pit to facilitate ongoing mining operations in Glendell Pit until determination of Glendell Continued Operations Project – no change to production rates or approved life of mining.	Application placed on public exhibition November 2018. Response to submissions received during exhibition period are being prepared.	
Mount Owen Continued Operations Consent				
SSD-5850	Mount Owen Continued Operations Project	Consolidated planning approvals for Ravensworth East Mine and Mount Owen Mine and CHPP under a single consent (and surrender of former consents for these operations) Approved extension of operations at Bayswater North Pit and North Pit Life of mine at Mount Owen Complex extended Continued integration with GRAWTS (initially approved under previous consents)	3/12/2016	31/12/2031
SSD-5850 Modification No. 1	Integra to Mount Owen Complex Water Pipeline Modification	Modification to facilitate the construction of a water pipeline to convey mine water from Integra Underground Mine to the Mount Owen Complex	15/09/2017	31/12/2031
SSD-5850 Modification No. 2	Mount Owen Continued Operations Project Modification 2	Modification application to extend the North Pit mining area and mine life by 6 years	Application placed on public exhibition August 2018. Application being assessed.	

The Glendell Modification 4 application seeks a minor extension to the approved pit area to extract an addition approximately 3.5 Mt ROM. The modification seeks only a minor change to the disturbance

footprint and does not seek a change to either the approved life of mining (end 2024) or the approved mining rate (up to 4.5 Mtpa ROM).

The Mount Owen Continued Operations Project Modification 2 applications seeks to extend the North Pit mining area. The proposed modification will enable approximately 35 Mt of additional ROM coal to be mined from the North Pit. Recovery of the additional coal reserve will result in approximately 46 ha of additional disturbance and require an increased depth across the extent of the North Pit to provide for mining down to the Hebden Seam. This change to the North Pit mine plan will allow the extension of the approved Mount Owen mine life through to 2037 (an additional 6 years).

Ravensworth Operations, Ravensworth Underground, Liddell Coal Operations and Integra Underground consents all include provision for the integration of water and tailings management systems as part of the GRAWTS. The existing water transfer pipeline between the Mount Owen Complex (Ravensworth East Mine) and Ravensworth Operations was approved under a development consent granted by Singleton Council on 22 December 2000 (DA 506/2000).

3.4.2 Environment Protection Licences

Table 3.4 identifies the Environment Protection Licences (EPLs) held under the *Protection of the Environment Operations Act 1997* (POEO Act) for the mining operations at Mount Owen Complex. Mount Owen is currently in the process of rationalising these EPLs to an EPL covering Glendell Mine and a separate EPL covering the remainder of the Mount Owen Complex operations. The Integra Underground EPL also includes surface areas that are within the Project Area.

Table 3.4 Environment Protection Licenses

	Mount Owen Mine	Glendell Mine	Ravensworth East Mine	Integra Underground
Licence	EPL 4460	EPL 12840	EPL 10860	EPL 3390

None of the EPLs for the Mount Owen Complex have licensed discharge points. Excess water at the Mount Owen Complex is managed under the GRAWTS with any necessary discharges occurring at the Ravensworth Operations or Liddell Coal Operations pursuant to licenses held by those operations, consistent with development consents held for the GRAWTS.

4.0 Glendell Continued Operations Project

The Project proposes the extension of mining at Glendell Mine to the north of the current Glendell Pit. Mining operations would extend the existing open cut operations to the north with mining down to the Hebden Seam (Glendell Pit Extension). Estimated ROM coal reserves in the proposed mining area are approximately 135 Mt. Mining operations would be undertaken using truck and excavator mining methods.

Mining operations would initially proceed at the current approved production rate (up to 4.5 Mtpa) with production increasing during the life of the operations as production at Bayswater North Pit and North Pit decline and eventually cease. Maximum annual production from the Glendell Pit Extension would be capped at 10 Mtpa ROM coal. **Section 4.2** contains further details of proposed mining operations.

ROM coal would be transported by truck from the Glendell Pit Extension to the Mount Owen CHPP for washing, consistent with current practice. The Project will not result in any increase to the currently approved 17 Mtpa ROM coal throughput at the Mount Owen CHPP, however the Project will extend the life of the Mount Owen CHPP and associated coal handling and transport infrastructure by an additional approximately 8 years. **Section 4.3** contains further details regarding mining infrastructure. **Figure 1.3** shows the key Project features. Overburden burden removed as part of the mining operations will be emplaced in-pit to the south of the mined area as mining progresses to the north. Overburden emplacement would also occur on existing Glendell emplacement areas and areas disturbed as part of the Ravensworth East operations. The final emplaced landform will be developed using natural landform techniques and will be progressively rehabilitated over the life of the Project.

Water and tailings management associated with the Project will be integrated with the Mount Owen Complex WMS and GRAWTS. The existing water transfer pipeline between the Mount Owen Complex to Ravensworth Operations will be impacted by the Glendell Pit Extension, necessitating a realignment of the easement. A separate modification application will be sought for this realignment and augmentation of this pipeline.

As a result of mining progressing to the north, the Project will require the realignment of a section of Hebden Road and the realignment of Yorks Creek. Indicative alignments for Hebden Road and Yorks Creek are shown in **Figure 4.1**. The pit extension will also mine through the current Glendell MIA. The Project will therefore require the construction of a new MIA. **Sections 4.3** to **4.9** provide further details regarding ancillary aspects of the Project. The Project will also mine through the site of the Ravensworth Homestead and the Project also proposes its relocation.

4.1 Key Objectives

Key objectives of the Project include:

- maximising the recovery of accessible reserves within relevant mining tenements while optimising the use of existing infrastructure and equipment
- avoiding the sterilisation of accessible reserves
- extending the economic life of the Glendell Mine, Mount Owen Complex infrastructure and providing ongoing employment for the existing workforce
- further development of the existing environmental mitigation and management strategies, expanding the existing commitments to mitigate and manage the predicted impacts associated with the Project and cumulative impacts

- establishing a final landform that is safe and stable, and which provides sustainable post mining land use options.

4.2 Conceptual Mine Plan

Mining at Glendell is currently occurring in the existing Glendell Pit. Overburden emplacement is occurring in-pit to the east and south of mining operations as the pit progresses northwards.

The Project will result in mining in the Glendell Pit extending to the north-west, generally along its current alignment. Mining will continue in a northerly direction with in-pit emplacement of overburden behind the active mining area (including the current Glendell Pit mining area) and other emplacement areas. A final void will remain in the northern section of the proposed pit area upon cessation of mining. **Figures 4.2** to **4.4** show the general conceptual progression of mining in the Glendell Pit Extension. The mining schedule and progression may change throughout the life of the Project as a result of mine design changes and refinements, geological issues, market demands etc.

As mining progresses to the north, the Glendell Pit Extension will mine down to (and including) the Hebden Seam. Glendell Pit Extension production rates will progressively increase as production rates decline with the cessation of mining at the Bayswater North Pit and North Pit. **Figure 4.5** shows an approximated production schedule for the Mount Owen Complex over the life of the Project, however this is subject to change with mine design refinements in the future.

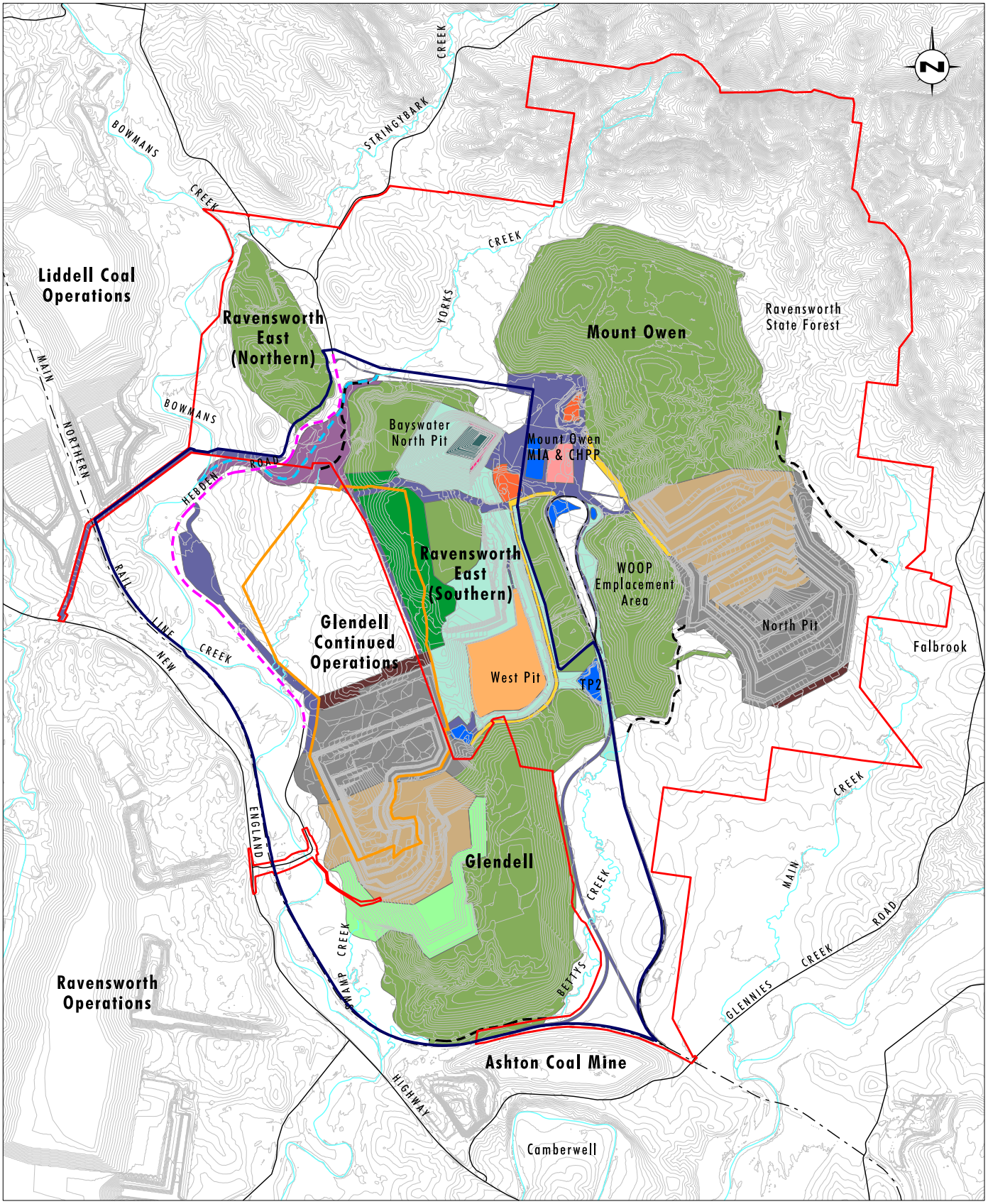
Table 4.1 provides a summary of key Project components.

Table 4.1 Project Summary

Project Component	Summary of the Project
Mining Method	Truck and Excavator/Shovel
Resource	All seams down to and including the Hebden Seam (Glendell Mine currently approved to mine down to a depth of approximately 200 m)
Disturbance Area	The Project will require the disturbance of an additional approximately 850 ha of land not currently approved for mining related disturbance. Approximately 670 ha of this is within the Verification Area (Gateway Disturbance Area - refer to **Section 1.4.2**).
Annual Production	Glendell Mine (Glendell Pit Extension) - up to 4.5 Mtpa increasing to up to 10 Mtpa ROM coal as production rates in Bayswater North Pit and North Pit decline
Mine Life	To 2044 (Glendell Pit currently approved to 2024)
Total Resource Recovered	Additional approximately 135 Mt ROM coal from Glendell Pit Extension
Coal Processing and Transport	Continued use of the Mount Owen CHPP - up to 17 Mtpa (no change). Extension of operating life of Mount Owen CHPP and associated coal handling and transport infrastructure to 2045[3]
Management of Overburden (Glendell Pit Extension)	Emplacement of overburden in-pit and on existing emplacement areas at Glendell Mine and areas disturbed as part of the Ravensworth East Mine Areas of out-of-pit emplacement to assist in final landform

[3] Coal extracted to the end of 2044 will require an extended approval timeframe for coal processing facilities.

Project Component	Summary of the Project
Mount Owen CHPP Rejects (coarse and fine)	Fine tailings emplacement within West Pit, Bayswater North Pit and other tailings facilities approved at neighbouring mining operations as part of the GRAWTS Ongoing coarse rejects co-disposed with overburden at Mount Owen Complex (including overburden associated with the proposed Glendell Pit Extension)
General Mine Infrastructure	Demolition of Glendell MIA New MIA required constructed to northwest of proposed Glendell Pit Extension. Heavy vehicle access road to be established for new MIA Adjustments required to alignment of the conveyor to the Liddell Mine and associated infrastructure and/or transport arrangements to accommodate the Yorks Creek realignment works Additional water management infrastructure such as sediment dams, clean and dirty water diversion drains, pipelines and use of voids for water storage Changes to GRAWTS pipeline infrastructure affected by Glendell Pit
Final Landform	Final landform at Glendell and Ravensworth East to 200 mAHD (approximately 40 m higher than existing approved operations at Glendell) No increase in number of voids relative to approved operations
Other Infrastructure Changes	Realignment of an approximately 5 km section of Hebden Road Relocation of local telecommunications and electricity infrastructure
Other Major Associated works	Realignment of Yorks Creek Final landform development across Mount Owen Complex including the Glendell Pit to return catchment to the former Swamp Creek and Bettys Creek and Yorks Creek. Relocation of Ravensworth Homestead
Operational Workforce	Overall workforce at the Mount Owen Complex will remain similar to current workforce numbers of approximately up to 1,220 FTE positions during concurrent operations. This will reduce following cessation of mining operations at Mount Owen Mine (circa 2036-7) Glendell workforce numbers will progressively increase over the duration of the Project from approximately 300 FTE to approximately up to 600 FTE positions in the latter stages of the Project. The increasing workforce at Glendell coincides with a reduced workforce at the Mount Owen and Ravensworth East Mines as production declines and then stops
Hours of Operation	No change – 24 hours per day, 7 days per week



Data Source: Glencore (2019)
Note: 5m Contour Interval

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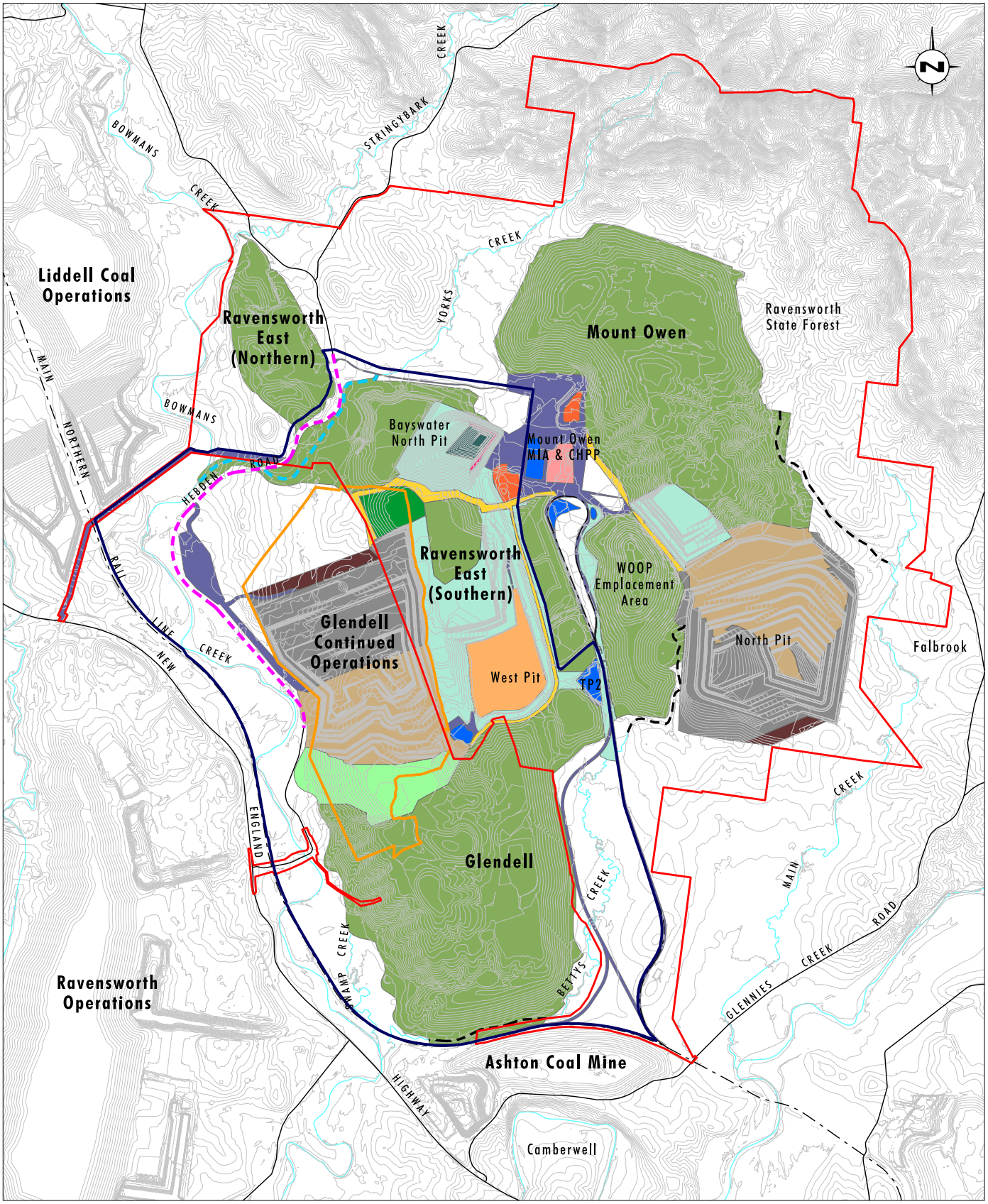
Legend

- Project Area
- Mount Owen Consent Boundary (MOD 2 Application)
- Proposed Glendell Pit Extension
- Existing Creek Diversion
- Yorks Creek Realignment
- Hebden Road Realignment
- Active Pit/Working Area
- Active Overburden Emplacement Area
- Topsoil Removal Strip
- Shaping for Final Landform
- Temporary Rehabilitation
- Rehabilitation
- Rehabilitation (Redisturbance)
- Creek Realignment Establishment
- Infrastructure/Vehicle Access Road
- Haul Road
- Coal Stockpile ROM
- Coal Stockpile Product
- Tailings Emplacement Area
- Water Storage
- Water Storage/Tailings
- Highwall

FIGURE 4.1

Conceptual Progression of Mining - Early Project Stage

File Name (A4): R07/4166_109.dgn
20190129 11.11



Data Source: Glencore (2019)
Note: 5m Contour Interval

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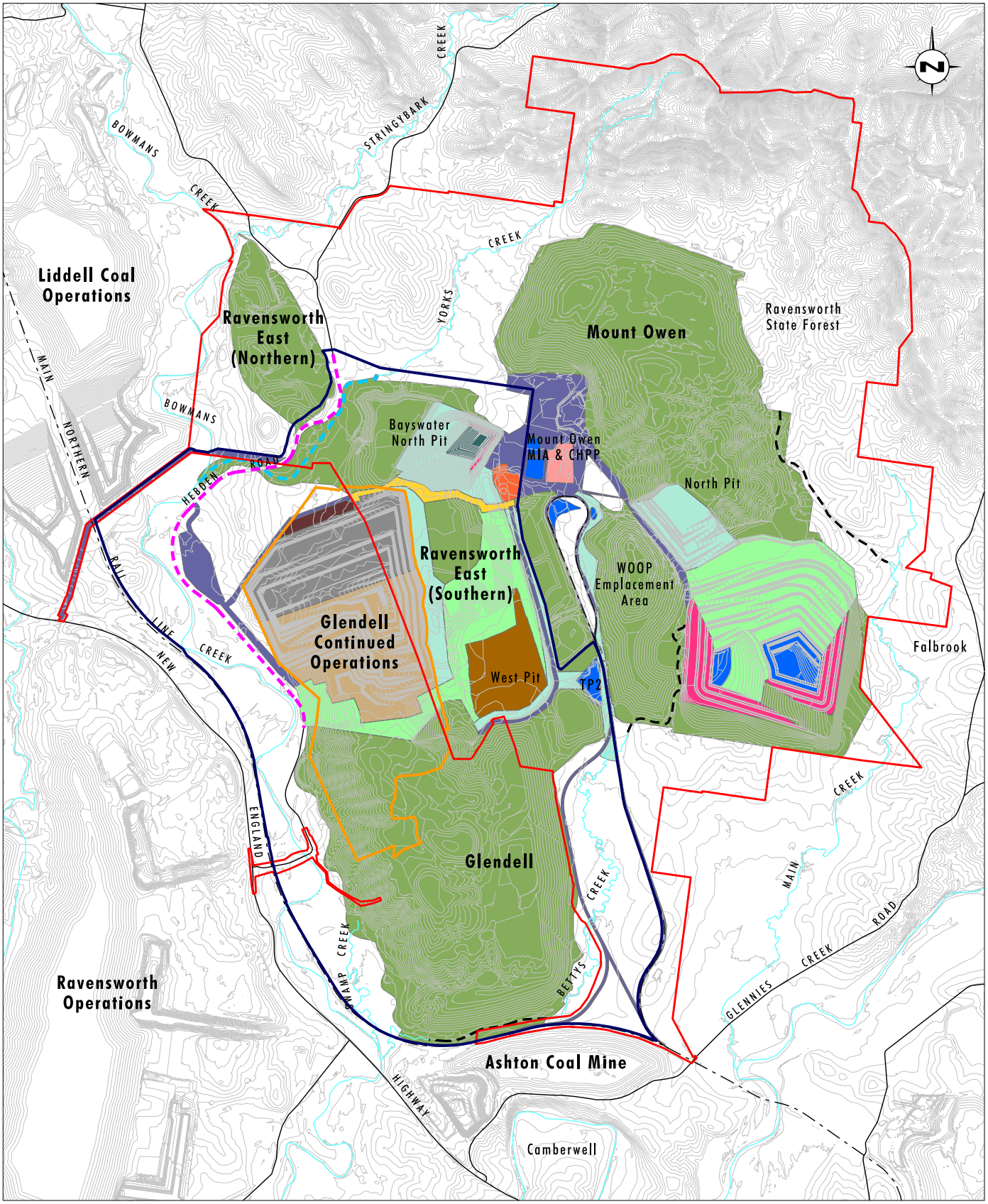
Legend

- Project Area
- Mount Owen Consent Boundary (MOD 2 Application)
- Proposed Glendell Pit Extension
- Existing Creek Diversion
- Yorks Creek Realignment
- Hebden Road Realignment
- Active Pit/Working Area
- Active Overburden Emplacement Area
- Topsoil Removal Strip
- Shaping for Final Landform
- Temporary Rehabilitation
- Rehabilitation
- Rehabilitation (Redisturbance)
- Infrastructure/Vehicle Access Road
- Haul Road
- Coal Stockpile ROM
- Coal Stockpile Product
- Tailings Emplacement Area
- Water Storage
- Water Storage/Tailings
- Highwall

FIGURE 4.2

Conceptual Progression of Mining - Mid Project Stage

File Name (A4): R07/4166_110.dgn
20190129 11.06



Data Source: Glencore (2019)
Note: 5m Contour Interval

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Legend

- Project Area
- Mount Owen Consent Boundary (MOD 2 Application)
- Proposed Glendell Pit Extension
- Existing Creek Diversion
- Yorks Creek Realignment
- Hebden Road Realignment
- Active Pit/Working Area
- Active Overburden Emplacement Area
- Topsoil Removal Strip
- Shaping for Final Landform
- Temporary Rehabilitation
- Rehabilitation
- Infrastructure/Vehicle Access Road
- Haul Road
- Coal Stockpile ROM
- Coal Stockpile Product
- Water Storage
- Water Storage/Tailings
- Highwall
- Tailings Capping in Progress

FIGURE 4.3

Conceptual Progression of Mining - Late Project Stage

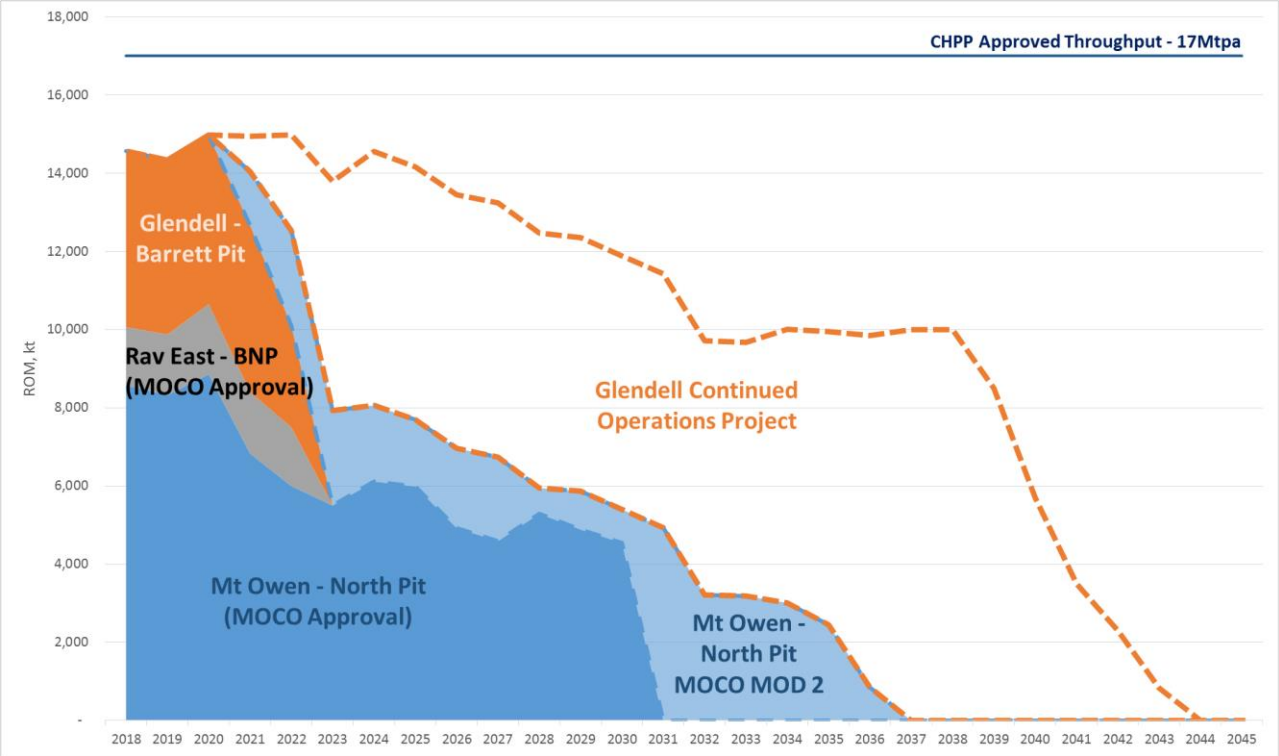

Figure 4.4 Mount Owen Complex Indicative Production Schedule

4.2.1 Overburden Management

The majority of overburden and interburden (referred to collectively as overburden) from mining operations associated with the Project will be emplaced in-pit behind the mining operations. Overburden will also be emplaced on the existing Glendell Mine in-pit and out-of-pit emplacement areas and in the areas disturbed as part of the Ravensworth East operations. Some out-of-pit emplacement will be required for final landform purposes. Overburden may also be used for the capping of tailings at West Pit and Bayswater North Pit (if used as a tailings facility). Overburden will be hauled from the pit to the emplacement location by haul truck.

To allow for the incorporation of natural landform design elements, emplacement across the overburden emplacement areas in Ravensworth East and Glendell utilised for the Project will be generally to 200 mAHD with local variations in topography to facilitate drainage and improve aesthetics. This emplacement strategy avoids the need for additional disturbance which would be associated with separate new out-of-pit emplacement areas. The increased height will not be uniform across the emplacement areas and the variability in height afforded by the increased dumping assists in the development of a natural looking final landform. The Project will not change approved dumping heights for the WOOP emplacement area or the North Pit in-pit emplacement.

Consistent with existing operations, proactive and reactive mine management will be undertaken to manage noise and dust impacts from the operations.

Overburden from the Project which meets appropriate engineering specifications may also be crushed and used as gravel in the construction of infrastructure on the site, including but not limited to the Hebden Road realignment, the MIA heavy vehicle access road, the MIA hardstand area and haul roads throughout the life of the Project.

4.2.2 Rejects and Tailings Management

Tailings emplacement within the Mount Owen Complex is undertaken within disused mining areas in accordance with the Tailings Management Strategy.

Continued use of the West Pit and Bayswater North Pit voids is proposed as part of the Project along with the management of tailings across a number of Glencore operations within the Greater Ravensworth Area forming part of the GRAWTS. Based on current approvals for operations within the GRAWTS, there is sufficient void capacity available to store tailings associated with all approved operations plus this Project and the Mount Owen Continued Operations Project Modification 2. A rejects and tailings strategy will be developed for the EIS.

In accordance with the current approvals, tailings emplacement areas at the Mount Owen Complex will be capped with overburden to achieve a stable final landform and allow the area to be rehabilitated in accordance with the proposed mine plans and the mine closure and rehabilitation strategy.

4.2.3 Blasting

Blasting will be undertaken on a regular basis for both overburden removal and coal extraction. Blast practices for the Project will include:

- up to 2 mining related blasts per day, and
- an average of 8 blasts per week (averaged over a 12 month period).

As with current operations, blasting will be restricted to between the hours of 9.00 am and 5.00 pm Monday to Saturday and no blasting will be conducted on Sundays or Public Holidays, except where approved by the Planning Secretary.

Temporary closures of Hebden Road will be required when blasting is within 500 m distance to the nearest point of Hebden Road. No blasts associated with the Project are proposed within 500 m of the New England Highway or Main Northern Rail Line. Depending on the timing of approval of the Project, some blasting associated with existing approved operations may still be required within 500 m of the Main Northern Rail Line; existing management practices regarding any such blasts will be maintained as part of the Project.

As noted in **Section 4.9**, some construction activities (e.g. cuttings associated with the Hebden Road realignment and Yorks Creek realignment works) may also require some blasting. Construction related blasts will be in addition to the mining related blasts. Some of these blasts may be within 500 m of Hebden Road however blasting associated with these works is unlikely to be located within 500 m of either the Main Northern Rail Line or the New England Highway.

The timing of road closures on Hebden Road will have regard to key transport times for the workforce, local residents, regular services such as school buses and local businesses.

4.2.4 Rehabilitation and Final Landform

Progressive rehabilitation has been undertaken throughout the life of Glendell, Ravensworth East and Mount Owen Mines. Rehabilitation works have included extensive flora and fauna monitoring and research projects in order to develop rehabilitation techniques and ensure the development and success of the rehabilitation programs in place. Disturbed areas will be rehabilitated as soon as practicable throughout the life of mining at the Mount Owen Complex.

The current Glendell Consent final landform incorporates a single void in the north-western corner of the Glendell Pit. The conceptual final landform developed for the Mount Owen Continued Operations Project includes two final voids remaining following rehabilitation (Bayswater North Pit and North Pit).

The Project will result in a single void in the north of the Glendell Pit Extension and will therefore not result in any additional voids at the Glendell Mine when compared to current approved operations. The Project may utilise the North Pit void for water storage following the cessation of mining at North Pit. The detailed mine planning process to be undertaken for the Project will consider opportunities for the Project to use the Bayswater North Pit void for water and tailings storage and overburden emplacement.

Natural landform design, incorporating micro-relief principles, will be developed for overburden emplacement areas for this Project.

The micro-relief design principles results in a more natural looking landform, which reduces the visual impact of the final landform and results in improved surface water drainage. Variable height in the topography also assists in the mitigation of potential visual impacts.

The design of the final landform is developed and refined progressively as part of the detailed mine planning process and is included in the staged rehabilitation plans contained in the MOP/Rehabilitation Management Plan. The progressive development of micro-relief in the landform as part of the detailed mine planning process is necessary to ensure that overburden material is efficiently handled and the drainage in the rehabilitated final landform works effectively as part of the mine water management system.

The rehabilitation strategy developed for the Project will have regard to the design principles approved for the Mount Owen Continued Operations Project including the incorporation of wildlife corridors, conservation areas and the management of water resources in the long term.

4.2.5 Hours of Operation

Mining, CHPP and coal transport operations will continue to be undertaken 24 hours per day, 7 days per week for the life of the Project.

4.2.6 Operational Workforce

During the life of the Project, workforce demands associated with each operation within the Mount Owen Complex will change however overall workforce numbers at the Mount Owen Complex (Glendell Mine, Mount Owen Mine, Ravensworth East Mine and the Mount Owen CHPP) will be maintained at approximately up to 1,220 full time equivalent (FTE) positions during concurrent operations and will decline to approximately up to 600 FTE positions after cessation of mining at North Pit.

Glendell workforce numbers will progressively increase over the duration of the Project from approximately 300 FTE to approximately up to 600 FTE positions in the latter stages of the Project. The increasing workforce at Glendell coincides with a reduced workforce at Mount Owen as operations at Bayswater North Pit and North Pit decline.

4.3 Mining Infrastructure

4.3.1 Coal Handling and Transport Infrastructure

The Project will utilise the existing Mount Owen CHPP and coal handling infrastructure (conveyors, stockpiles and train loading facilities) for the processing and transport of coal. ROM coal will be hauled from the Glendell Pit Extension to the Mount Owen CHPP via truck (refer to **Figure 4.4**).

The currently approved operating capacity of the Mount Owen CHPP and train loading facility will remain the same and has approval to process up to 17 Mtpa of ROM coal. The Project will extend the current approved life of the Mount Owen CHPP to 2045.

The Project will retain the option of transferring up to 2 Mtpa ROM coal and crushed gravel on an 'as required' basis via the existing overland conveyor to Liddell Coal Operations and the Ravensworth Coal Terminal; alternative transport arrangements will also be considered as part of the design studies being undertaken during the preparation of the EIS.

The Mount Owen Complex infrastructure facilities will continue to operate 7 days per week.

4.3.2 New Mining Related Infrastructure

New infrastructure requirements for the Project include:

- demolition of the existing Glendell MIA and Ravensworth East MIA (noting that the demolition of the Ravensworth East MIA is the subject of the current Mount Owen Continued Operations Consent)
- construction of a new MIA
- construction of a new heavy vehicle access road to the new MIA
- water management infrastructure including water fill point/s
- temporary construction facilities and laydown areas
- realignment and alterations to the Ravensworth East to Liddell Coal Operations conveyor or construction and use of alternative transport arrangements.

The progression of mining to the north of the Glendell Pit will necessitate the demolition of the current Glendell MIA and the construction of a new MIA. The demolition will need to occur in the early stages of the Project (circa 2021-2022) meaning any alternative MIA (or use of temporary facilities) would need to be available prior to demolition (i.e. in 2020-2021).

In considering alterative MIA options, various alternatives were reviewed. The continued use/upgrade of the Ravensworth East MIA for the Project is not considered to be feasible for use by the Project due to the restricted size of the area available at Ravensworth East and the continued need for the MIA for maintenance activities associated with approved operations at Mount Owen Mine and Ravensworth East. Additionally, the progression of the Glendell Pit Extension to the north necessitates the realignment of Yorks Creek and the works associated with this realignment (see **Section 4.8.1** below) make the continued use of the Ravensworth East MIA for the Project unfeasible.

As the Mount Owen MIA will continue to be used to support mining operations at North Pit, it also does not have capacity to handle both Glendell and Mount Owen mobile equipment without a significant upgrade.

The indicative location of the new MIA for Glendell and associated heavy vehicle haul road are shown on **Figure 4.1**. A range of temporary infrastructure will also be required for the construction period including a construction site office(s), car parking areas and hardstand/laydown areas.

Further design studies will be undertaken to refine the concept details and requirements for ancillary infrastructure that might be required to service the Project.

4.4 Water Management System

The Glendell water management system is an integrated component of the Mount Owen Complex WMS and the GRAWTS as described in **Section 3.1.2**.

The Project will require changes to the Mount Owen Complex WMS and approved GRAWTS arrangements, including a realignment of the water pipeline between the Mount Owen Complex and Ravensworth Operations. Drainage infrastructure will need to be constructed and installed to capture water from additional areas disturbed by the Project. This infrastructure will include clean water diversions, pipelines, pumps and sediment dams and dirty water diversion drains. The realignment of the GRAWTS water pipeline between the Mount Owen Complex and Ravensworth Operations is required as the Glendell Pit Extension will mine through the current alignment of this pipeline connection between the operations. A separate modification application to the Mount Owen Continued Operations Consent will be sought for this realignment and augmentation of this pipeline. It is noted that this pipeline does not require a mining lease and is not a feature of the Project requiring consideration as part of the Gateway application.

Following the cessation of mining in Bayswater North Pit it will be used as a mine water dam and/or tailings storage facility consistent with current approval requirements. North Pit will also be used for water storage for the Project following the cessation of mining in that pit. The utilisation of North Pit as a water storage would enable the Bayswater North Pit to be used for tailings or coarse rejects disposal or overburden emplacement for the Project.

This proposed change to the use of the North Pit void optimises the value of the void during the life of the Project. This change will not materially alter the conceptual final land-use of the North Pit void as the Mount Owen Continued Operations Consent currently contemplates a pit lake in the North Pit void.

4.5 Site Access

Glendell Mine currently has a single primary site access at the southern end of Hebden Road; approximately 2 km from the Hebden Road intersection with the New England Highway (refer to **Figure 1.2**).

The primary access for the site will be via a new mine access road linking the proposed MIA and the proposed realigned Hebden Road. As with existing operations, a number of minor access points off Hebden Road and associated hardstand areas will be developed for maintenance and other purposes.

4.6 Hebden Road Realignment

The Glendell Pit Extension will necessitate the realignment of a section of Hebden Road. The realignment will also include a crossing of the proposed Yorks Creeks realignment (refer to **Section 4.8.1**).

It is proposed that an approximately 5 km section at the southern end of Hebden Road will be realigned to the west around the Glendell Pit Extension in the location shown on **Figure 1.3**. This realignment would extend the trip distance for some road users travelling on Hebden Road by approximately 1.3 km.

The realignment design has also taken into consideration potential future mine planning options for Glendell which may include a possible further extension to the north-west into a portion of the old Liddell Underground Mine that is located to the east of Bowmans Creek. The proposed realignment location would avoid the need for a subsequent realignment of Hebden Road should this option be pursued in the future.

Consultation will commence with the Singleton Council regarding the design of the road. Consultation with Hebden Road stakeholders such as residents and the Hebden quarries has been undertaken and will continue.

In order to minimise disruptions to traffic, where possible, the realigned section of Hebden Road will be fully constructed prior to decommissioning of the existing section. This is anticipated to be completed in 2021.

Due to the proximity of sections of Hebden Road (both existing alignment and proposed realignment) to the Glendell Pit Extension, temporary closures of sections of Hebden Road will be required for blasting located within 500 m of the road.

The Gateway Disturbance Area includes disturbance associated with the realignment of Hebden Road, however it is noted that these works do not require a mining lease and are linear infrastructure that does not require consideration under the Gateway process.

4.7 Other Infrastructure

Powerlines and telecommunications infrastructure located within the proposed Gateway Disturbance Area will need to be relocated. These relocations will generally follow the Hebden Road realignment. As with the Hebden Road realignment, these works do not require a mining lease and are linear infrastructure that does not require consideration under the Gateway process.

4.8 Creek Interactions

4.8.1 Yorks Creek

The progression of the Glendell Pit Extension to the north will necessitate the realignment of the lower portion of Yorks Creek, an ephemeral tributary of Bowmans Creek running in a roughly north-south alignment though the Project Area. Earthworks upstream of the Glendell Pit Extension will also be required to manage the risk of flood waters entering the pit. This area has been previously disturbed by mining and infrastructure associated with the Ravensworth East Mine.

The proposed realignment will commence north of the existing Ravensworth East MIA and progress in a south-westerly direction where it will enter Bowmans Creek. The proposed realignment includes the realignment of the section of Yorks Creek that has previously been diverted (refer to **Section 3.1.3.1**).

This realignment is proposed to be permanent and its design will have regard to a wide range of environmental factors. The realignment is required to be in place by approximately 2027. It is contemplated that construction activities would commence earlier to improve the environmental performance of the proposed realignment.

4.8.2 Swamp Creek

The Project will mine through the remnants of currently diverted Swamp Creek located immediately north of Glendell Pit. Parts of Swamp Creek to the west of Glendell Pit will be impacted by emplacement activities related to the development of natural landform features and water management systems associated with the management of runoff from disturbed areas. The Pit Extension and diversion of catchment from

disturbed areas will further reduce the catchment of Swamp Creek. As the landform is appropriately revegetated, runoff from the slopes of the south-western part of the final landform of the Project will be directed towards the lower reaches of Swamp Creek to enable the return of some catchment flows.

The terrain developed by the in-pit emplacement of overburden as part of the mining of the Project will result in a reduction to the Swamp Creek catchment. Areas of Swamp Creek catchment within the existing mining disturbance area will generally be diverted towards Bettys Creek as part of final landform drainage. This is discussed further below.

4.8.3 Bettys Creek

As discussed above, the Project will result in the redirection of part of the former Swamp Creek catchment towards Bettys Creek as part of the conceptual final landform design. This increase in the Bettys Creek catchment would occur progressively as areas of the former Swamp Creek catchment are rehabilitated such that run-off is of suitable water quality. The overall size of the Bettys Creek catchment in the final landform will not be greater than the pre-mining catchment area.

4.8.4 Bowmans Creek

Other than the change in confluence point for Yorks Creek, the Project will not have any direct impacts on Bowmans Creek. Potential indirect impacts include:

- Minor impacts on baseflows associated with groundwater interactions;
- Reduced catchment during operational phases;
- Changes in tributary catchments (Yorks Creek, Swamp Creek and Bettys Creek) however the overall catchment of Bowmans Creek in the final landform will be similar to that contemplated for the currently approved operations save for a small decrease in catchment associated with the slightly larger final void; and
- Potential changes to flood flows associated with construction of Hebden Road and the changes to the Yorks Creek confluence point.

4.9 Construction Activities

4.9.1 Construction Activities and Schedule

The Project has been designed to maximise the use of existing and currently approved infrastructure, however as outlined in the previous sections, the Project will involve a number of significant construction activities including new mine infrastructure, the realignment of Hebden Road and the realignment of Yorks Creek.

The indicative timing of construction activities is set out in **Table 4.2**.

Table 4.2 Indicative Construction Schedule

Feature	Indicative Construction Period
Construction of new Glendell MIA	2020-2021 (approximately 14 months)
Construction of heavy vehicle access road	2020-2021 (approximately 12 months)
Construction of Hebden Road realignment	2020-2021 (approximately 12 months)
Demolition of Glendell MIA	2021-2022 (approximately 6 months)
Demolition of Ravensworth East MIA	2024-2025 - coinciding with Yorks Creek realignment works (approximately 6 months)
Relocation of Ravensworth Homestead	By 2027 (approximately 12-24 months)
Yorks Creek Realignment	2024-2025 but works associated with western sections may commence as early as 2020-2021. Full commissioning by approximately 2025

Construction activities in some areas will include blasting for cuttings (Hebden Road and Yorks Creek realignment). Crushing of overburden and blasted material from cuttings may also be required for road and MIA construction fill.

4.9.2 Construction Hours

Construction activities will generally be undertaken within standard construction hours (7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm Saturday). Construction activities outside these hours will be subject to the ability to meet Project noise criteria.

Blasting associated with construction activities will only be undertaken 9.00 am to 5.00 pm, Monday to Friday and 9.00 am to 1.00 pm Saturday.

4.9.3 Construction Workforce

The construction workforce on site at any one time will vary depending on the timing of the various construction components of the Project. The construction workforce is estimated to peak at approximately 300 FTE employees in 2021. This includes the construction of the heavy vehicle access road, new MIA, and the Hebden Road realignment.

It is expected that some short term increases in traffic associated with key infrastructure construction periods will occur.

5.0 Assessment against Gateway Criteria

Clause 17H (4) of the Mining SEPP identifies the Criteria that must be addressed in a Gateway Application for Projects potentially impacting on BSAL:

> *The relevant criteria are as follows:*
>
> *(a) in relation to biophysical strategic agricultural land – that the proposed development will not significantly reduce the agricultural productivity of any biophysical strategic agricultural land, based on a consideration of the following:*
>
> *(i) any impacts on the land through surface area disturbance and subsidence,*
>
> *(ii) any impacts on soil fertility, effective rooting depth or soil drainage,*
>
> *(iii) increases in land surface micro-relief, soil salinity, rock outcrop, slope and surface rockiness or significant changes to soil pH,*
>
> *(iv) any impacts on highly productive groundwater (within the meaning of the Aquifer Interference Policy),*
>
> *(v) any fragmentation of agricultural land uses,*
>
> *(vi) any reduction in the area of biophysical strategic agricultural land.*

As identified in **Section 1.4**, and shown on **Figure 1.7**, the Project will not directly impact on any CICs. The Project is not visible from any CICs and indirect impacts on enterprises associated with the CICs will be negligible. As the Project will not have any impacts on land identified as CICs, as assessment against Gateway Criteria relevant to CICs is not required.

The following sections address the issues for consideration identified in clause 17H(4) of the Mining SEPP.

5.1 Surface area disturbance and subsidence

The Verification Area is approximately 700 ha (**Figure 1.5**).

The Gateway Disturbance Area is shown in **Figure 1.8**. **Figure 5.1** shows regional land and soil capability mapping undertaken by the Office and Environment and Heritage (OEH, 2012). As can be seen from OEH regional mapping, the Gateway Disturbance Area is primarily located on land identified as being Class 6 Low Capability Land. The alluvial terraces associated with Bowmans Creek and Swamp Creek are identified as being Class 3 High Capability Land and the areas to the west of Bowmans Creek are mapped as being Class 5 Moderate to Low Capability Land. **Table 5.1** provides a breakdown of the area of each of the OEH mapped land capability classifications within the Gateway Disturbance Area and Verification Area.

The Project will result in topsoils and subsoils being stripped from areas directly impacted by key infrastructure and mining. The Glendell Pit Extension will result in top soil, subsoil and overburden material being removed and relocated from approximately 440ha of the Verification Area. As shown on **Figure 1.6**, no parts of the verified BSAL will be directly impacted by the Glendell Pit Extension itself; impacts on Verified BSAL are limited to the construction of the new Glendell MIA and the associated Heavy Vehicle Access Road and the realignment of Hebden Road (refer to **Figure 2.1**).

Topsoils and subsoils stripped prior to mining and the construction of infrastructure will be used in the rehabilitation of disturbed area.

Table 5.1 OEH Land and Soil Capability Mapping – areas potentially affected by the Project

Land Capability Class	Approximate area within Verification Area (ha)	Approximate area of proposed Glendell Pit Extension in Verification Area (ha)
Class 3 – High capability land	75	69
Class 6 – Low capability land	623	598

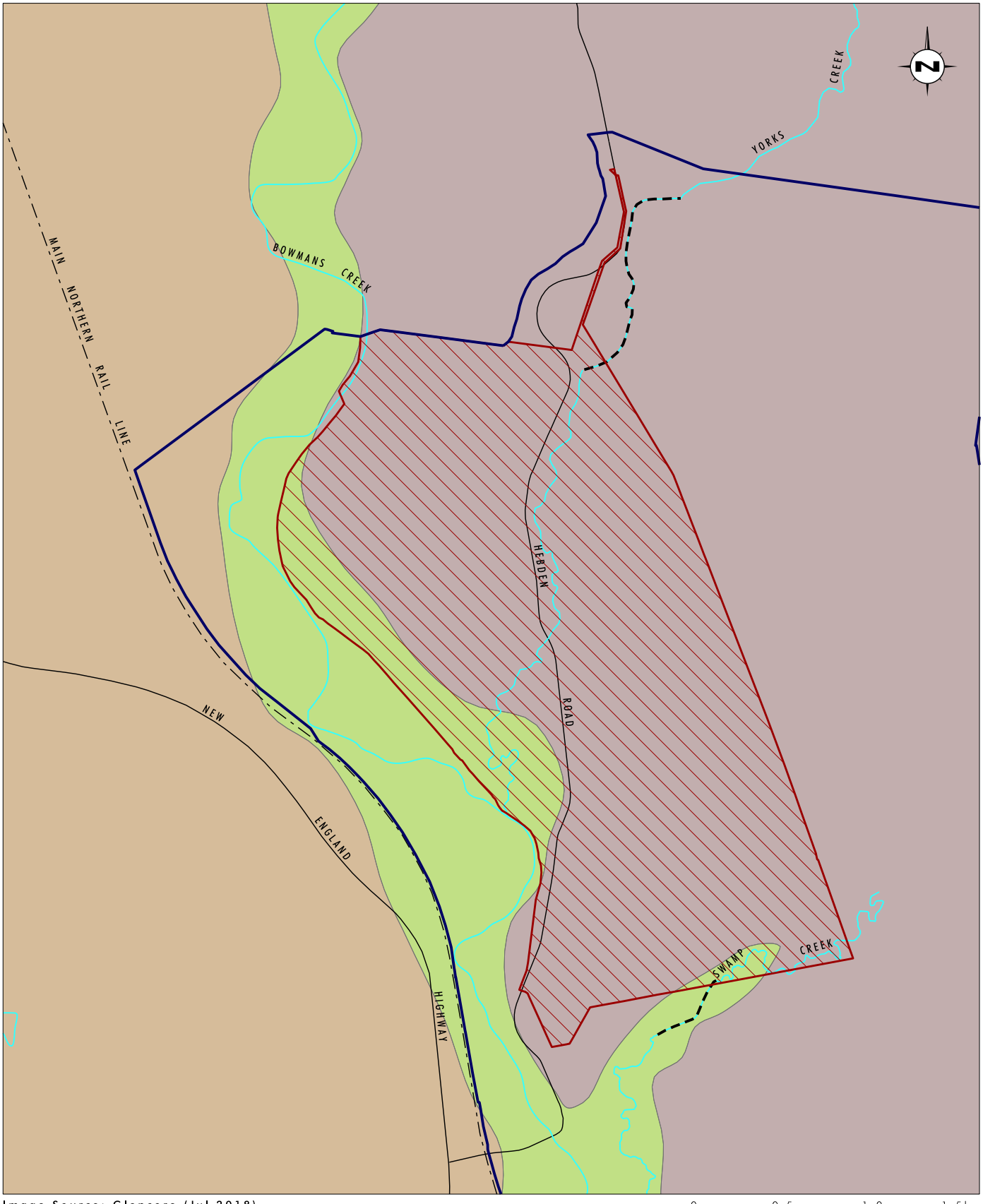

Image Source: Glencore (Jul 2018)
Data Source: Glencore (2019), OEH (2012)

0 0.5 1.0 1.5km
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Legend

- Project Area
- Verification Area
- Existing Creek Diversion

Land Capability (OEH 2012):

- Class 3 - High Capability Land
- Class 5 - Moderate - Low Capability Land
- Class 6 - Low Capability Land

FIGURE 5.1

Land and Soil Capability Mapping OEH 2012

This regional land and soil capability mapping will be updated for the Agricultural Impact Statement (AIS) being prepared for the Project based on soil survey results undertaken for the Project. The AIS will be prepared in accordance with the *Agricultural Impact Statement technical notes* (Department of Primary Industries, 2013). The land and soil capability mapping will also identify existing areas of disturbance by mining. Land and soil capability mapping will also be developed in the EIS for the post mining landform.

The aspects of the Project which may impact on the areas verified as being BSAL are the proposed realignment of Hebden Road, a heavy vehicle access road, MIA and potential creek bank stability works associated with the Yorks Creek realignment (refer to **Figure 2.1**). Water management works associated with the construction and operation of the Hebden Road realignment, heavy vehicle access road and MIA may also be required in the area identified as being BSAL. Approximately 34 ha of BSAL is located in the area identified as potentially being disturbed as a result of additional disturbance associated with the Project for which a mining lease may be required.

The Project will not have any subsidence impacts. Parts of the Verification Area are located over areas that have previously been mined and subsided as a result of the mining of the Liddell Underground (refer to **Figure 1.2**). The Project will not increase subsidence impacts associated with these former workings beyond the proposed open cut mining area.

5.2 Soil fertility, effective rooting depth, soil drainage, land surface micro-relief, soil salinity, rock outcrop, slope and surface rockiness or soil pH

Appendix A includes the results from the soil sampling and analysis undertaken in the Verification Area.

The soils directly affected by the Glendell Pit Extension will be removed prior to mining and reused in the rehabilitation of overburden emplacement areas. This process will impact on the soil fertility, effective rooting depth, soil drainage, land surface micro-relief, rock outcrop, slope and surface rockiness and potentially soil pH and soil salinity of these areas. The Project's impacts on these features in other areas within the Gateway Disturbance Area will depend on the final project design. Detailed mine closure objectives and rehabilitation/closure criteria will be developed for these areas which include consideration of these factors. These objectives and performance criteria will be set based on the identified target land uses for these areas post mining.

The AIS prepared for the Project will include a full assessment of the Projects impacts on soil fertility, effective rooting depth, soil drainage, land surface micro-relief, soil salinity, rock outcrop, slope and surface rockiness and soil pH in the areas to be impacted by the Project and any adjacent areas that may also be impacted.

5.3 Highly productive groundwater

5.3.1 Hydrogeological Context

The two main hydrogeological features occurring within and surrounding the Mount Owen Complex and areas potentially impacted by the Project are:

- The alluvial aquifers along the creek lines – the area within and broadly surrounding the Project Area contains Bettys Creek, Swamp Creek and Yorks Creek, (tributaries of Bowmans Creek); Bowmans Creek itself, and Main Creek, a tributary of Glennies Creek. Both Bowmans and Glennies Creeks are tributaries of the Hunter River. The alluvial aquifers associated with these systems are shallow unconfined aquifers of limited extent with unconsolidated alluvium. The alluvial aquifers directly applicable to mining within the Glendell Pit Extension are those associated with Yorks Creek, Swamp Creek and Bowmans Creek. The Project may induce drawdown in the Bowmans Creek, Swamp Creek and Bettys Creek alluvium. The Project is likely to have only negligible impacts on aquifers associated with the Main Creek alluvium.

- Deeper hard rock aquifers that contain the coal measures are semi-confined and contain sandstones, siltstones and coal seams. The coal seams form low transmissivity groundwater systems and are separated by low permeability interburden that forms an intervening aquitard. Water yields from the hard rock aquifers within the Project Area are low and have limited ability to transmit groundwater. There has been extensive depressurisation of these hard rock aquifers within and surrounding the Mount Owen Complex, as a result of previous and current approved mining operations.

The Project will extract the same sequence of coal seams that are currently being mined at Glendell Mine to the south, however the Project will also extract the Hebden seam. The coal seams occur within the Permian Vane Subgroup and include the Bayswater, Lemington, Pikes Gully, Arties, Liddell and Barrett Seams (refer to **Figure 5.2**). The Camberwell Anticline runs through the Project Area in an approximate north-south alignment resulting in the coal seams dipping away to the east and to the west at the boundaries of the Project Area (refer to **Figure 5.3**). Yorks Creek and Swamp Creek pass through the Project Area and join with Bowmans Creek west of the proposed mining area.

Flood plains occur along the alignment of the creek systems that have deposited a relatively thin sequence of alluvial sediments generally less than 10 m comprised of sand, silt and clay. The assessments being undertaken for the EIS include the definition of the extent of the alluvial sediments using a variety of datasets including LiDAR imagery, publically available datasets, test pits and drilling.

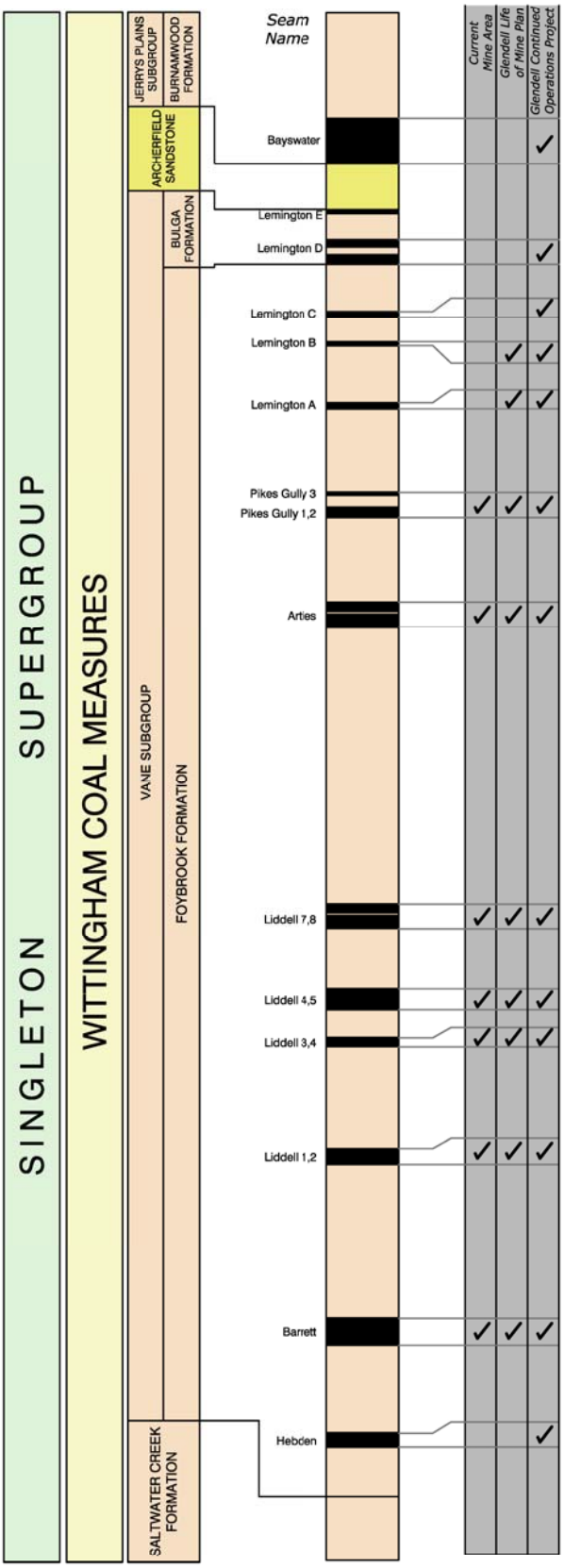

FIGURE 5.2

Target Stratigraphy at Glendell

Image Source: Glencore (2018)

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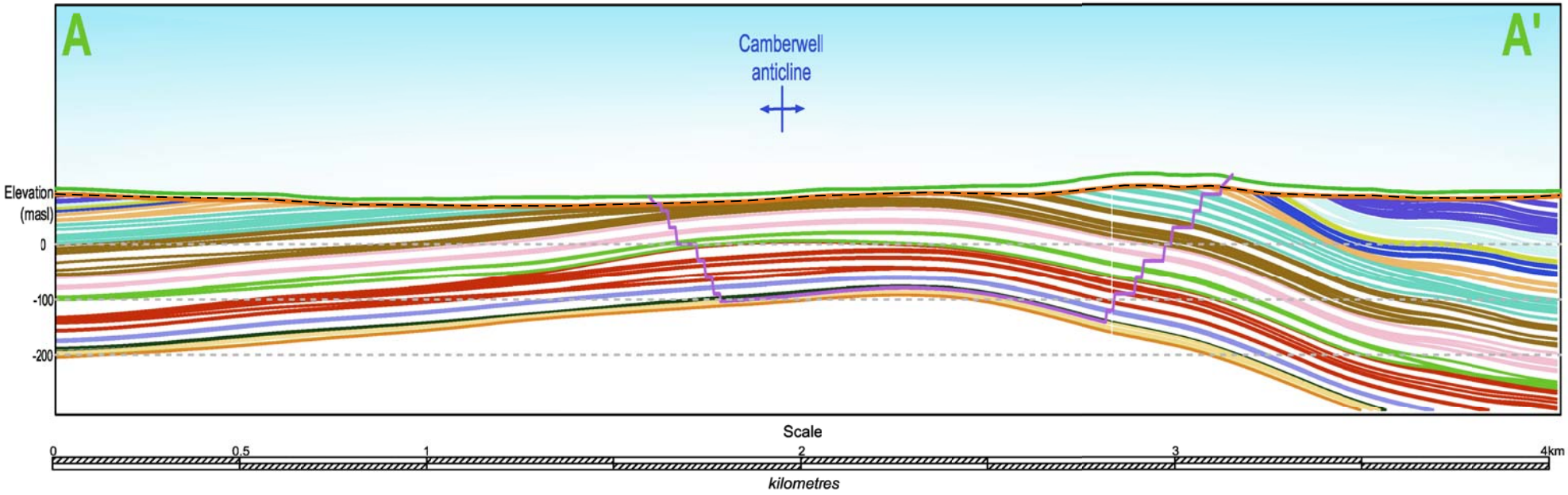
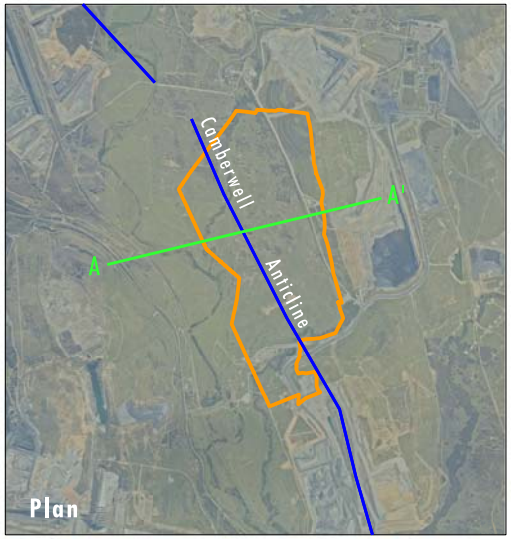
20180607 15.49





Legend

- Proposed Glendell Pit Extensio
- Mined Area
- Surface
- Base of Weathering
- Anticline
- Section Line

Seams Legend

- Ravensworth
- Ravensworth
- Lemington E
- Lemington D
- Lemington C
- Lemington B
- Lemington A
- Pikes Gully
- Arties
- Liddell
- Barrett
- Upper Hunter
- Hebden
- Lower Hebden

FIGURE 5.3

Geological Cross Sections of Proposed Glendell Pit Extension Showing Camberwell Anticline

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

File Name (A4): R07/4166_114.dgn
20190129 11.27

5.3.2 Highly productive groundwater criteria

A “highly productive” groundwater source is defined by the Aquifer Interference Policy (AIP) as a groundwater source which has been declared in regulations and datasets, based on the following criteria:

- has a Total Dissolved Solids (TDS) concentration less than 1,500 mg/L; and
- contains water supply works that can yield water at a rate greater than 5 L/s.

Highly productive groundwater sources are further grouped by geology into alluvial, coastal sands, porous rock, and fractured rock. “Less productive” groundwater sources are all other aquifers that do not satisfy the “highly productive” criteria for yield and water quality.

The NSW Department of Industry - Lands and Water (DILW) has produced a map of groundwater productivity across NSW, which shows areas classified as either highly or less productive (DILW, 2013). The DILW groundwater productivity map has been produced based on regional scale geological maps. **Figure 5.1** shows the DILW groundwater productivity map, which indicates the alluvium along Bowmans Creek, Yorks Creek and Swamp Creek has been classified as highly productive. The deeper hard rock aquifers do not satisfy either the water quality or flow rate criteria for highly productive aquifers and are therefore considered to be ‘less productive groundwater sources’.

Salinity is the key constraint to groundwater use, and can be described by TDS concentrations. TDS concentrations are commonly classified on a scale ranging from fresh to extremely saline. The Food and Agricultural Organisation of the United Nations (2013) provide a useful set of categories for assessing salinity based on TDS concentrations as follows:

- Fresh water <500 mg/L;
- Brackish (slightly saline) 500 to 1,500 mg/L;
- Moderately saline 1,500 to 7,000 mg/L;
- Saline 7,000 to 15,000 mg/L;
- Highly saline 15,000 to 35,000 mg/L; and
- Brine >35,000 mg/L.

Monitoring of water quality in creeks and alluvial aquifers associated with Bowmans Creek, Yorks Creek and Swamp Creek has been undertaken. Electrical conductivity has been used to estimate TDS concentrations by multiplying by 0.67 (ANZECC, 2000). A violin plot shows the density of data at different values in each of the systems monitored and has been used to illustrate the density of data within each of the salinity categories above. These results are shown in **Figure 5.5** which shows graphically a number of factors including the generally variable nature of salinity within the groundwater systems and the contrast between the surface water and the groundwater salinity. The plot shows samples collected from the monitoring bores installed within the alluvium at Bowmans Creek vary from fresh to saline, with most of them being brackish or moderately saline. At the confluences with Yorks Creek and Swamp Creek, the samples yield a wide range in salinity, which can be classified from fresh to highly saline, with most being saline to highly saline at Yorks Creek alluvium.

The available data collected from the alluviums at Yorks Creek and Swamp Creek indicate relatively high salinity, meaning that these alluvial systems do not meet the NSW government criteria of a highly

productive groundwater source. Data collected from Bowmans Creek is partially within and partially outside of this threshold value for TDS. Water yields are also likely to be lower than the 5L/s thresholds form highly productive aquifer systems in saturated areas of Swamp Creek and York Creek and some sections of Bowmans Creek alluvium.

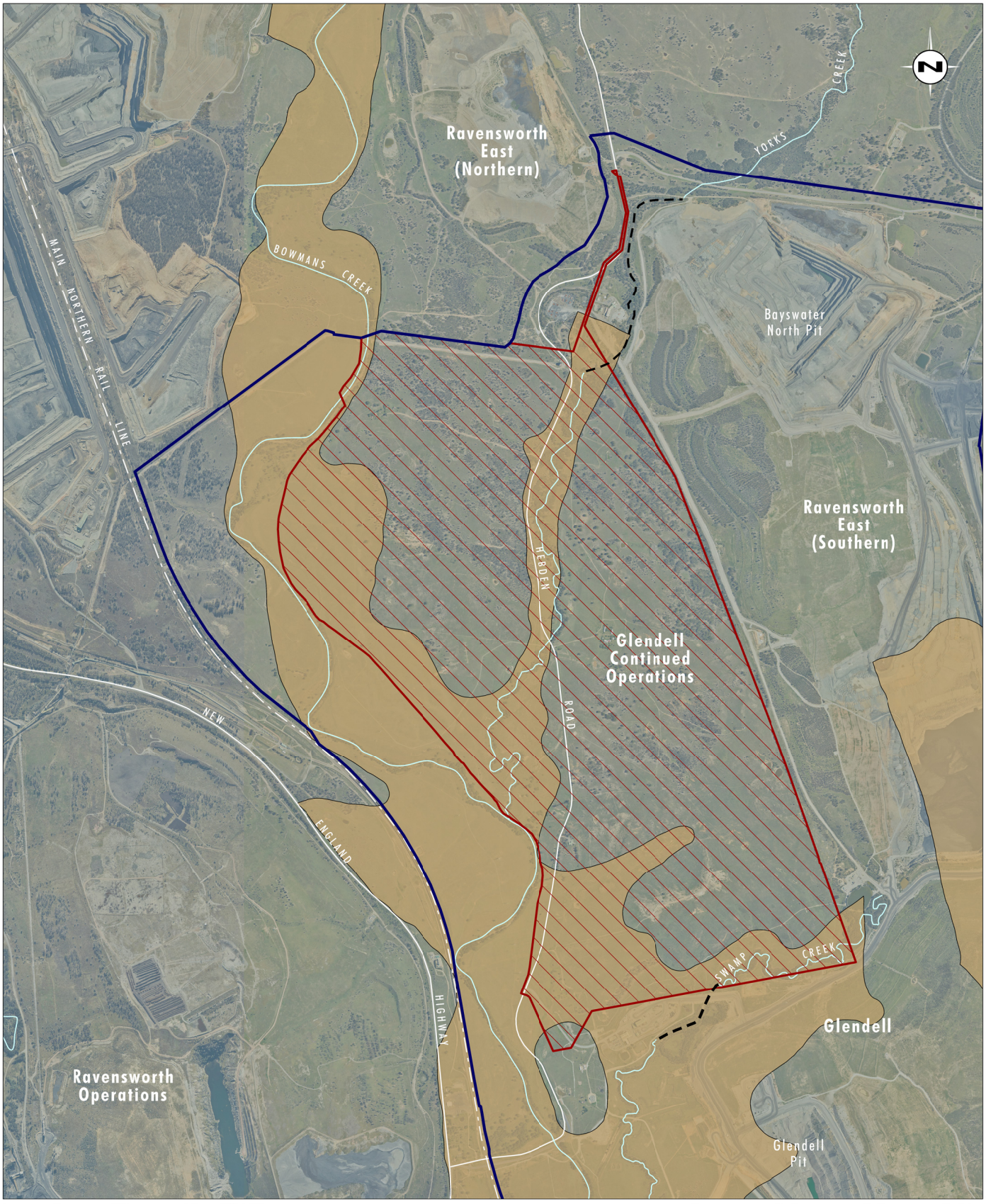


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Department of Primary Industries, NSW Department of Industry - Lands and Water (2012)

0 0.5 1.0 1.5km
1:30 000

Legend

- Project Area
- Verification Area
- Existing Creek Diversion
- Highly Productive Groundwater - Porous Rock (DILW 2012)

FIGURE 5.4

DILW 2012 Mapping of Highly Productive Groundwater

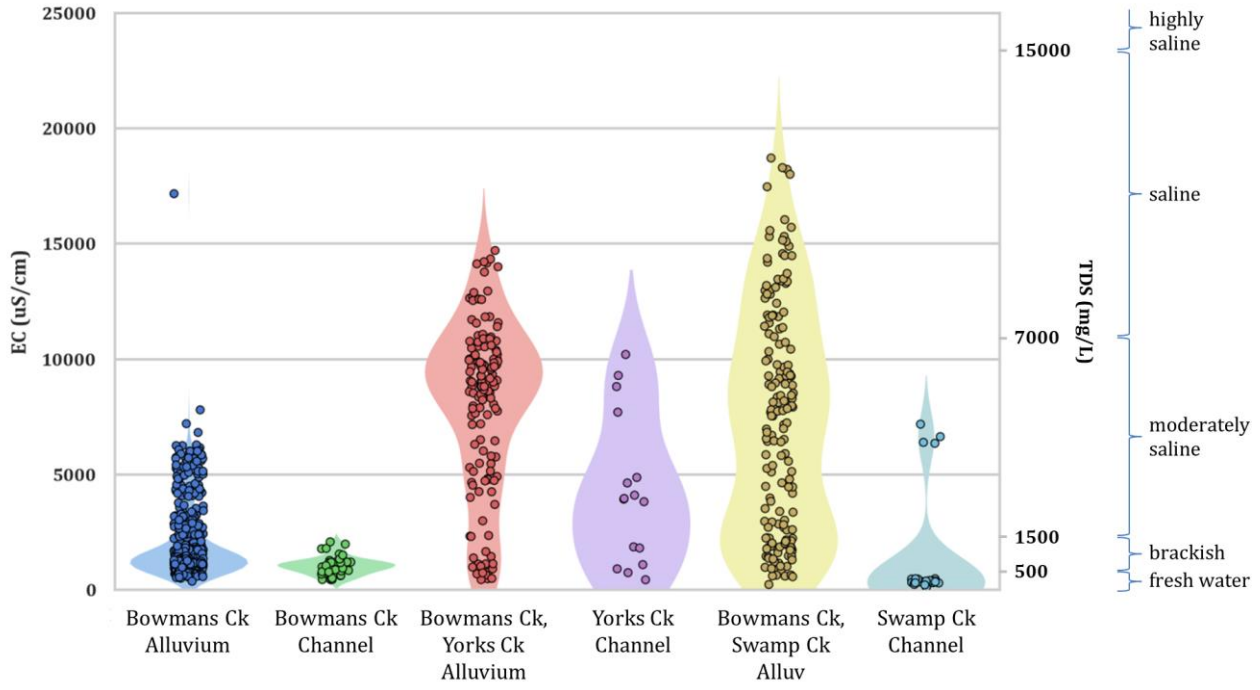


Figure 5.5 Electrical conductivity (EC) violin plot of monitoring data

© AGE, 2018

5.3.3 Potential Impact Mechanisms

The proposed open cut mining activity will depressurise the geological strata directly intersected by the mining activities. The will create a zone of drawdown around the mining activity where groundwater levels will decline during the life of the Project. The depressurisation will also create an area of low pressure within the groundwater system centred on the Project that will encourage groundwater to flow towards the mining area drawing groundwater from the adjacent water sources. The presence of the anticline means the coal seams being mined in the Glendell Pit Extension do not directly subcrop under Bowmans Creek. Further, the aquifers in the coal seams in the area are already significantly impacted by past and current mining at Liddell Coal Operations, Ravensworth East, Glendell, Mount Owen, Ravensworth Operations, Integra Underground and Ashton Coal Mine.

The groundwater associated with the Bowmans Creek alluvium is the main aquifer systems identified as being potentially highly productive that may be impacted by the Project. All other aquifers potentially or likely to be impacted by the Project are considered to be less productive aquifers. The potential connectivity between the regolith and Bowmans Creek, Yorks Creek and Swamp Creek alluvial aquifers may create a depressurisation pathway to the Glendell Pit Extension with localised depressurisation effects.

5.3.4 Groundwater Modelling

Detailed delineation of the extent of the Bowmans Creek alluvium and monitoring of the Bowmans Creek aquifer is being undertaken to ensure the modelling undertaken for the Project accurately represents the this potentially highly productive aquifer. Additionally, three new alluvial monitoring bores have been paired with a deeper bore constructed within the underlying regolith/ weathered zone layer to determine connectivity between the Bowmans Creek alluvium and underlying bedrock. Monitoring associated with these boreholes will be used to inform the groundwater model.

5.3.5 Assessment against gateway criteria

The Guidelines for gateway applicants identify specific matters for consideration in relation to potential impacts on highly productive groundwater. These issues (***bold italics***) are addressed below

- ***Estimates of all quantities of water that are likely to be taken from any water source on an annual basis during and following cessation of the activity***

The proposed open cut mining activity will depressurise the geological strata directly intersected by the mining activities. The will create a zone of drawdown around the mining activity where groundwater levels will decline during the life of the Project. The depressurisation will also create an area of low pressure within the groundwater system centred on the Project that will encourage groundwater to flow towards the mining area drawing groundwater from the adjacent water sources. The presence of the anticline means the coal seams being mined in the Glendell Pit Extension do not directly subcrop under the Bowmans Creek. Further, the aquifers in the coal seams in the area are already significantly impacted by past and current mining at Liddell Coal Operations, Ravensworth East, Glendell, Mount Owen, Ravensworth Operations, Integra Underground and Ashton Coal Mine.

A numerical groundwater flow model has previously been developed for the local region for previous environmental assessments of mining projects at Mount Owen, Integra Underground, and Liddell Coal Operations. This model was developed with the purpose of estimating the extent of the zone of influence and the volume of groundwater taken from the affected water sources. The current numerical groundwater flow model will be refined to reflect improved knowledge of the local conditions and proposed mining associated with the Project.

Prior to making predictions the refined numerical model will be calibrated using water level records collected from the baseline monitoring network installed at Glendell and from adjacent surrounding mining operations. A significant network of monitoring bores exists both on the Project site and at adjacent mining operations. The model will also be calibrated to estimates of groundwater ingress into surrounding mining areas to reduce uncertainty.

The numerical modelling will be used to determine if the depressurisation due to the Project will significantly reduce the flow of Permian groundwater to the alluvial aquifers during mining.
This depressurisation of the bedrock will potentially result in some lowering of groundwater levels within areas of the Quaternary alluvium. The potential for riparian vegetation occurring along the creek lines to depend on groundwater and be affected by any drawdown will be determined and discussed as part of the assessment.

- ***A strategy for obtaining appropriate water licence/s for maximum predicted annual take***

NSW Water Sharing Plans (WSPs) establish rules for sharing water between the environmental needs of rivers and aquifers, and water users, as well as between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation.

The Crown Lands and Water Division (CLWD) (formerly known as DPI Water) is progressively developing WSPs for rivers and groundwater systems across NSW following the introduction of the *Water Management Act 2000*.

Three WSP's apply to the aquifers and surface waters within the vicinity of the Project - these are the WSP for the:

- Hunter Regulated River Water Source 2016 (Hunter Regulated WSP);

- Hunter Unregulated and Alluvial Water Sources 2009 (Hunter Unregulated WSP); and
- North Coast Fractured and Porous Rock Groundwater Sources 2016 (North Coast Fractured and Porous Rock WSP).

The North Coast Fractured and Porous Rock WSP commenced on 1st July 2016 and established the management regime relevant for groundwater taken from the Permian bedrock. The Project falls within the Sydney Basin – North Coast Groundwater Source of the North Coast Fractured and Porous Rock WSP.

The Hunter Regulated WSP covers the Hunter River surface water flows and highly connected alluvials described in the plan. The Hunter Regulated Water Source is divided into three management zones (Zone 1, Zone 2 and Zone 3). The zones are defined from a single common point, which is the junction of Glennies Creek with the Hunter River. The Project is located to the north of Zone 3A along Glennies Creek. This zone extends from the upper reaches of Glennies Creek Dam down to the Hunter River junction.

The Hunter Unregulated WSP includes the unregulated rivers and creeks within the Hunter River catchment, the highly connected alluvial groundwater (above the tidal limit) and the tidal pool areas. In total, there are 39 water sources covered by the Hunter Unregulated WSP and nine of these are further sub-divided into management zones. The Project Area occurs within the Jerrys Water Source and the Glennies Water Source however the Verification Area (and Gateway Disturbance Area) is wholly within the Jerrys Water Source. The Hunter Regulated River Alluvial Water Source which covers the Quaternary alluvium associated with Glennies Creek and Station Creek is also a separate water source managed under the Hunter Unregulated WSP.

Figure 5.6 shows the water sources and management zones occurring within and in the vicinity of the Project Area. **Table 5.2a and Table 5.2b** summarise the number of water access licenses (WALs) and the surface water and aquifer license shares held for each water source.

Table 5.2a Water access licenses and surface water and aquifer license shares for Jerrys Water Source

	No. of WAL(s)	Total Share Component
Aquifer	10	1,246
Domestic and Stock	2	8
Domestic and Stock (Domestic)	2	2
Major Utility	1	7,700
Unregulated River	19	2,097

Source: NSW Water Register
Note: based on 2018/2019 financial year data

Table 5.3b Water access licenses and surface water and aquifer license shares for Glennies Water Source

	No. of WAL(s)	Total Share Component
Aquifer	2	10
Unregulated River	12	446

Source: WaterNSW, NSW Water Register
Note: based on 2018/2019 financial year data

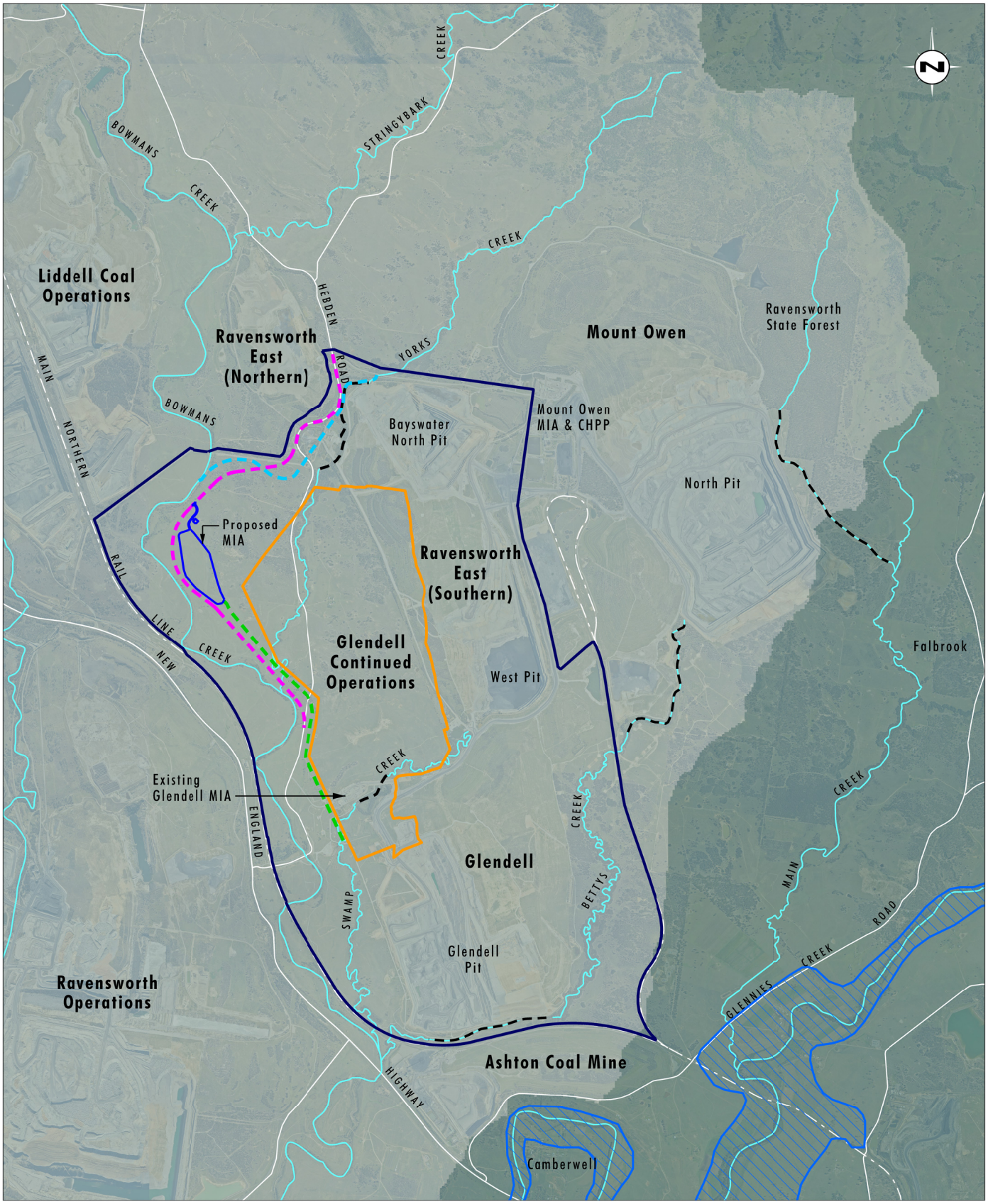


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), NSW Government (2009 and 2016)

Legend

- Project Area
- Proposed Glendell Pit Extension
- Existing Creek Diversion
- Glennies Water Source (Hunter Unregulated and Alluvial Water Sources WSP 2009)
- Jerrys Water Source (Hunter Unregulated and Alluvial Water Sources WSP 2009)
- Glennies Creek Management Zone 3 (Hunter Regulated River Water Source WSP 2016)

Project Features:

- Proposed MIA
- Proposed Heavy Vehicle Access Road
- Proposed Yorks Creek Diversion
- Proposed Hebden Road Realignment

FIGURE 5.6

Water Sharing Plan, Water Sources and Management Zones

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A numerical groundwater flow model has previously been developed for the local region for previous environmental assessments of mining projects at Mount Owen, Integra Underground, and Liddell Coal Operations. This model was developed with the purpose of estimating the extent of the zone of influence and the volume of groundwater taken from the affected water sources. This regional model will be updated to reflect the local conditions and proposed mining associated with the Project.

Based on the local geology and the monitoring of impacts associated with past mining activities, the Project's impacts are likely to be largely limited to the Jerrys Water Source and the Sydney Basin North Coast Groundwater Source. There are significant share components available for trade within these water sources.

- ***Establishment of baseline groundwater conditions including groundwater depth, quality and flow based on sampling of all existing bores in the area, any existing monitoring bores and any new monitoring bores that may be required under an authorisation issued under the Mining Act 1992 or the Petroleum (Onshore) Act 1991***

A network of baseline monitoring bore and vibrating wire piezometers has been installed within the Permian coal seams and the alluvial sediments for both existing and previous operations at the Mount Owen Complex and adjoining mining operations (refer to **Figure 5.7**).

Water level and water quality data have been routinely collected from the monitoring network and 13 years of baseline records are now available to describe the existing conditions at the Project site. The data indicates that the alluvium along Yorks Creek and Swamp Creek has a high clay content retarding the permeability of the aquifer material. The saturated thickness is also generally limited and the water quality in Yorks and Swamp Creeks is generally brackish to saline indicating these systems do not meet the NSW Government definition of a highly productive aquifer (refer to **Section 5.3.2**).

Bowmans Creek has a larger catchment and therefore a slightly thicker sequence of alluvial sediments, although high clay content and brackish water quality have also been identified in bores. Further drilling and installation of monitoring bores along Bowmans Creek has also been undertaken to confirm the thickness of the alluvium in areas not previously assessed and its aquifer potential. As noted earlier, three of the new alluvial monitoring bores have been paired with a deeper bore constructed within the underlying regolith/ weathered zone layer to determine connectivity between the alluvium and underlying bedrock.

The baseline monitoring from vibrating wire piezometers installed has identified water level drawdown within the coal seams due to the cumulative impact of approved activities that surround the proposed Glendell Pit Extension. No nearby landholders reliant on groundwater have been identified.

- ***A strategy for complying with any water access rules applying to relevant categories of water access licences, as specified in relevant water sharing plans***

A numerical groundwater flow model has previously been developed for the local region for previous environmental assessments of mining projects at Mount Owen, Integra Underground, and Liddell Coal Operations. This model was developed with the purpose of estimating the extent of the zone of influence and the volume of groundwater taken from the affected water sources. This regional model will be updated to reflect the local conditions and proposed mining associated with the Project.

The Project's impacts are likely to be largely limited to the Jerrys Water Source and the Sydney Basin North Coast Groundwater Source. There are significant share components available for trade within these water sources.

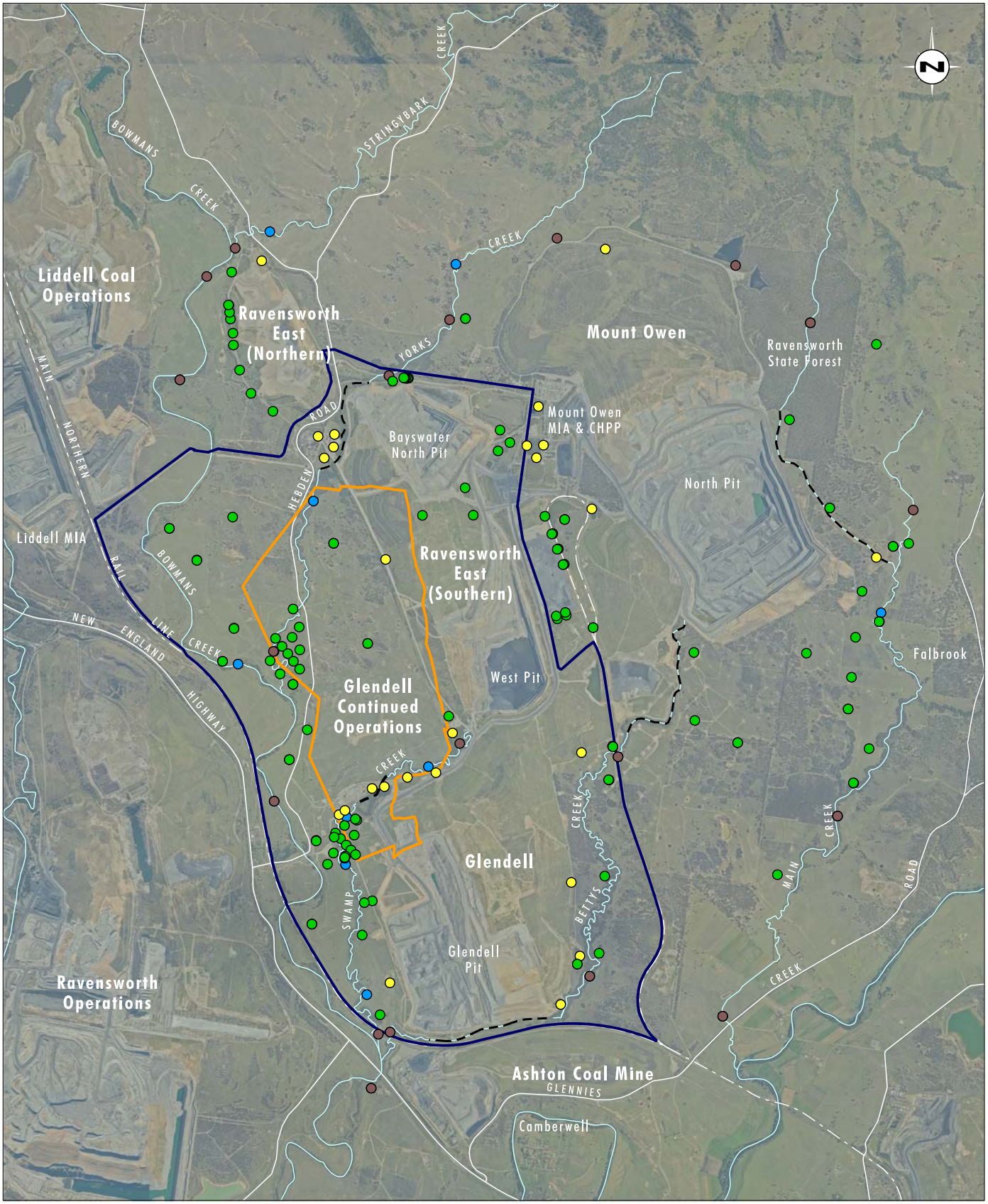

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

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Legend

- Project Area
- Proposed Glendell Pit Extension
- Existing Creek Diversion
- Groundwater Monitoring Location
- Surface Water - Channel Stability and Stream Health
- Surface Water Onsite Storage
- Surface Water - Watercourse

FIGURE 5.7

Groundwater and Surface Water Monitoring in the Vicinity of the Project

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- ***Estimates of potential water level, quality and pressure drawdown impacts on nearby water users who are exercising their right to take water under a basic landholder right***

The numerical modelling will be used to determine if the depressurisation due to the Project will significantly reduce the flow of Permian groundwater to the alluvial aquifers during mining.
This depressurisation of the bedrock will potentially result in some lowering of groundwater levels within areas of the Quaternary alluvium.

- ***Estimates of potential water level, quality and pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources;***

There have been no private water bores identified within proximity to the Project to date. The numerical modelling will be used to determine any potential impacts on groundwater users

- ***Estimates of potential water level, quality and pressure drawdown impacts on groundwater dependent ecosystems***

The numerical modelling will be used to determine if the depressurisation due to the Project will significantly reduce the flow of Permian groundwater to the alluvial aquifers during mining.
This depressurisation of the bedrock will potentially result in some lowering of groundwater levels within areas of the Quaternary alluvium. The potential for riparian vegetation occurring along the creek lines may depend on groundwater and whether they may be affected by any drawdown will be determined and discussed as part of the assessment.

During operations, the Project is unlikely to have a significant effect on groundwater quality. Post mining the rainfall, runoff and groundwater will slowly flood the residual void. The groundwater assessment will determine if the final void is likely to be a 'sink' and therefore concentrate salts in the lake that will form in the void, or a 'source' whereby water will flow from the void into the aquifers preventing the build-up of salts.

- ***Estimates of potential for increased saline and contaminated water inflows to aquifers and highly connected river systems***

The Project is considered unlikely to result in any significant saline or contaminated groundwater inflows to river systems and may even have a slightly positive impact on groundwater quality in alluvial systems due to reduced inflows from saline aquifers in coal seams sub-cropping under regolith areas and alluvial systems located further afield.

The EIS will include a detailed assessment of the site water balance for the Project. As discussed in **Section 4.0**, the Project will be linked to the GRAWTS. Discharges from the GRAWTS are via the licensed discharge point at Ravensworth Operations or Liddell Coal Operations. These discharges are subject to the Hunter Salinity Trading Scheme. It is not anticipated that the Project will require any change to the currently licensed discharge arrangements for the GRAWTS. The water management system is discussed further below.

- ***Estimates of the potential to cause or enhance hydraulic connection between aquifers***

The Project is an open cut mining operation. The mining activities themselves are unlikely to cause or enhance hydraulic connection between aquifers however the recovery of water within the mined areas post-mining (both in the void and in areas filled with spoil) will increase connectivity. The extent of this interaction will be modelled as part of the numerical modelling process.

It is noted that past and currently approved mining in the areas will have had, and will have similar impacts to that identified above. That is, similar connectivity impacts in the area immediately surrounding the proposed Glendell Pit Extension has already occurred or will occur as a result of existing approved operations; the Project is not considered likely to cause any significant increase in aquifer connectivity relative to that which is already occurring or will occur.

- ***Estimates of the potential for river bank instability, or high wall instability or failure to occur***

The Project is considered unlikely to affect riverbank stability.

The pit crest of the Glendell Pit Extension is set back at least 200 m from the highbank of Bowmans Creek. Geotechnical investigations will support the highwall design which will be designed to be long term stable. In-pit overburden emplacement will also support the highwall and prevent collapse in areas where the pit crest is located closer to Bowmans Creek.

- ***Outline of the method for disposing of water inflows to a mine or extracted water (in the case of coal seam gas activities)***

As discussed in **Section 3.1.3** the Glendell Mine WMS is an integrated component of the Mount Owen Complex WMS. In addition, the Mount Owen Complex is an integral part of the GRAWTS and is connected to the water management systems of Liddell Coal Operations, Ravensworth Operations and Integra Underground. The GRAWTS allows greater flexibility in mine water management by the Mount Owen Complex by allowing water to be transferred from sites with excess water to sites with storage capacity and/or higher usage demands or discharge opportunities.

The Project will require changes to the WMS and approved GRAWTS arrangements, including a realignment of the water pipeline between the Mount Owen Complex and Ravensworth Operations. Drainage infrastructure will need to be constructed and installed to capture water from additional areas disturbed by the Project. This infrastructure will include clean water diversions, pipelines, pumps and sediment dams and dirty water diversion drains.

Following the cessation of mining in Bayswater North Pit, it will be used as a mine water dam consistent with current approval requirements. North Pit will also be used for water storage for the Project following the cessation of mining in that pit. The utilisation of North Pit as a water storage would enable the Bayswater North Pit to be used for either tailings disposal or overburden emplacement for the Project. This proposed change to the use of the North Pit void optimises the value of the void during the life of the Project. This change will not materially alter the conceptual final land-use of the North Pit void as the Mount Owen Continued Operations Consent currently contemplates a pit lake in the North Pit void.

Consistent with the current GRAWTS arrangements, all discharges of mine water from the integrated operations will be via the existing approved Ravensworth Operations or Liddell Coal Operations discharge points. There will be no discharges of mine water directly from the Mount Owen Complex into adjoining water courses. The Project does not propose any changes to the approved discharge arrangements at Ravensworth Operations or Liddell Coal Operations.

Sediment dams are designed to capture and contain all rainfall events consistent with the design criteria prescribed by the Blue Book (*Managing Urban Stormwater: Soils and Construction Volumes 1* and *2E*) (Landcom, 2004), DECC,2008). The Blue Book design criteria has been developed to manage risks associated with elevated sediment levels from runoff from disturbed areas of mine sites and roads. Spills from sediment dams will occur for rainfall events above the Blue Book design criteria. The Blue Book design criteria has been developed to manage environmental risks associated with sediment in run-off water to acceptable levels.

5.4 Fragmentation of agricultural land uses

The land within the Verification Area is owned by Glencore or associated entities with the exception of a parcel of Crown land, a parcel of land owned by Alpha Distribution Ministerial Holding Company (a related entity to Ausgrid) and the road reserve for Hebden Road for which Singleton Council is the Roads Authority. The dominant land use within the Gateway Disturbance Area (and Verification Area) is agriculture. The agricultural use of the land is almost exclusively low intensity grazing however the areas of higher fertility soils (including the areas verified as being BSAL) have potential to be used for cropping. The grazing on the land to be impacted by the Project is managed by Colinta Holdings Pty Limited, a Glencore related entity. The higher value soil areas potentially impacted by the Project are typically small (approximately 34 ha within the Verification Area) and have not been cropped in recent history other than for pasture purposes.

The Project will remove up to 670 ha of land from agricultural production during the maximum extent of mining impact. The vast bulk of this land is Class 6 low capability land only suitable for grazing. Some of this land will be returned to grazing production post-mining. Until directly impacted by mining, much of the potential impact area will remain grazed. The area removed from agricultural production does not fragment existing operations or affect the viability of surrounding private landholdings.

The Project will have only a negligible impact on the transport of local agricultural products or access to markets being that associated with the increased road distance associated with the Hebden Road realignment (approximately 1.3 km extra travel distance each way). The Project will not increase rail traffic on the Main Northern Rail Line.

5.5 Reduction in the area of BSAL

The total area of identified BSAL within the Verification Area is approximately 34 ha, or 5% of the Verification Area. The majority of this BSAL area is situated to the east of Bowmans Creek, with a small parcel sited to the north of the creek (refer to **Figure 1.6**). This smaller BSAL area within the Verification Area occupies only 0.7 ha, and thus does not comply with the minimum size criterion of 20 ha, however, it is expected that the BSAL is continuous in the area outside but adjacent to the Project Area. Adjacent BSAL in the area outside of the Verification Area has been estimated based on the original SRLUP mapping and slope analysis and is shown on **Figure 1.6**.

Not all of the BSAL within the Verification Area will be impacted by the Project and aspects of the Project located within the Verification Area that do not formally trigger Gateway Approval considerations (e.g. disturbance associated with the realignment of Hebden Road) have been included in the area of BSAL potentially affected by the Project.

The approximately 34 ha of BSAL affected by the Project represents a very small percentage of the total area of BSAL mapped in the Upper Hunter SRLUP.

6.0 Conclusion

The Project is an extension of existing operations at the Glendell Mine and is located in an area which is already impacted by a long history of coal mining.

The Project will impact on up to 34 ha of land verified as being BSAL, although this includes development that is likely to fall outside the proposed mining lease/s (and is therefore not 'mining development' for the purposes of the Mining SEPP) and therefore is a conservative assessment. The Project will not impact on any areas identified as being CIC and is located approximately 15 km from the nearest CIC. The Project is not visible from any areas of CIC and will have negligible impacts on enterprises associated with CICs.

The areas of BSAL potentially impacted by the Project will not be impacted by the mining pit or overburden emplacement area. With the exception of the realignment of Hebden Road (which is excluded from the definition of 'mining development' given it will be located outside the proposed mining lease/s), the Project's impacts on areas of BSAL are temporary and limited to the duration of the Project. Mining related infrastructure potentially located on the areas of BSAL can be removed following the cessation of mining and the areas rehabilitated with the reinstatement of soils.

Detailed mine planning is still being undertaken meaning the likely extent of the Project impacts have not yet been assessed. The EIS for the Project will include an Agricultural Impact Statement prepared in accordance with relevant guidelines. Further, the regional hydrogeological model used for the assessment of recent Glencore mining projects in the area is being updated for the Project and a detailed Groundwater Impact Assessment will be undertaken as part of the EIS. A detailed Surface Water Impact Assessment will also be undertaken as part of the EIS process. The EIS will therefore include a full assessment of the Project's potential impacts on agricultural productivity in the areas impacted by the Project and the broader region.

A Preliminary Environmental Assessment (PEA) was lodged with the Secretary for Planning on 15 May 2018 to inform the request for Secretary's Environmental Assessment Requirements (SEARs) for the EIS for the Project. This document supports a Gateway Application and seeks a conditional gateway certificate which identifies the matters to be addressed in the EIS relevant to the assessment of potential impacts on BSAL.

7.0 References

ANZECC (2000), "*Australian and New Zealand guidelines for fresh and marine water quality. Volume 3, Primary industries*" / Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand

Department of Primary Industries (2013), *Agricultural Impact Statement technical notes*

Food and Agricultural Organisation of the United Nations (2013), *The use of saline waters for crop production - FAO irrigation and drainage paper 48* http://www.fao.org/docrep/t0667e/t0667e05.htm

NSW Government (2012), Upper Hunter, Strategic Regional Land Use Policy

NSW Government (2013a), *Fact Sheet, Strategic Regional Land Use Policy: Guideline for Applicants, September 2013*

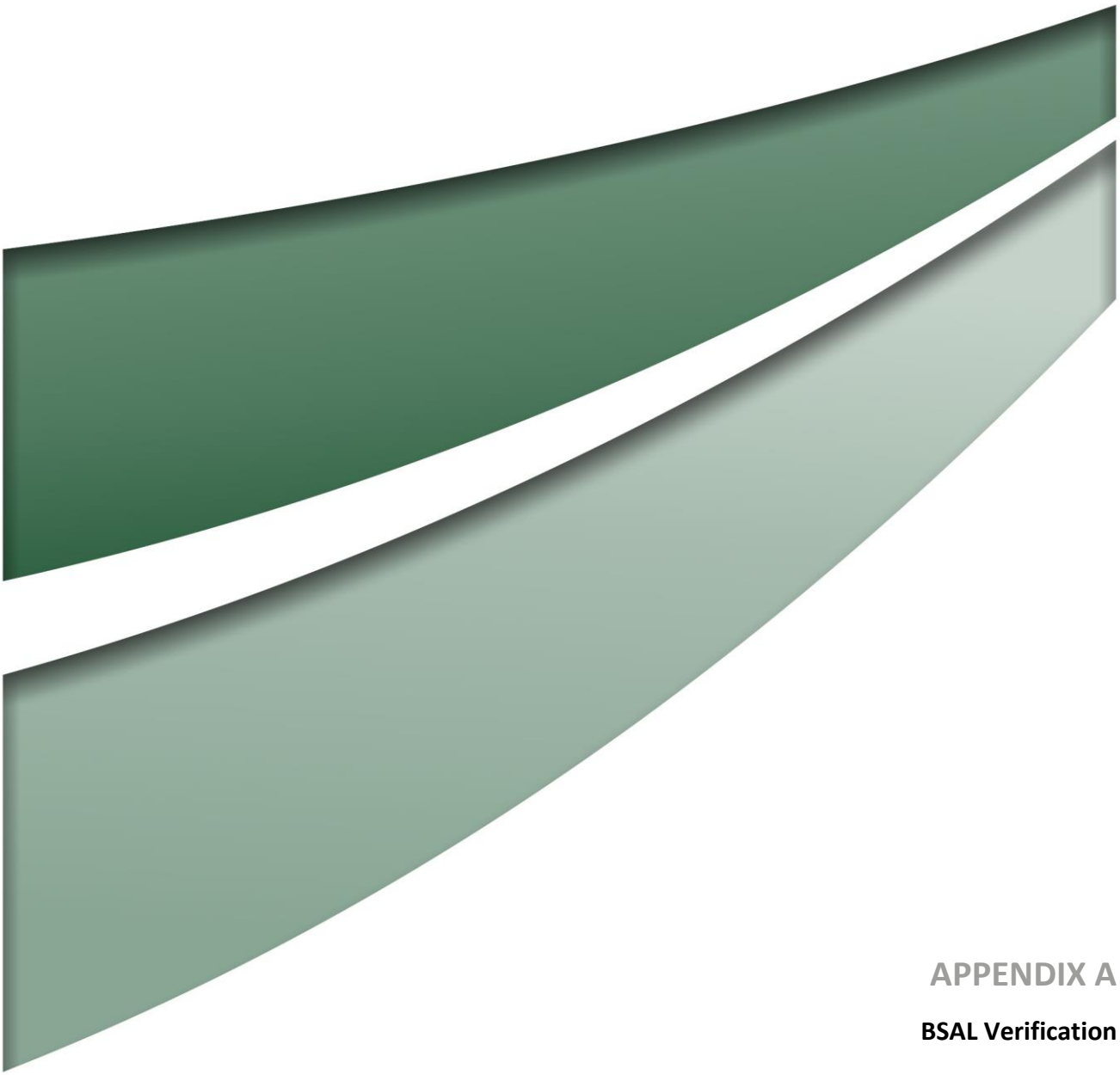
NSW Government (2013b), *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land*

NSW Office of Water (NOW) (2012), *NSW Aquifer Interference Policy, NSW Government Policy for the licensing and assessment of aquifer interference activities*

Office of Environment and Heritage (2012), *Soil and Land Capability Mapping, Upper Hunter Strategic Regional Land Use Policy*

Landcom (2004), Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition

Department of Environment and Climate Change (DECC) (2008), Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries



APPENDIX A

BSAL Verification

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GLENCORE

BIOPHYSICAL STRATEGIC AGRICULTURAL LAND VERIFICATION ASSESSMENT

Glendell Continued Operations Project

FINAL

April 2019

GLENCORE

BIOPHYSICAL STRATEGIC AGRICULTURAL LAND VERIFICATION ASSESSMENT

Glendell Continued Operations Project

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Glendell Tenements Pty Ltd

Project Director:	Bret Jenkins
Project Manager:	David Holmes
Technical Director:	Stuart Macnish
Technical Manager:	Anne Schneider
Report No.	4166/R04
Date:	April 2019

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
Final	David Holmes	15 March 2019	Bret Jenkins	03 April 2019

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1.0 Introduction

The Glendell Continued Operation Project (the Project) is a proposed extension of the open cut coal mining operations at Glendell Mine, which is part of the Mount Owen Complex (MOC) owned by Glencore and its Joint Venture partners. The MOC is located in the Upper Hunter Valley near Muswellbrook in New South Wales (NSW) (refer to **Figure 1.1**).

Biophysical Strategic Agricultural Land (BSAL) is land with a combination of soil properties and water resources that enable sustained cropping or improved pasture uses, without significant degradation. Generally, BSAL falls into Land and Soil Capability Classes (LSC) 1, 2 and 3. The Office of Environment and Heritage (OEH) has mapped BSAL at the regional scale for the Upper Hunter Strategic Regional Land Use Policy (SRLUP). This mapping was done at a regional scale and not at a property boundary level. OEH mapping of BSAL in the vicinity of the verification area is shown in **Figure 1.2**. Areas of the Bowmans Creek floodplain and a smaller area associated with Swamp Creek have been mapped as BSAL in the SRLUP, as shown in **Figure 1.2**.

The *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (NSW Government, 2013) (Interim Protocol) provides a guideline for the assessment of BSAL. This Report has been prepared in accordance with the Interim Protocol, to assess the presence of BSAL in areas of the Glendell Continued Operations Project Area (Project Area) that are potentially subject to the requirement for a Gateway Certificate under clause 50A of the *Environmental Planning and Assessment Regulation 2000*. This area is referred to as the Verification Area in this Report.

1.1 Verification Area

The Verification Area is the areas that are potentially impacted by components of the Project but are not subject to a relevant mining lease issued under the *Mining Act 1992* (and where mining lease/s may be required). The location of mining leases in and around the Project Area are shown in **Figure 1.3.** A number of tenements are located within the Verification Area, namely CCL 708, EL 6594, EL 8184 and ML 1629. The only current mining lease applying to the surface of this area is ML 1629 which is for mining purposes only and does not authorise the mining of coal in this area. Underlying ML 1692 is CCL 708 which permits the extraction of coal but excludes the surface; therefore a new mining authority will be required for the depth of surface exception to enable mining in the areas covered by ML 1629, as well as areas covered by EL 8184 and EL 6594. The Verification Area is shown in **Figure 1.4** and comprises a total area of approximately 700 hectares (ha).

Additional areas of the Project are located within areas where existing mining leases are held in relation to the land to be mined/directly impacted by the Project; these Project areas located within mining leases are not subject to the requirements of clause 50A of the EP&A Regulation and are therefore not subject to the gateway process or a requirement to verify the location of BSAL.

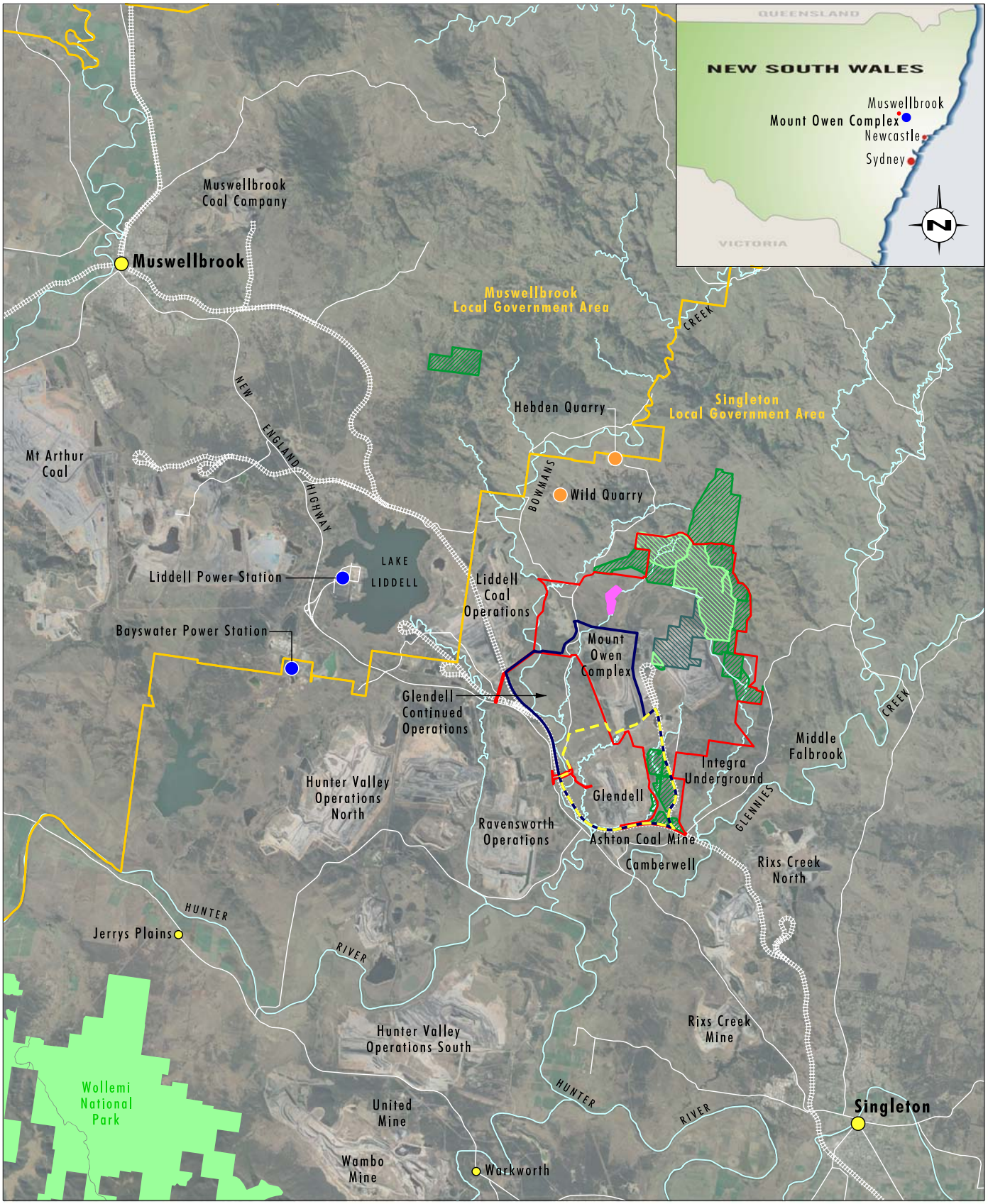

Image Source: Google Earth (Sep 2018)
Data Source: Glencore (2019), OEH (2013), Forest Corporation of NSW (2013)

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Legend

- Mount Owen Consent Boundary
- Project Area
- Glendell Consent Boundary (Current)
- Local Government Area Boundary
- Existing Mount Owen Complex Biodiversity Offset Area
- Ravensworth State Forest
- Ravensworth State Forest within Mount Owen Continued Operations Operational Area
- Yorks Creek Voluntary Conservation Area
- National Park
- Road
- Railway
- Drainage Line
- Towns
- Power Stations
- Quarry

FIGURE 1.1

Regional Locality Plan

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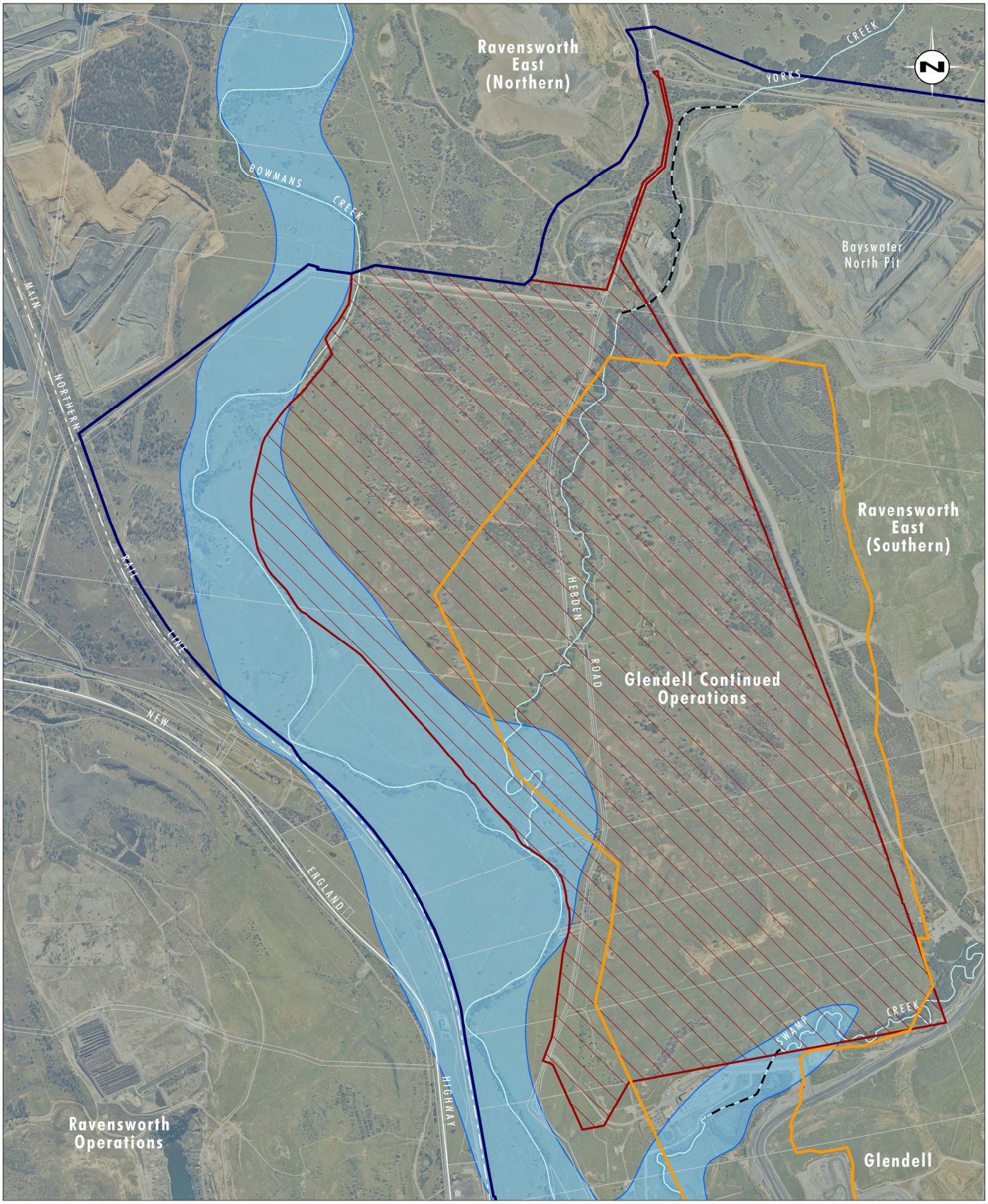

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), NSW Department of Planning and Infrastructure (2013)

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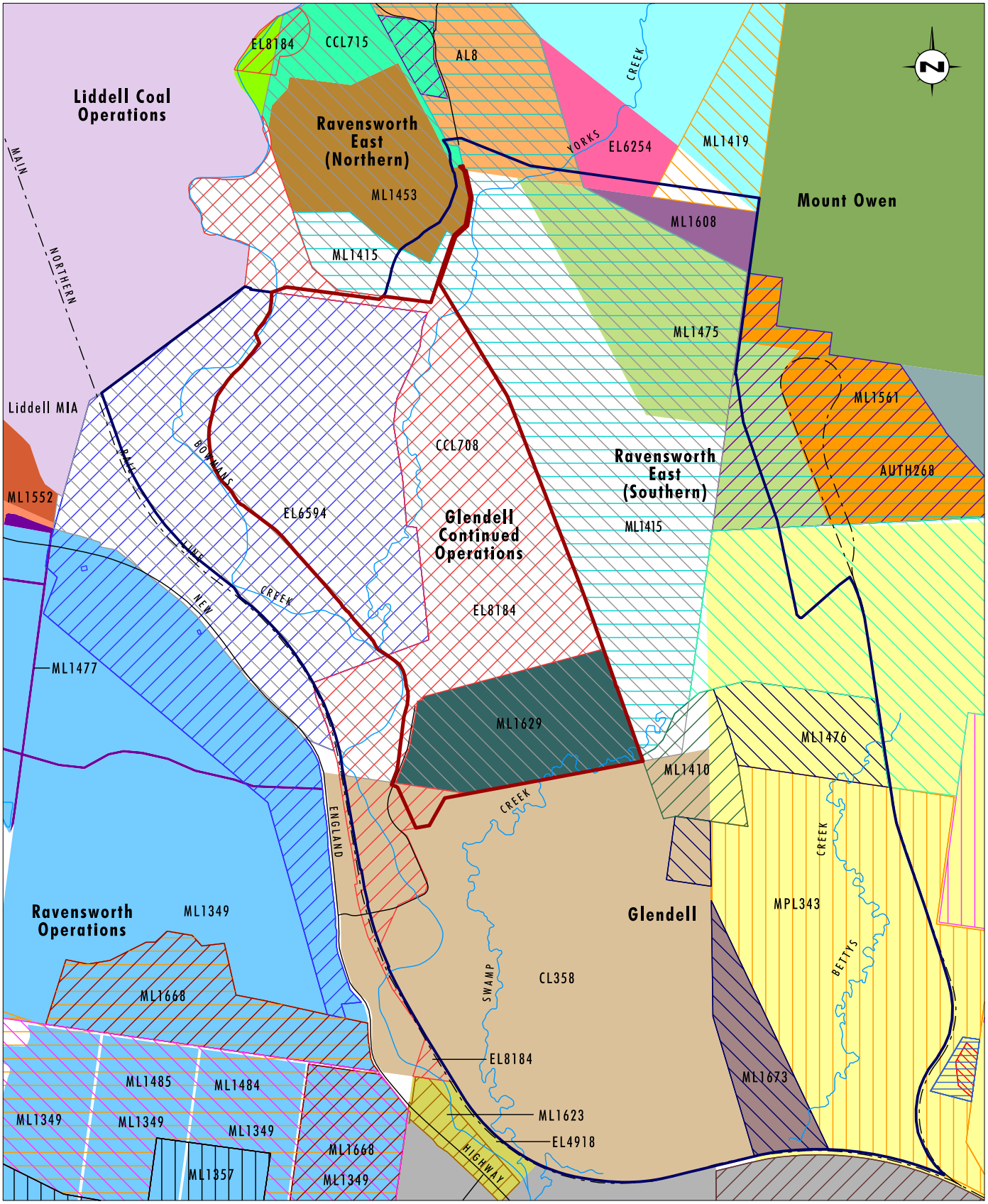
Legend

- Project Area
- Proposed Glendell Pit Extension
- Verification Area
- Mapped BSAL (Upper Hunter SRLUP, 2013)
- Existing Creek Diversion

FIGURE 1.2

Potential Biophysical Strategic Agricultural Land Hunter SRLUP Mapping

File Name (A4): R04/4166_020.dgn
20190129 9.15



Data Source: Glencore (2018), Minview (2018)

0 0.5 1.0 2.0km
1:40 000

Legend

Project Area	CL358	ML1398	ML1485	ML1629/ELA5736
Verification Area	CL382	ML1410	ML1525	ML1668
AL8	CL383	ML1415	ML1529	ML1673
AUTH268	CCL708	ML1419	ML1533	ML1676
AUTH423	CCL715	ML1453	ML1552	ML1694
EL4918	ML1313	ML1475	ML1561	MPL343
EL6254	ML1349	ML1476	ML1597	
EL6594	ML1355	ML1477	ML1608	
EL8184	ML1357	ML1484	ML1623	

FIGURE 1.3

Mining Lease Authorities in the Project Area

File Name (A4): R02/4166_064.dgn
20190403 16.19

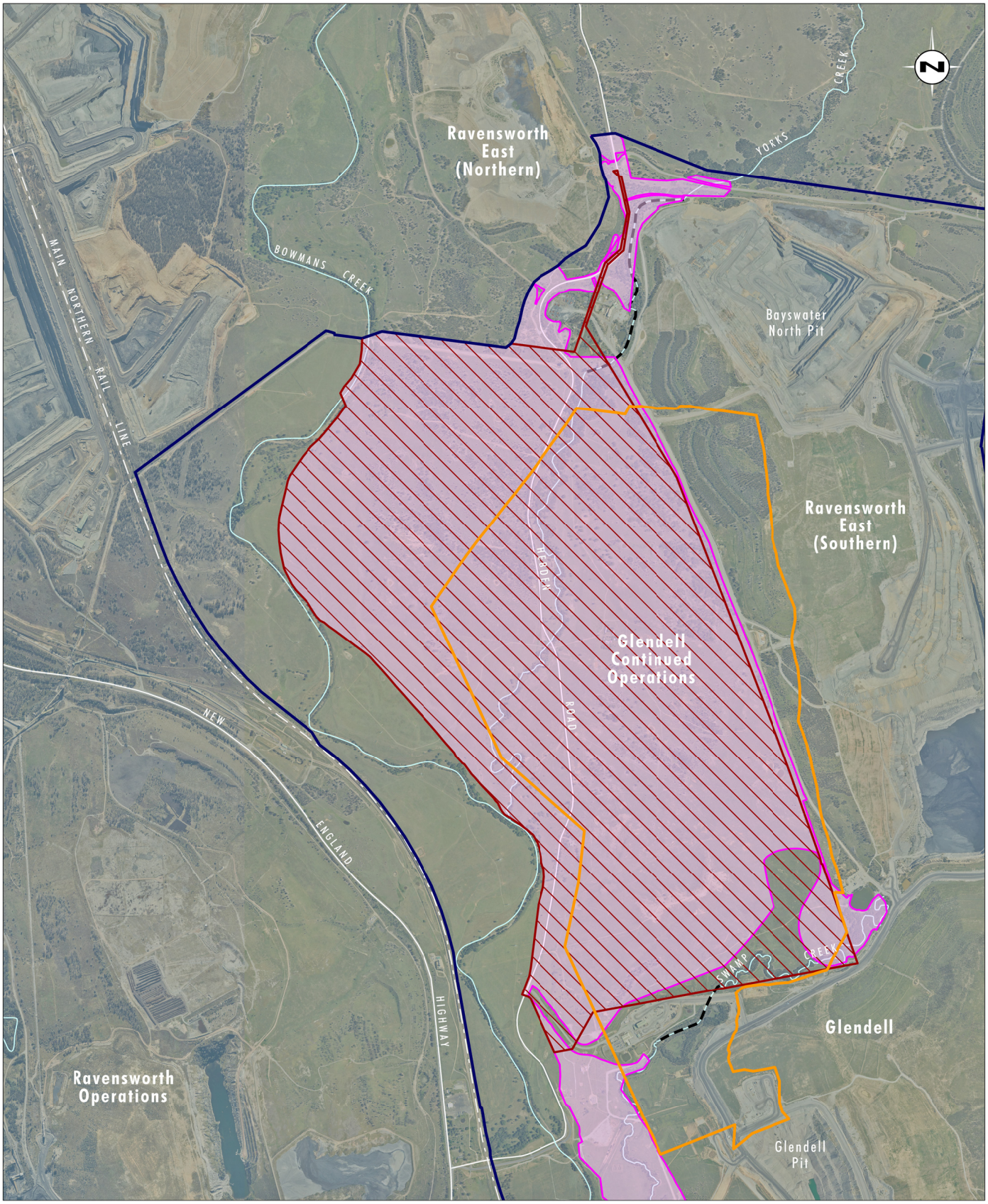


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 0.5 1.0 1.5km
1:30 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Additional Disturbance Area
- Verification Area
- Existing Creek Diversion

FIGURE 1.4

Verification Area

1.2 Report Structure

The Interim Protocol requires detailed soil sampling and testing to provide further evidence about soil quality and constraints affecting the soil materials in the Verification Area (NSW Government, 2013). This report provides evidence of the soil types and an assessment of the presence of BSAL in the Verification Area, in accordance with the requirements of the Interim Protocol.

Section 2.0 outlines the Interim Protocol assessment requirements for the BSAL verification process.

Section 3.0 details the assessment methodology undertaken for the BSAL assessment.

Section 4.0 details the results of the soils assessments undertaken for the verification assessment.

Section 5.0 contains the BSAL assessment findings for the Verification Area.

Section 6.0 summarises the findings of the assessment.

2.0 Interim Protocol Requirements

The Verification Area excludes areas within the Project Area where existing mining leases are in place that will enable mining activities associated with the Project that require a mining lease to occur. As shown in **Figure 1.3**, the Verification Area is located on parts of EL 6594, EL 8184 and ML 1629. In accordance with the Mining SEPP, ML 1597 to the north-west and CL 358 to the south are excluded from the site verification. CCL 708 covers the verification area however this mining lease excludes the surface in the Verification Area and therefore a new mining lease will be required over parts of this area for the Project to occur.

2.1 BSAL Assessment Process and Area

The assessment process described in this section follows the Interim Protocol.

As the purpose of the BSAL Verification Process is to identify land with a combination of soil properties and water resources that enable sustained cropping or improved pasture uses. The entire area covered by the Upper Hunter SRLUP is regarded as having access to a reliable water supply. The Interim Protocol assessment process for identifying appropriate soil properties for BSAL is provided in **Figure 2.1.** As noted in **Figure 2.2** should any of the criteria not be satisfied then the land is not considered to be BSAL. The criteria set out in **Figure 2.1**are addressed in this report.

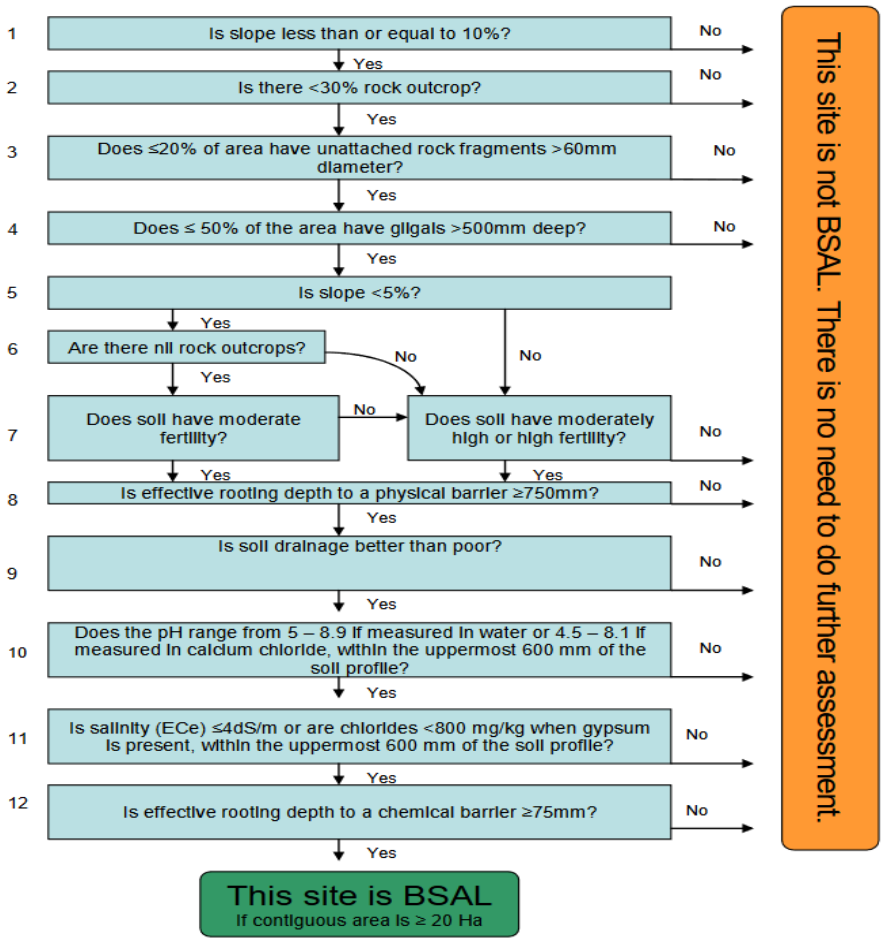


Figure 2.1 BSAL assessment process as per the Interim Protocol

Reproduced from NSW Government 2013

2.2 Mapping Approach

The Interim Protocol requires that the assessment should be conducted for the entire Verification Area. Where BSAL within the Verification Area is part of a larger contiguous mass of BSAL, the boundary of the larger area must be also identified.

The Interim Protocol provides the following inclusions and exclusions from the Verification Area sampling and assessment area:

- *The verification process, following Section 6 of the Interim Protocol (on-site soil assessment), must be conducted across all parts of the Verification Area to which the proponent has access, subject to the exclusions noted below*.

- *Areas to which the proponent has access but are not used for agriculture (such as heavily forested areas) may be excluded from the sampling area. The BSAL status of these areas is assessed using information from adjacent areas, and the similarity of underlying geology, terrain and previous regional mapping*.

Mount Owen has access to the entire Verification Area and the area is currently grazed. There are limited areas of native vegetation along both Bowmans and Yorks Creeks, which have been avoided in relation to detailed soil sampling. In addition, an archaeological due diligence survey was carried out prior to commencing the detailed soil sampling process with the aim to exclude disturbance through soil pits to areas identified as Aboriginal archaeological sites. In accordance with the Interim Protocol, the BSAL status of these areas within the Verification Area has been assessed utilising the detailed information from the areas immediately adjacent to these excluded areas.

2.3 Slope Analysis

In accordance with the Interim Protocol land that is greater than or equal to 10% slope are not considered to be BSAL. An analysis of slope across the Verification Area has been completed and identified approximately 113 ha with a slope greater than or equal to 10% (**Figure 2.2**). The slope analysis was undertaken using a digital terrain model created from LiDAR data collected in 2017. The areas identified as having slope >10% are excluded from further detailed assessment consistent with Step 1 of the BSAL assessment process (refer to **Figure 2.2**).

2.4 Risk Assessment

The Interim Protocol refers to a risk assessment process to provide guidance on the appropriate sampling density. Appendix 3 of the Interim Protocol notes that sampling densities should be linked to risk:

- *Sampling density 1 site per 25 to 400 ha for low risk to agriculture.*

- *Sampling density 1 site per 5 to 25 ha for high risk to agriculture*.

The risk criteria in Appendix 3 of the Interim Protocol are drawn from the Guideline for Agricultural Impact Statements (NSW Government, 2015), and were not originally intended for risks to BSAL. It refers to 'agricultural resources or industries' not to the best quality agricultural resources which are included in BSAL. However, if the criteria identified in Tables 7, 8 and 9 of Appendix 3 of the Interim Protocol are applied as written, the consequence of the proposed mining activities in the Verification Area would fit the 'severe consequence' description and the likelihood is 'almost certain'. This would lead to an assessment of 'high risk'.

Based on this risk analysis, a sampling density of approximately 1 site per 10 - 13 ha has been applied to the survey design within the Verification Area. This conforms to the high risk density requirement of 1 site per 5 - 25 ha and is consistent with recent BSAL assessments carried out by Umwelt (Australia) Pty Limited (Umwelt) in the MOC (Umwelt 2015, 2016, 2017).

2.5 BSAL Assessment Criteria

The assessment criteria can be broken up into two parts, as shown on **Figure 2.1**:

1. soil physical and landscape verification criteria – Criteria 1-9 and

2. soil chemical verification criteria – Criteria 10-12.

Details of the soil descriptions and sampling methodology are detailed in **Section 4.0**, and the full results of the BSAL assessment within the Verification Area are provided in **Section 5.0**.

2.6 Interim Protocol Checklist

The BSAL assessment has been undertaken in accordance with the Interim Protocol and other relevant guidelines. **Table 2.1** provides the Interim Protocol checklist and references to the relevant sections of the report.

Table 2.1 Interim Protocol Checklist (Chapter 12 of the Interim Protocol)

Checklist Item	Addressed in Section
A qualified soil scientist is overseeing the verification assessment and has signed off on the quality and extent of the work.	**Appendix D**
Laboratories for soil samples are compliant with AS ISO/IEC17025	**Appendix C**
Results within 15 per cent of threshold levels are analysed in a laboratory.	**Appendix C**
All soil profile descriptions and observations are recorded and submitted to SALIS.	**N/A** All profile descriptions have been uploaded to SALIS.
Laboratory data is supplied to OEH using their standard spreadsheet templates	**N/A** Laboratory data has been supplied to OEH in standard Spreadsheet
Three 1:25 000 maps showing: base level information; soil types and BSAL;	**Section 4 and Section 5**
GIS output files, and metadata statements	**N/A** All spatial files and metadata have been supplied.
Laboratory report	**Appendix C**

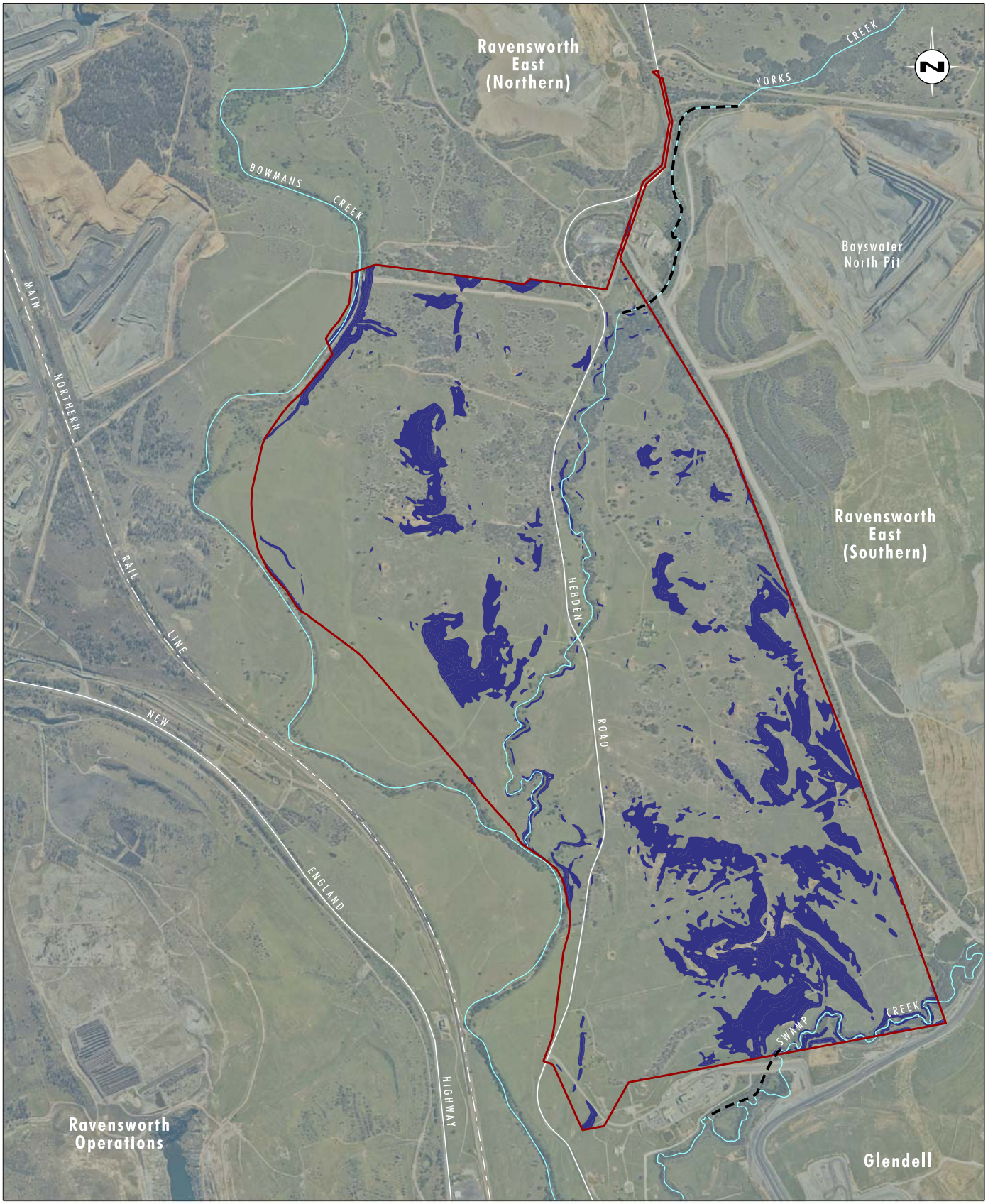


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2017 & 2019)

0 0.25 0.5 1.0km
1:25 000

Legend
- Verification Area
- Slope ≥10%
- Existing Creek Diversion

FIGURE 2.2

Soil Sampling Exclusion Area within Verification Area due to Slopes ≥10%

File Name (A4): R04/4166_021.dgn
20190403 16.24

3.0 Assessment Methodology

This section describes the methodology used for the BSAL assessment, including field assessment (soil description, soil sampling) methodology and laboratory analysis.

3.1 Field assessment

3.1.1 Soil Survey Design

The Verification Area has an area of approximately 700 ha. Approximately 113 ha within the Verification Area have slopes greater than or equal to 10% (refer to **Section 2.3**), which were excluded from further on the ground assessment.

Based on the size of the Verification Area and the Interim Protocol requirements a survey density of approximately 1 site per 10 - 13 ha has been implemented.

Umwelt has in the past undertaken BSAL assessments in the MOC (Umwelt 2015, 2016, 2017) and identified one major soil type (Sodosol) and three minor soil types (Kurosol, Rudosol and Chromosol). A soil survey for the adjacent Liddell Coal Operation additionally mapped Dermosol (GSSE, 2013). These results confirm earlier soil survey work undertaken for environmental assessment processes associated with the Mount Owen, Ravensworth East, Glendell and Liddell mines over the past 30 - 40 years.

The Interim Protocol requires a minimum of three detailed soil sampling sites for each soil type (NSW Government, 2013). Based on the initial data review, which has included geology information, publically available soil data as well as the aforementioned studies by Umwelt and GSSE, the occurrence of six soil types was anticipated. Survey sites were selected to provide representative coverage of the Verification Area and to address soil variability across the site based on existing slope, soils and vegetation information. Further, findings from the Archaeological Due Diligence resulted in a relocation of some survey sites and prevented locating detailed sites in some areas.

Initially, 37 sites were assessed and an area of BSAL was identified with another 20 sites subsequently surveyed to provide a higher degree of certainty of the location and extent of BSAL. The Verification Area was modified after the survey was carried out as a result of further Project definition. These changes reduced the area of potential impact in areas previously mapped as being BSAL in the Upper Hunter SRLUP. As a result of the changes in the Verification Area, some sites sampled are located outside the Verification Area. These sites are still included in this report as they provide further information about the area.

3.1.2 Detailed Sites

In the initial survey (carried out between 16 and 25 August 2017), 18 detailed sites were excavated using a backhoe (GN2 - GN18, GN32, GN39). In the follow up surveys (11 to 13 October 2017 and 18 to 22 December 2017), another eight detailed soil pits were excavated (GN66-GN71, GN73, GN75, GN80) (**Figure 3.1**)**.** Soil pits were excavated to at least 750 mm in depth, or less, where bedrock was encountered at a shallower depth. Photos of the soil profile and the landscape context (ground cover, vegetation community) for each of the sites were taken.

Soil descriptions were recorded for the full depth of the excavated profile and all descriptions follow the Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain 2009).

In accordance with the Interim Protocol the following information was recorded:

- site ID and GPS coordinates
- general site condition, including run-on, run-off, surface condition, ground cover, evidence of erosion
- layer status, depth and boundary conditions
- colour and mottles (Munsell)
- bedrock type (where evident)
- texture
- pH (Raupach)
- structure and fabric
- consistence
- presence of coarse fragments
- presence of roots and
- evidence of drainage condition.

Slopes were recorded with a hand-held clinometer and were rounded to the nearest whole number as per the Interim Protocol.

3.1.3 Check Sites

In the initial survey, 19 check sites were surveyed (GN20-GN31, GN33- GN38, GN40) and 12 further check sites (GN64, GN65, GN70, GN72, GN74, GN77-GN79, GN81-GN83) were assessed in the follow-up survey (**Figure 3.1**).

All check sites, apart from GN81-GN83, were excavated with a backhoe to either 500 mm depth or until the B horizon, whichever occurred first. Sites GN81-GN83 were surveyed with a hand-held auger to either 500 mm depth or until the B horizon, whichever occurred first. GPS coordinates, soil profile and landscape photos were taken for all sites. Additionally, the following attributes were recorded on most check sites:

- layer status, depth and boundary conditions
- colour and mottles (Munsell)
- texture
- pH (Raupach) and
- presence of coarse fragments.

GN64, GN70, GN72, GN74, GN77, GN78 were assessed through a full pit profile description. However, as they were not analysed in the laboratory these are reported as check sites.

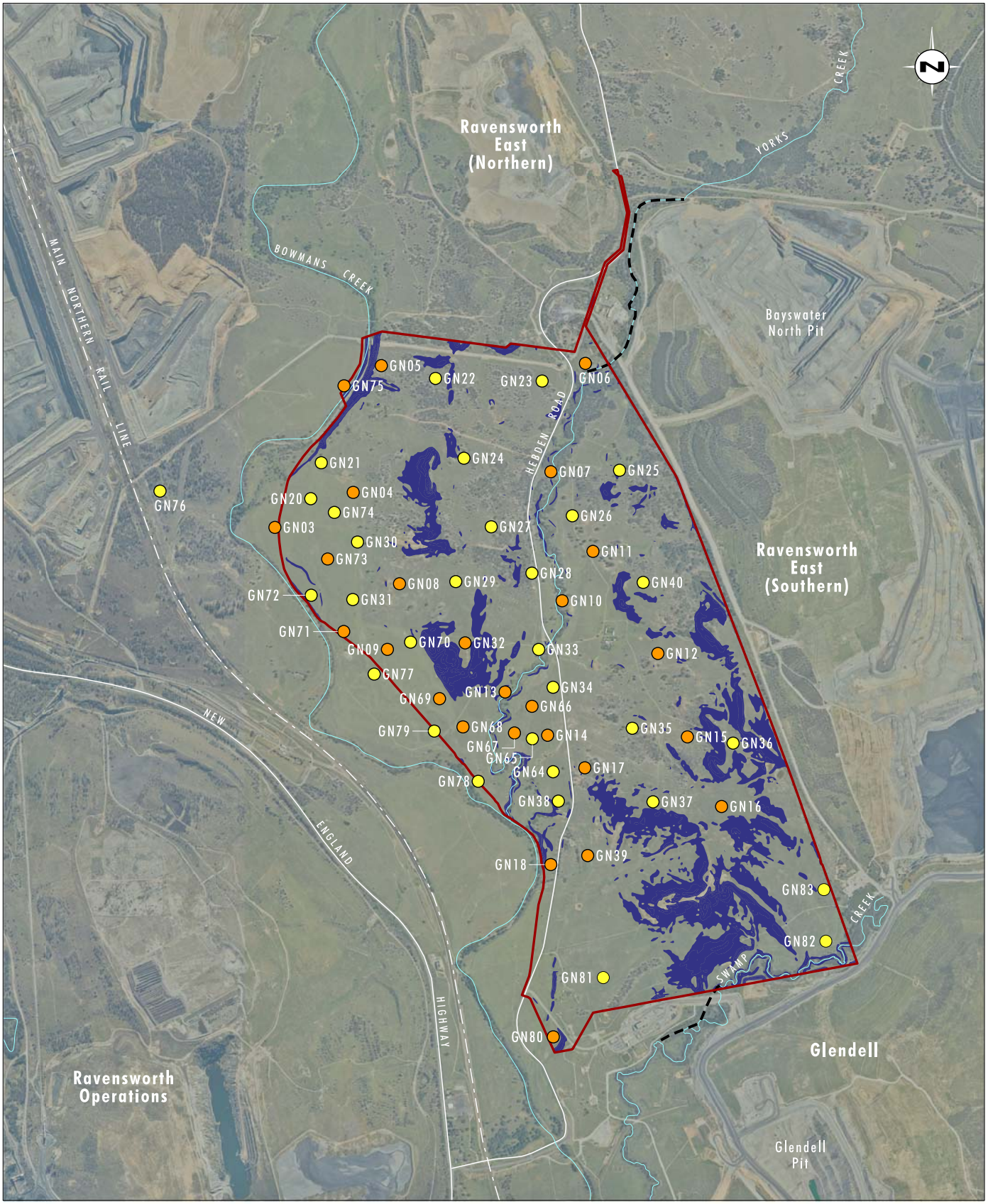


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2017 & 2019)

0 0.5 1.0 1.5km
1:30 000

Legend

- Verification Area
- Slope ≥10%
- Soil Sampling Sites - Check Sites
- Soil Sampling Sites - Detailed Sites
- Existing Creek Diversion

FIGURE 3.1

Soil Survey Locations

3.1.4 Soil Sampling

Soil sampling was undertaken for all detailed sites. Soil sampling depths were based on the recommended sampling depths of the Interim Protocol. These depths are:

- 0 - 50 mm
- 50 - 150 mm
- 250 - 300 mm
- 300 - 600 mm
- 600 - 1000 mm

Samples must be obtained entirely within a single soil horizon and be identified by soil profile layer, as well as by depth in line with the protocol. For the soils in this Verification Area where horizon boundaries did not conform with the Interim Protocol sampling depths requirements, soil sampling was amended to ensure that samples were taken entirely from within a discrete soil horizon.

3.2 Laboratory Testing

Laboratory testing was conducted to provide data for the following parameters related to fertility and chemical barriers in the profile:

- salinity (EC and ECe)
- pH
- cation exchange capacity (CEC) and Exchangeable Cations (Calcium, Magnesium, Potassium, Sodium)
- exchangeable sodium percentage (ESP) and
- Ca:Mg ratio.

The samples were analysed by a NATA and ASPAC accredited laboratory.

4.0 Results

4.1 Soil Profile Descriptions

The soil survey found six soil orders present within the Verification Area:

- Chromosol
- Dermosol
- Kandosol
- Rudosol
- Tenosol and
- Sodosol.

Each soil order will be discussed below and detailed soil survey descriptions are presented in **Appendix A.** Soil profile classifications for the detailed sites and check sites are presented in **Tables 4.7** and **4.8** respectively.

In addition, soil profile descriptions of soil materials present have been entered into the NSW Soil and Land Information System (SALIS) database.

4.1.1 Sodosol

Brown, Red, Yellow, Grey or Black Sodosols, either Mesonatric or Subnatric, occur on the hillslope and footslope of the rolling hills (**Plates 4.1** and **4.2**). This ASC Order is associated with sandstone or mudstone bedrock or deposited material derived from this geology.

Sodosols are the dominant ASC Order of the Verification Area, making up approximately 87% of the Verification Area. Detailed sites which have been classed as a Sodosol are GN5, GN7, GN8, GN12, GN14, GN16, GN18, GN39, GN66, GN68 and GN80. Check sites in the same ASC Order are GN22, GN23, GN24, GN25, GN27, GN28, GN29, GN30, GN36, GN38, GN40, GN64, GN65, GN70, GN74, GN76, GN78 and GN81.

Sandstone rock outcrop and surface rocks are scattered throughout the hillslopes, however the densities of these are low and occurrences are random (**Plates 4.3** and **4.4**). Rock outcrops are predominantly flat.

Sodosols in the Verification Area commonly had A horizons with a Silty or Sandy Loam to Silty or Sandy Clay Loam texture overlying a B2 horizon with a Light Medium to Medium Heavy Clay texture. Many of the surveyed Sodosols showed a conspicuously bleached A2 horizon and sub-rounded, medium pebbles were often present in this horizon. The structure of the A horizon typically ranged from apedal massive to moderate sub-angular blocky while the structure of the B horizon generally was moderate to strong sub-angular to angular blocky. Some profiles showed columnar and prismatic structures, breaking to angular blocky. Mottling of the B horizon was frequently observed.

Plate 4.1 GN70, footslope, looking south

Plate 4.2 GN39, midslope, looking south

Plate 4.3 Surface rock at GN39

Plate 4.4 Rock outcrop near GN17

This ASC Order has severe limitations for agricultural use due to its dispersion risk and gully erosion is observed within the Verification Area on the midslopes as well as the footslopes (**Plate 4.5**). Further, bleached A2 horizons and mottling of B horizons were present at many sites, indicating additional limitations to agriculture through imperfect drainage and water logging.

Plate 4.5 Gully erosion in Yorks Creek floodplain

As an example for a Sodosol in the Verification Area, the detailed profile description of GN12 is presented in **Table 4.1,** with the GN12 soil profile and landscape setting shown in **Plates 4.6** and **4.7** respectively**.**

Table 4.1 Soil Profile Description – GN12

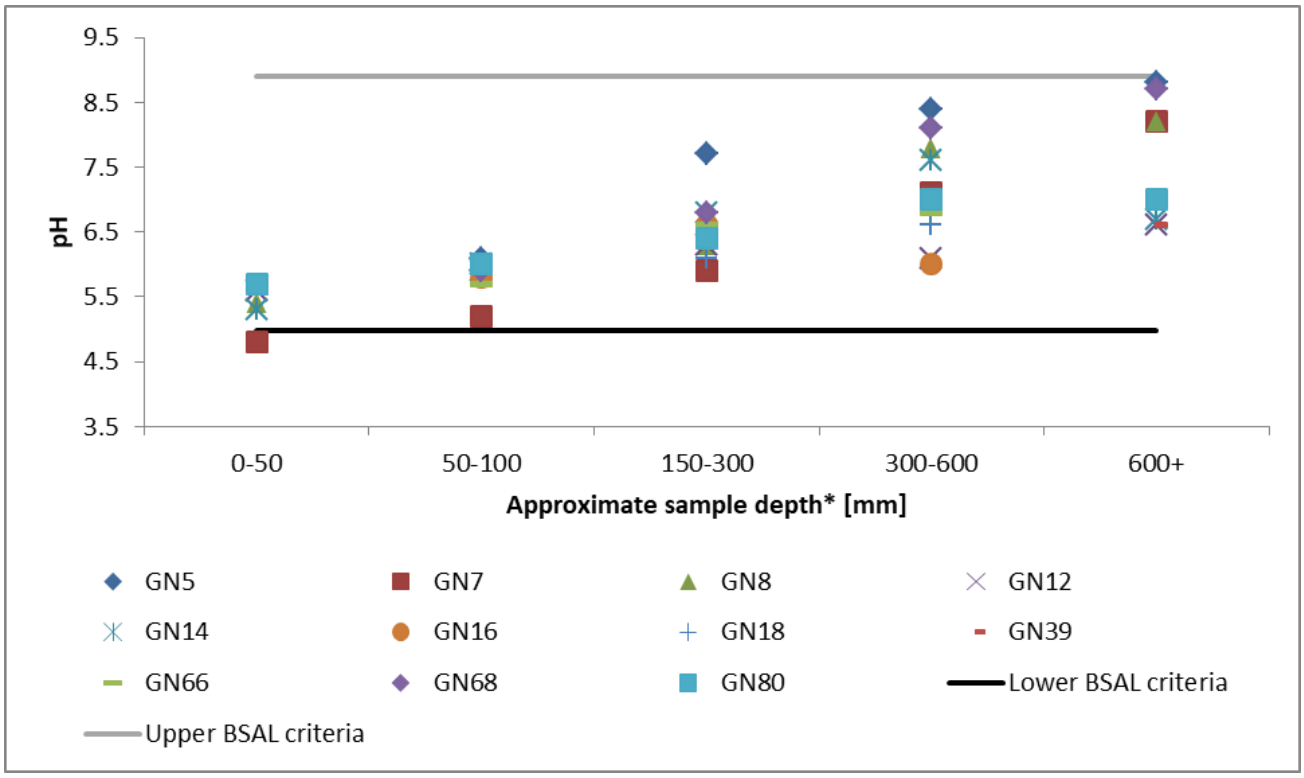
GN12	**Datum: GDA 94 Zone 56** **Easting: 318308.87** **Northing: 6411895.18** **Recorded: 17th August 2017**
Landscape Element: Hillslope Slope: 2% Soil Surface Condition: Firm Vegetation: Derived native grassland, box ironbark Estimated effective rooting depth: 600 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol
Profile Characteristics	
A1 0-20 mm	10YR 4/3 (moderately moist) Silty Clay Loam. pH 5.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 20-100 mm	10YR 6/2 (moderately moist), 10YR 7/2 (dry) Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (10-20%), 6-20 mm sub-rounded ironstone pebbles. Abrupt boundary.
B21 100-600 mm	10YR 5/4 (moderately moist) Medium Clay. pH 6.2. Moderate pedality, rough-ped fabric, angular blocky structure, 20-50 mm. Few (2-10%), fine, distinct, orange mottles. Gradual boundary
B22 600-700 mm	10YR 5/6 (moderately moist) Sandy Light Clay. pH 6.6. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Many (20-50%), fine, distinct, orange mottles. Gradual boundary
B23 700-800 mm	10YR 4/6 (moderately moist) Light Clay. pH 7.0[1]. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Gradual boundary
C1 800+ mm	10YR 5/6 (moderately moist) Coarse Sandy Clay Loam. pH 7.0[1]. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Limit of observation.

[1] Field pH, maximum laboratory sampling depth 600-700 mm

Plate 4.6 Soil profile GN12

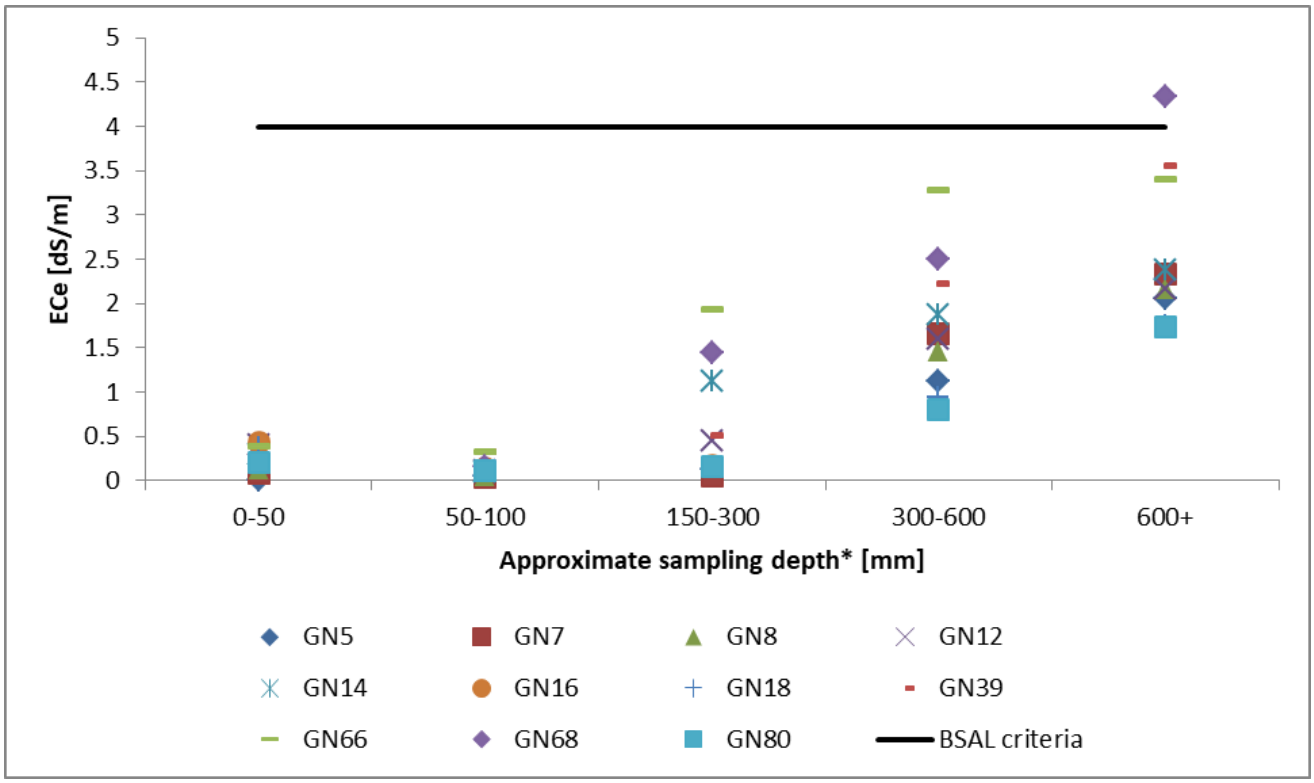
Plate 4.7 GN12, located on a lower, south facing slope

The laboratory pH for all analysed Sodosol soil samples ranged from strongly acid (pH 4.8) to moderately alkaline (pH 8.8), with pH increasing with increasing depth. A horizon pH ranged from pH 4.8 to pH 7.7, while B horizon pH was between pH 6.3 and pH 8.8 (**Figure 4.1**). The saturated paste electrical conductivity (ECe) varied between 0.05 dS/m and 4.33 dS/m (**Figure 4.2**), thus ranging from non-saline (<2 dS/m) to moderately saline. The ESP ranged from non-sodic (ESP 0.9) to highly sodic and hypernatric (ESP 35.2). With the exception of GN80, the soils displayed an increase of sodicity in the B2 horizon with depth (**Figure 4.3**). The CEC of many profiles is moderate to high, but this is most likely the result of a high sodium content, which is reflected in high ESP values (**Figures 4.3** and **4.4**).



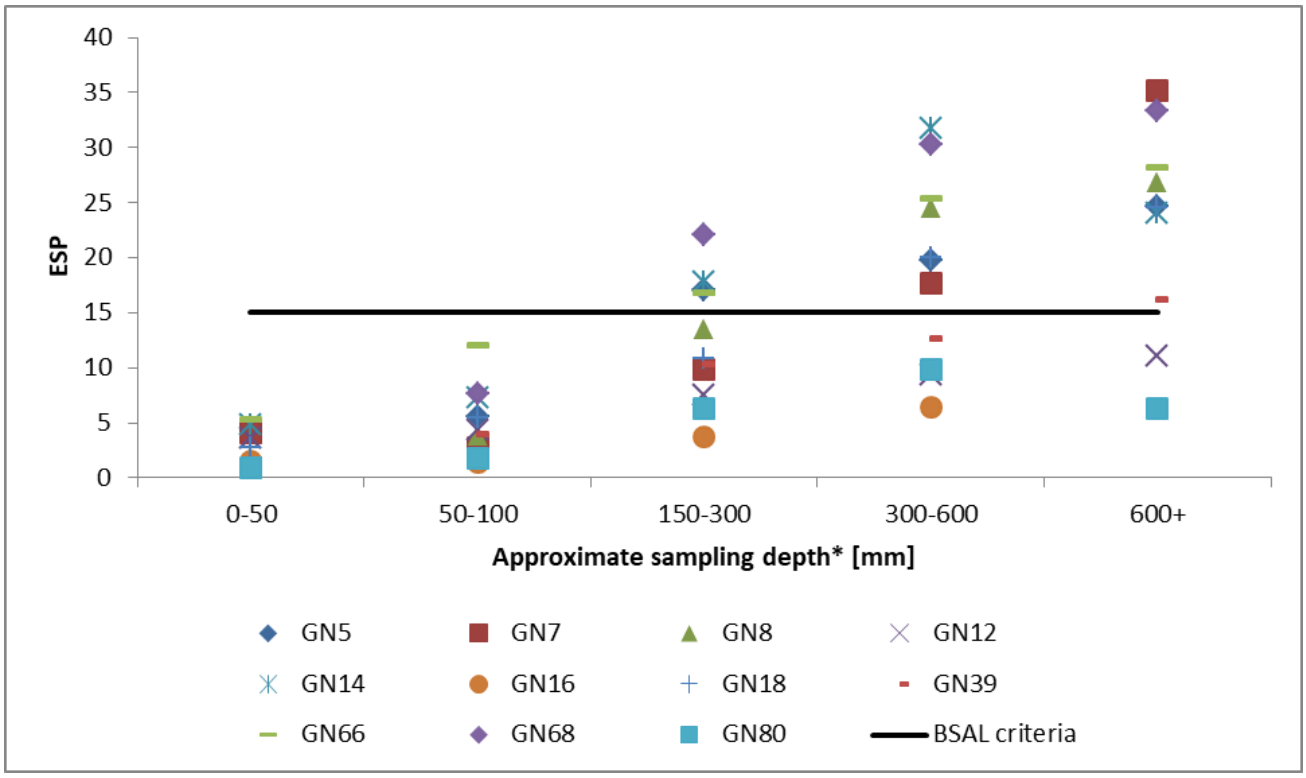
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.1 pH for sampled Sodosols



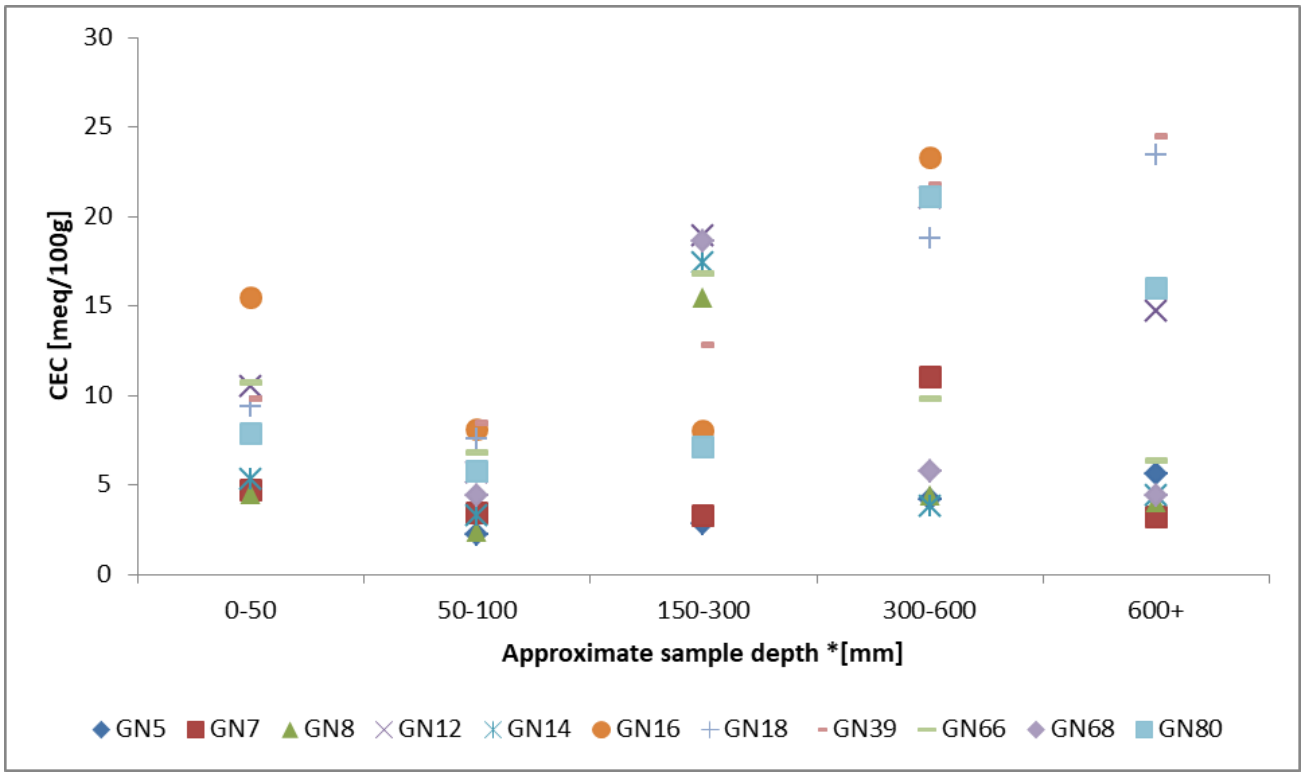
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.2 Saturated paste Electrical Conductivity (ECe) for sampled Sodosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.3 Exchangeable sodium percentage (ESP) for sampled Sodosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.4 Cation exchange capacity (CEC) for sampled Sodosols

4.1.2 Tenosol

Tenosols in the Verification Area occur as Brown-Orthic and are associated with the floodplains of Yorks, Bowmans and Swamp Creeks (**Plates 4.7** and **4.8**). Due to the lower flow capacity of Yorks and Swamp Creek, its floodplain and associated Tenosols have a relatively narrow distribution and is absent in some reaches of the creek in the Verification Area.

Plate 4.8 GN3, lower terrace, looking east towards upper terrace

Plate 4.9 GN20, upper terrace, looking west towards Bowmans Creek

During the initial survey campaign, GN3 was the only detailed site classed as a Tenosol with several check sites (GN20, GN21, GN21, GN33, GN37) identifying this ASC Order. In the follow up survey, sites GN70 to GN75 were selected with the aim to detect further Tenosols and thus to collect more information linked to this ASC Order. However, only GN72, GN73 and GN75 were identified as Tenosols. The total area of this ASC Order is approximately 35 ha or 5% of the Verification Area.

GN3 and GN72 are located on a lower terrace, with a band of large pebbles occurring at 650 mm and 800 mm, respectively. The textures of the sites on the lower terrace were Sandy Clay Loams, Sandy Loams and Sand. On the upper terrace (GN20, GN21, GN21, GN33, GN37, GN73, GN75) Sandy to Silty Clay Loams were the dominant soil textures. Soil structures were mainly apedal to weak sub-angular blocky. Aside from the mentioned band of large pebbles, very few coarse fragments were present in the profiles.

The coarse fragments recorded on the lower floodplain terrace, restrict root growth and thus are an impediment to agriculture. Further, the risk of frequent flooding on this lower landscape poses a limitation to agriculture as well.

Tenosols on the upper floodplain terrace may be well suited for agriculture, but likely require fertiliser input.

Tenosols associated with Yorks Creek and Swamp Creek, are narrow and have a high flood risk as well.

Table 4.2 shows the profile description of GN75, with **Plate 4.10** and **4.11** presenting the soil profile and associated landscape.

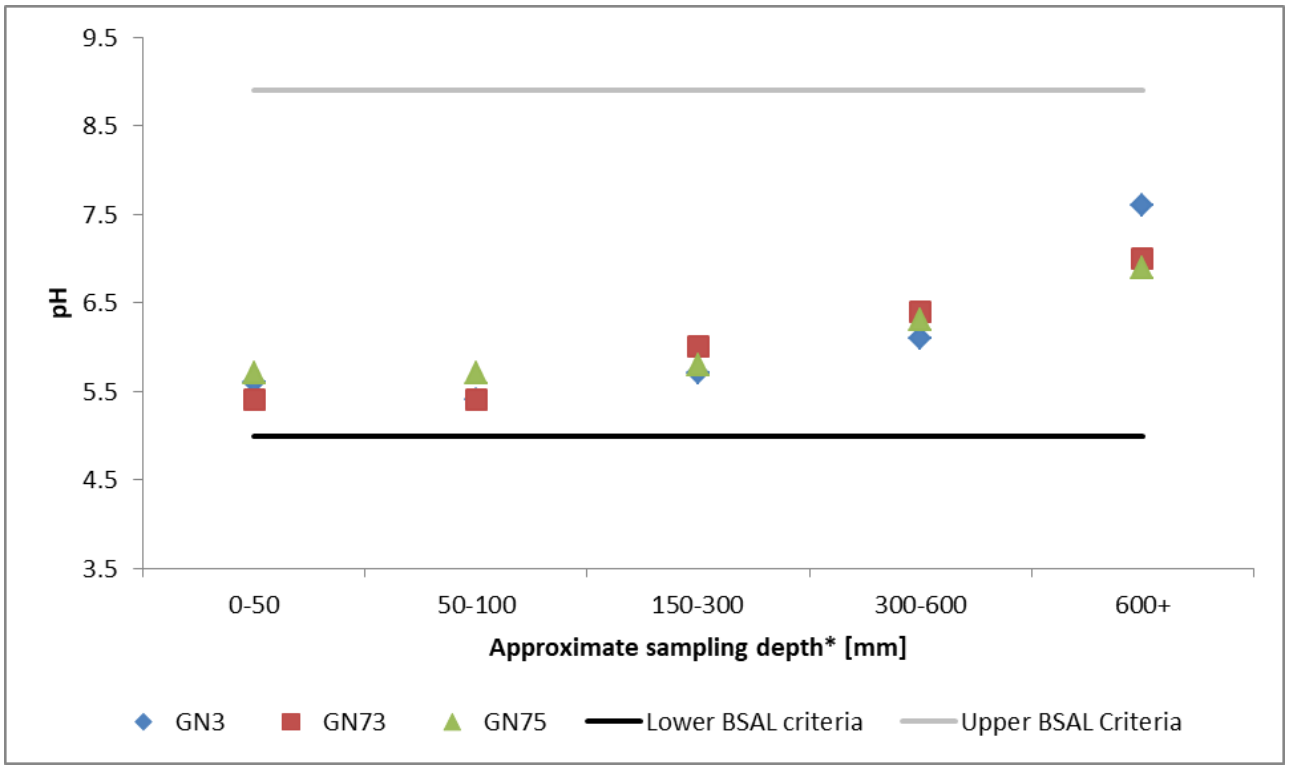
Table 4.2 Soil Profile Description – GN75

GN75	**Datum: GDA 94 Zone 56** **Easting: 316554.43** **Northing: 6413391.67** **Recorded: 21st December 2017**
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 900 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown-Orthic Tenosol
Profile Characteristics	
A1 0-100 mm	10YR 4/3 (moderately moist) Silty Clay Loam. pH 5.7. Moderate pedality, rough-ped fabric, granular structure, 10-20 breaking to 2-5 mm. Clear boundary.
B21 100-350 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 5.8. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary.
B22 350-600 mm	7.5YR 3/4 (moderately moist) Sandy Clay Loam. pH 6.3. Weak pedality, rough-ped fabric, sub-angular blocky, 2-5 mm. Clear boundary.
2D 850^{+} mm	10YR 2.5/3 (moderately moist) Light Clay Coarse Sandy. pH 6.9. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Limit of observation.

Plate 4.10 Soil profile description GN75

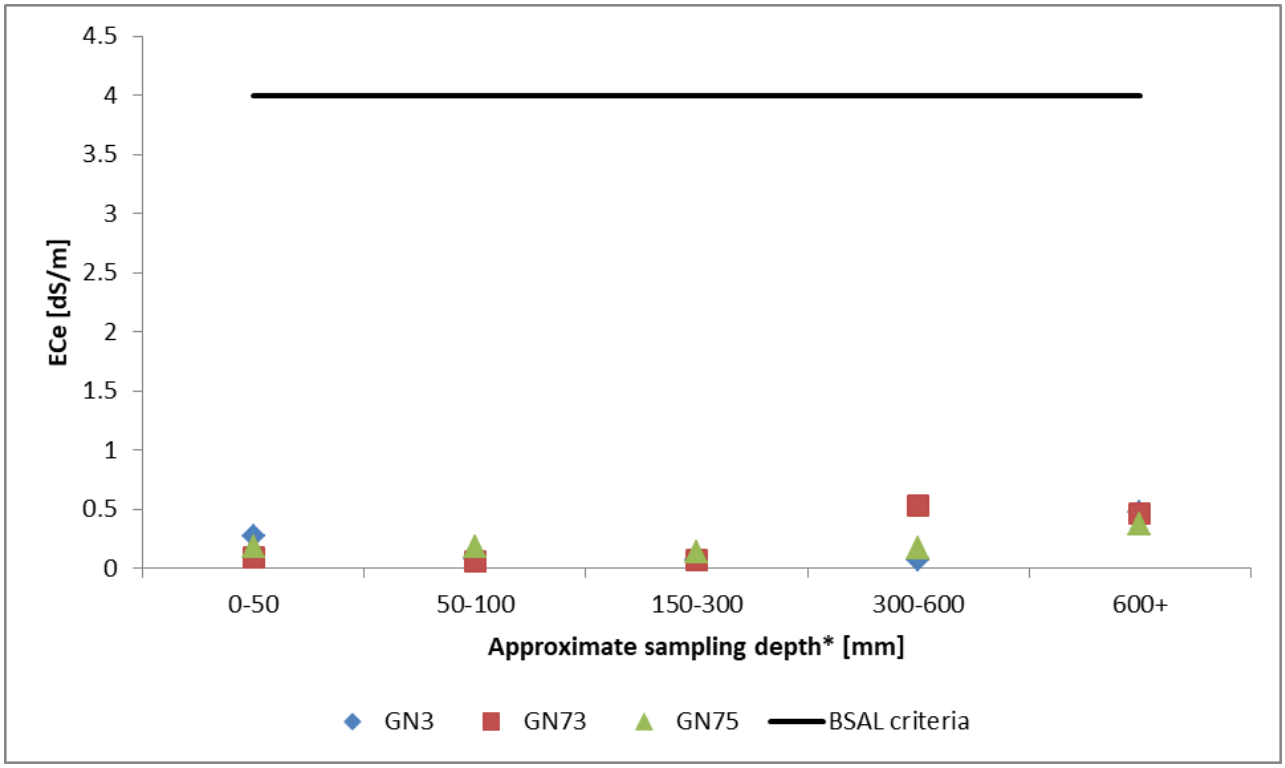
Plate 4.11 GN75, looking north

The A horizon pH of sampled Tenosols ranged from pH 5.4 (strongly acid) to 5.7 (moderately acid). In the B horizon, recorded pH varied from pH 5.4 to 7.6 (slightly alkaline). For all profiles the pH increased with depth (**Figure 4.5**). The Tenosols in the Verification Area are non-saline; GN3 and GN75 are also non-sodic throughout the profile (**Figures 4.6** and **4.7**, respectively). The sodicity of GN73 however, increases with depth and below 300 mm the profile is sodic (**Figure 4.7**). The measured CEC for all three profiles was low to moderate in the upper 300 mm. Thereafter, the CEC of GN75 remained moderate, GN3 decreased to low, whereas GN73 had a high CEC (>15) (**Figure 4.8**). The high CEC of GN73 is most likely due to a high amount of sodium in the profiles, which is reflected in the sites elevated ESP (**Figure 4.7**).



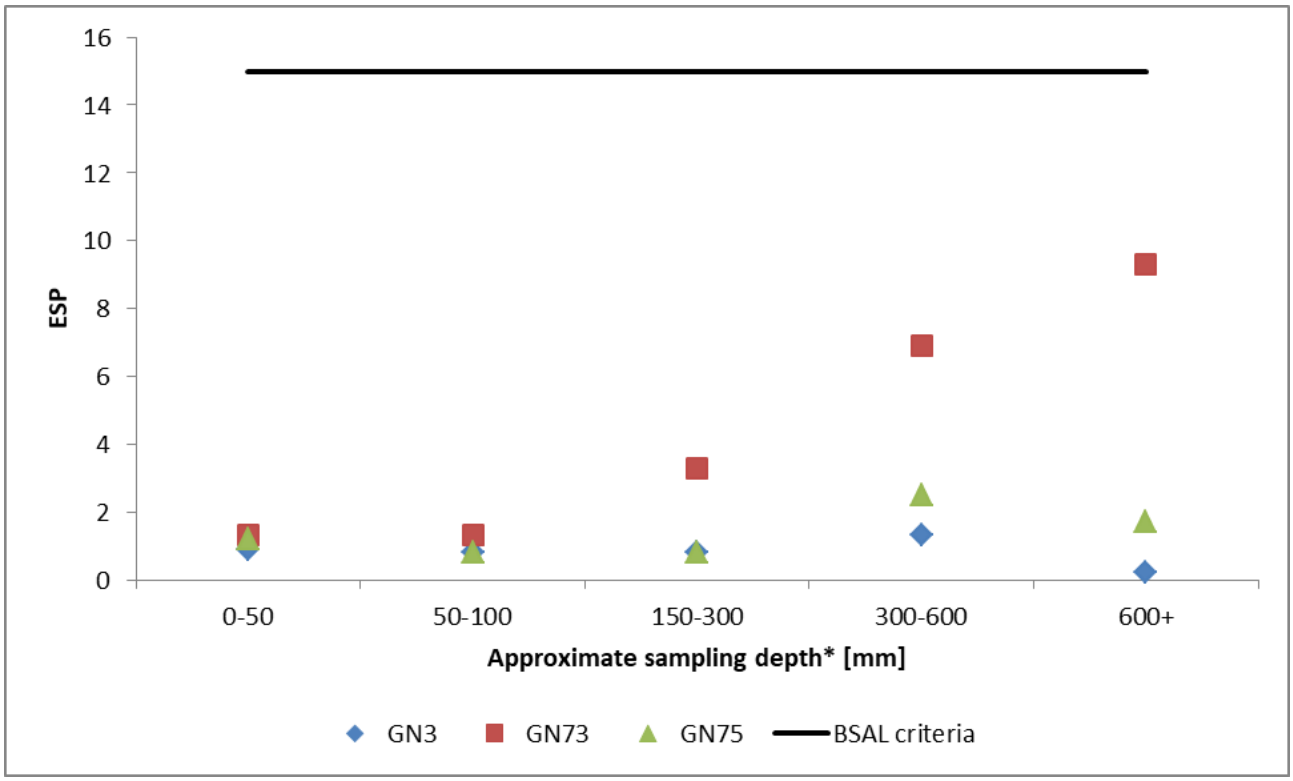
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.5 pH for sampled Tenosols



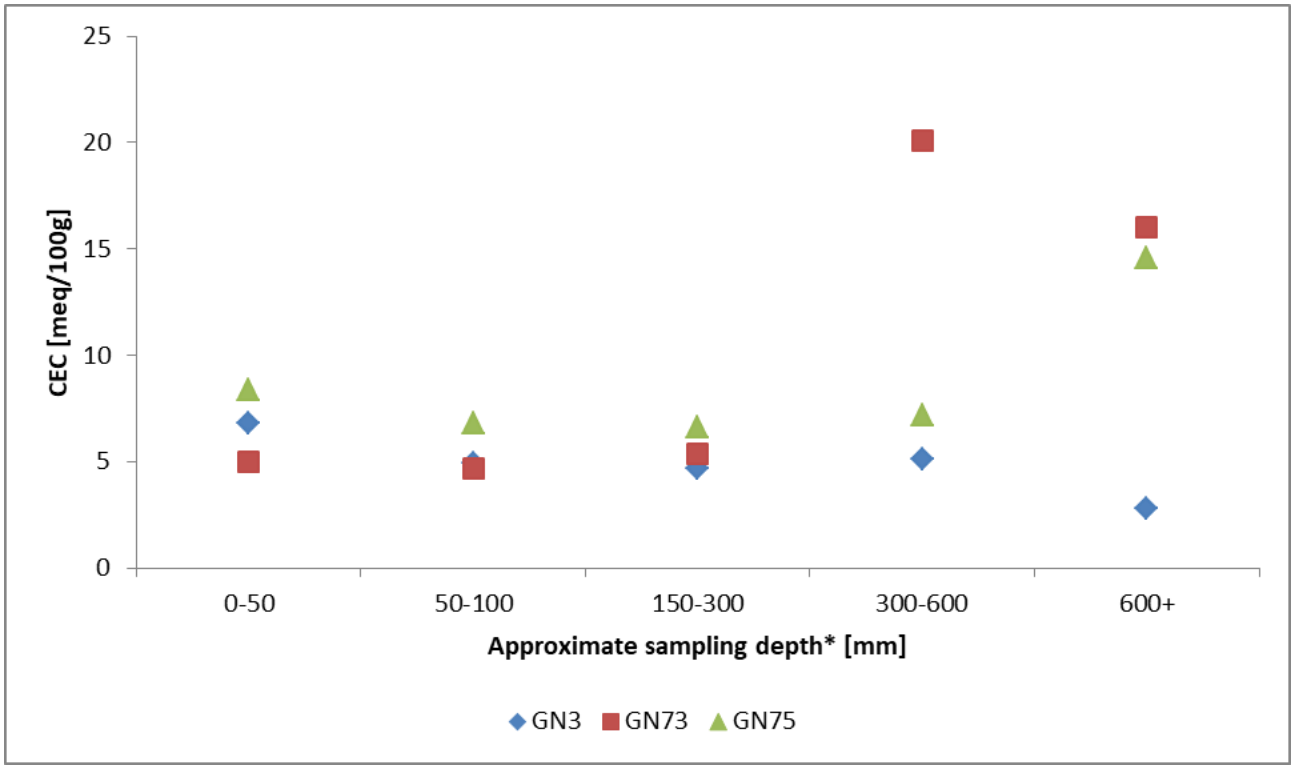
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.6 Saturated paste Electrical Conductivity (ECe) for sampled Tenosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.7 Exchangeable sodium percentage (ESP) for sampled Tenosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.8 Cation exchange capacity (CEC) for sampled Tenosols

4.1.3 Rudosol

Clastic Rudosols occur on hill crests where weathering of parent material is insufficient to form a more mature soil profile (GN32 as shown in **Plate 4.12**). Stratic Rudosols are found where repeated fluvial depositions have occurred without further soil profile development (GN4, GN10, GN11) (**Plate 4.13**). The Clastic Rudosol is derived from the underlying Sandstone, whereas the Stratic Rudosol was formed by *ex-situ* material deposition. Rudosols covered approximately 7 ha, or 1%, of the Verification Area.

The lack of soil formation is a limitation for agricultural use, especially for Clastic Rudosols.

Plate 4.12 GN32, hillcrest, looking north

Plate 4.13 GN11, area under influence of local spring

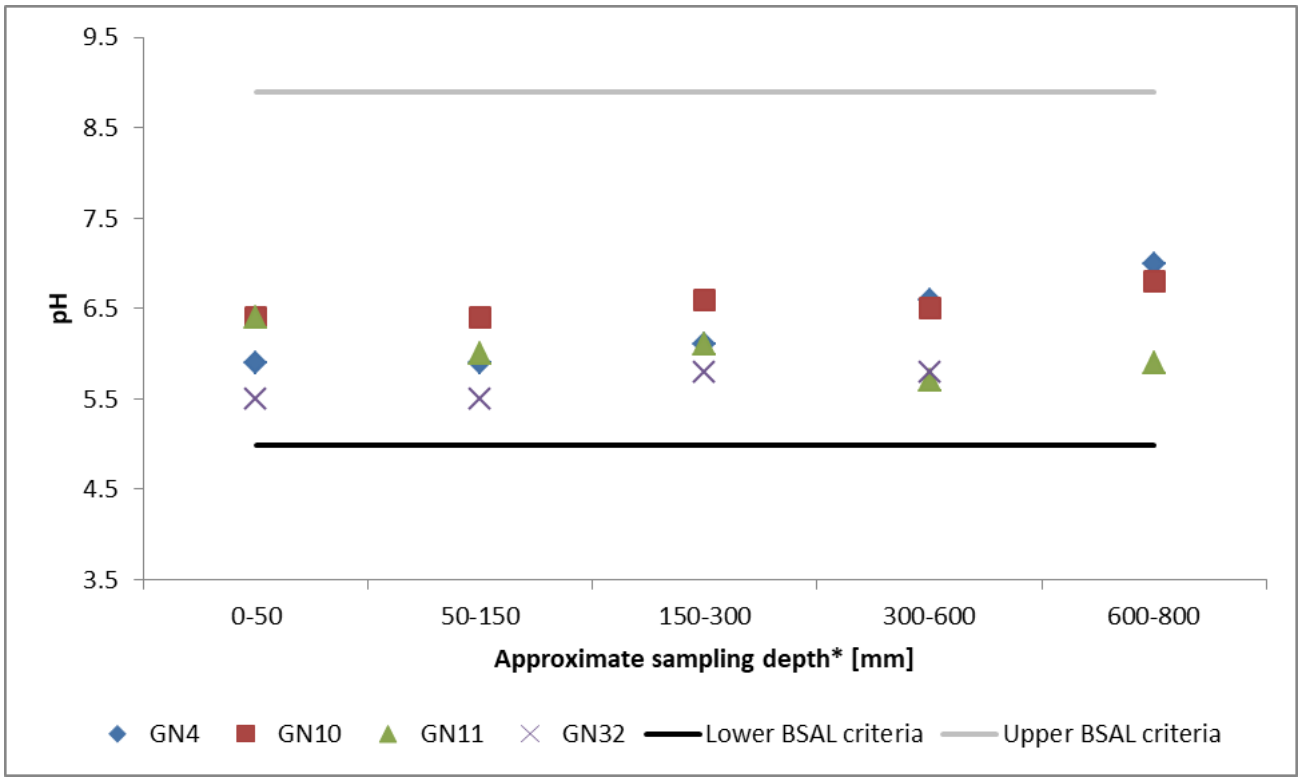
The Clastic Rudosol (GN32) had a Sandy Clay Loam texture with a weak granular to strong sub-angular blocky structure and few coarse fragments throughout the profile. Soil textures of the Stratic Rudosols ranged from Loamy Coarse Sand to Silty Clay Loam, the profiles showed an apedal to weak, granular and sub-angular blocky structure. GN4 showed generally a coarser texture and had few coarse fragments through the profile. GN10 and GN11 had a predominantly Clay Loam texture without coarse fragments. **Table 4.3** presents the soil description of GN11, with the soil profile being shown in **Plate 4.14** and the landscape context in **Plate 4.13.**

Table 4.3 Soil Profile Description – GN11

GN11	**Datum: GDA 94 Zone 56** **Easting: 317945.92** **Northing: 6412465.9** **Recorded: 18th August 2017**
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland, red gum regeneration Estimated effective rooting depth: 800 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Stratic Rudosol
Profile Characteristics	
A1 0-100 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.4. Moderate pedality, rough-ped fabric, granular structure, 5-10 mm. Abrupt boundary.
B21 100-250 mm	10YR 4/3 (moderately moist) Fine Sandy Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Abrupt boundary.
B22 250-350 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.1. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary
B23 350-500 mm	10YR 5/3 (moderately moist) Silty Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary
B24 500^{+} mm	10YR 3/2 (moderately moist) Silty Clay. pH 5.9. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Limit of observation.

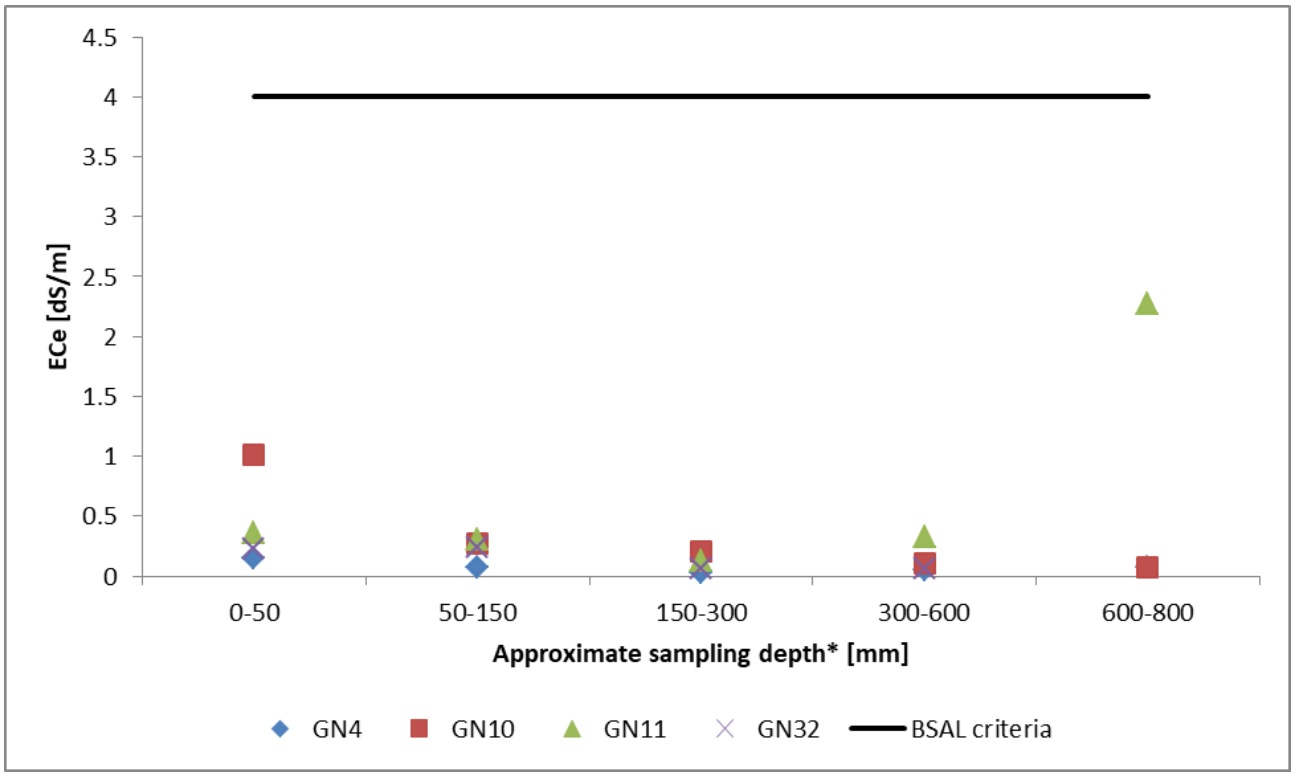
Plate 4.14 Soil profile GN11

The pH of all analysed soil samples was moderately acid to slightly acid. A horizon pH ranged from 5.5 to 6.4 and recorded B horizon pH varied from 5.8 to 6.8 (**Figure 4.9**). All samples are classed as non-saline (**Figure 4.10**). GN4 and GN32 are non-sodic, whereas the topsoil of GN10 (0-50 mm) and 250-500 mm depth of GN11 exceed an ESP of 6 and are therefore considered sodic (**Figure 4.11**). CEC is low to moderate, with the GN11 topsoil showing a high CEC (>15) (**Figure 4.12**).



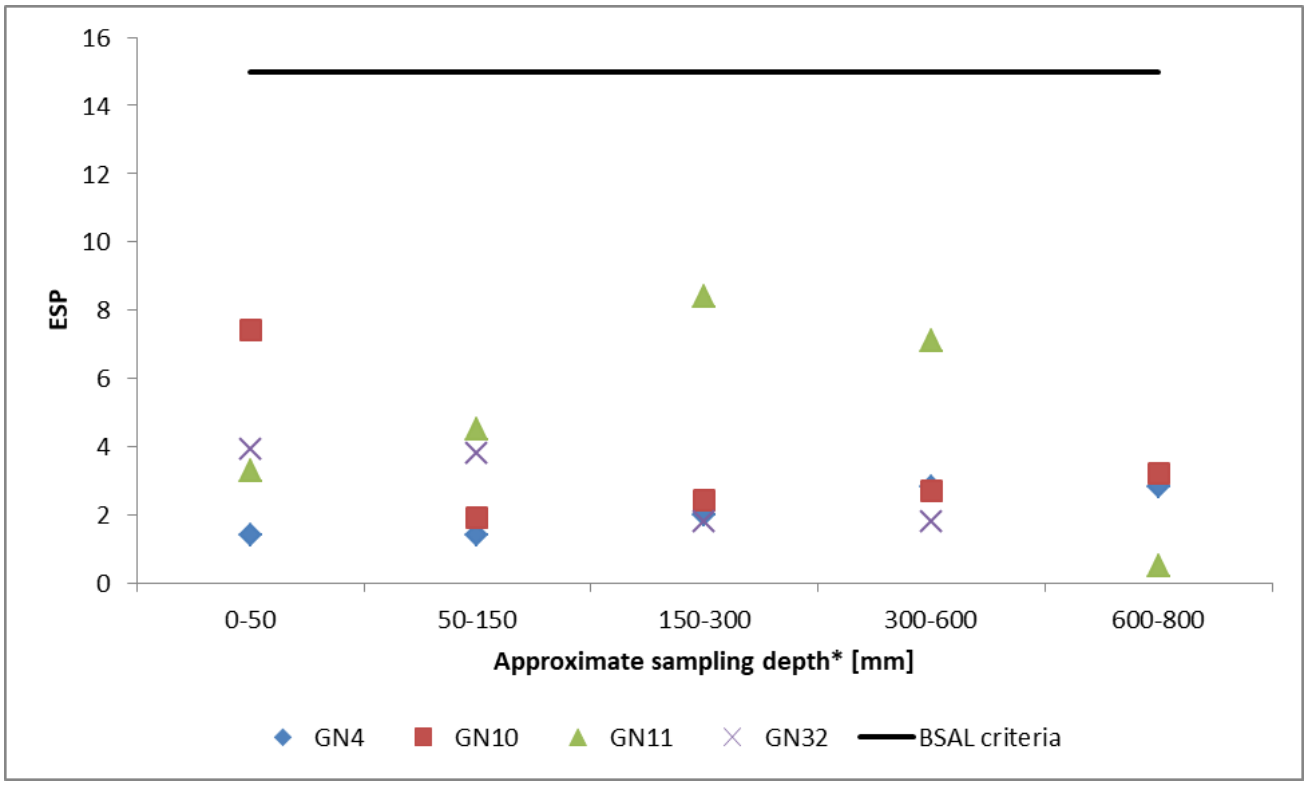
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.9 pH for sampled Rudosols



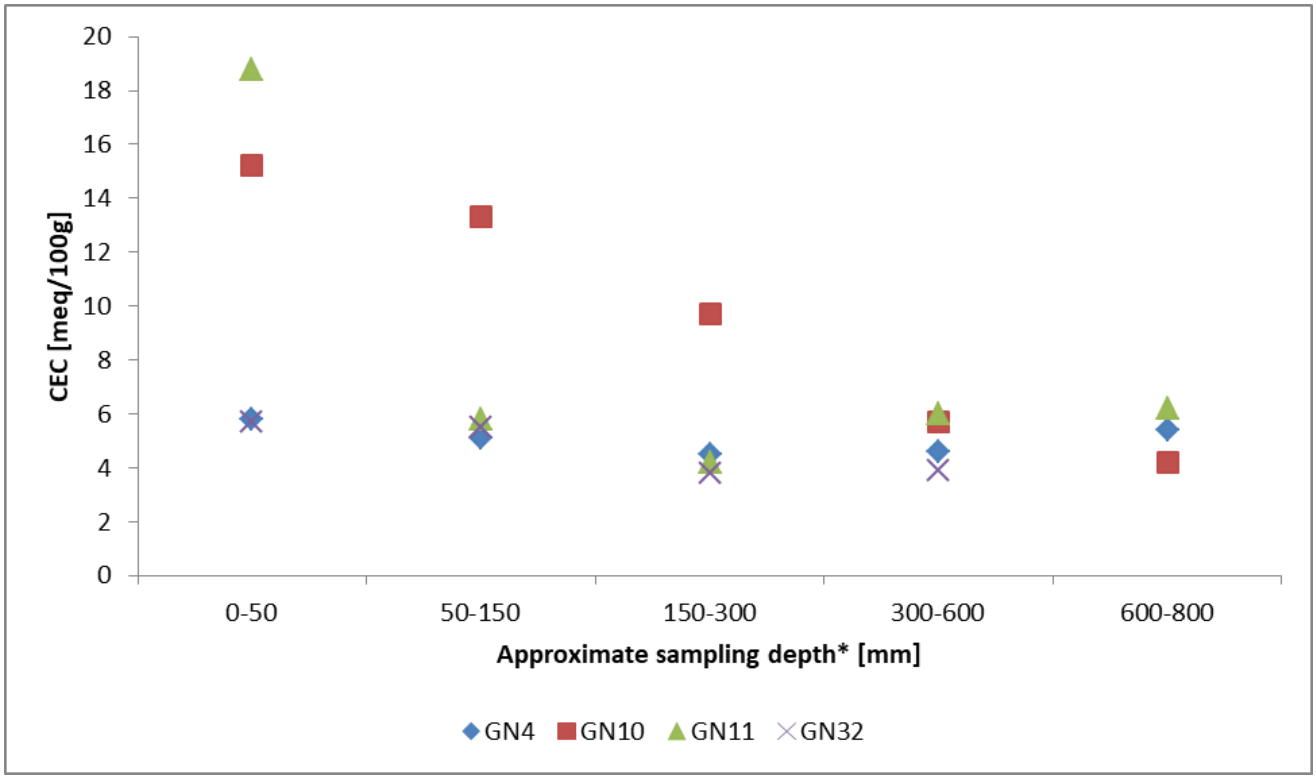
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.10 Saturated paste Electrical Conductivity (ECe) for sampled Rudosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.11 Exchangeable sodium percentage (ESP) for sampled Rudosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.12 Cation exchange capacity (CEC) for sampled Rudosols

4.1.4 Kandosol

Brown Kandosols occur isolated on hillslopes (GN15) (**Plate 4.14**), footslopes (GN34, GN83) (**Plate 4.15**) and on a lower alluvial terrace (GN13). The occurrence of Kandosols may be a result of the weathering of isolated, coarser grained sandstones or sandstone conglomerates. GN15 is located in a drainage depression, and as a result accumulation of *ex-situ* derived material may have contributed to all sites. Kandosols are found on approximately 6 ha, or less that 1% of the Verification Area.

Plate 4.15 GN15, midslope, looking east

Plate 4.16 GN34, footslope, looking north

Sites have a Clay Loam texture grading into Light Clay or a Sandy Loam with apedal massive to moderate sub-angular blocky structures. Common to many mottles were evident in the B horizon of all profiles. GN15 showed few to common rounded pebbles throughout the profile.

The water logging, evident through mottling, is a limitation to agriculture for all sites. In addition, the presence of coarse fragments and a shallow rooting depth for GN15 further impedes land use in this location.

Table 4.4 shows the detailed description of GN15, the soil profile is displayed in **Plate 4.17** and landscape context is provided in **Plate 4.15**.

Table 4.4 Soil Profile Description – GN15

GN15	**Datum: GDA 94 Zone 56** **Easting: 318473.97** **Northing: 6411428.96** **Recorded: 17th August 2017**
Landscape Element: Hillslope Slope: 2% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 650 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Conglomerate Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Kandosol
Profile Characteristics	
A1 0-100 mm	10YR 5/3 (moderately moist) Sandy Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 2-6 mm, rounded conglomerate pebbles. Clear boundary.
B21 100-250	10YR 4/3 (moderately moist) Sandy Clay Loam. pH 5.8. Apedal massive structure, sandy fabric. Common (10-20%) 6-20 mm, rounded conglomerate pebbles. Gradual boundary.
B22 250-600 mm	10YR 5/3 (moderately moist) Coarse Sandy Clay Loam. pH 6.3. Apedal massive structure, sandy fabric. Many (20-50%) 20-60 mm, rounded conglomerate large pebbles. Gradual boundary
BC 600^{+} mm	10YR 5/3 (moderately moist) Light Clay. pH 6.5[2]. Apedal massive structure, sandy fabric. Many (20-50%), very coarse, distinct brown mottles. Many (20-50%) 6-20 mm, rounded conglomerate pebbles. Limit of observation.

[2] Field pH, maximum soil sampling depth 600-650 mm

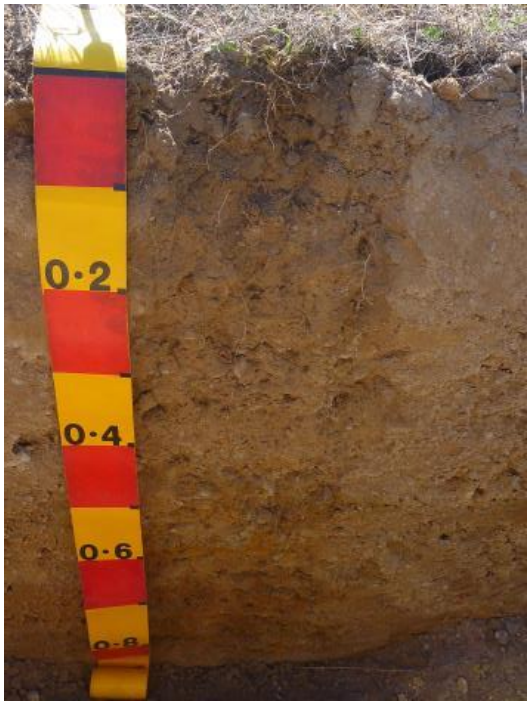
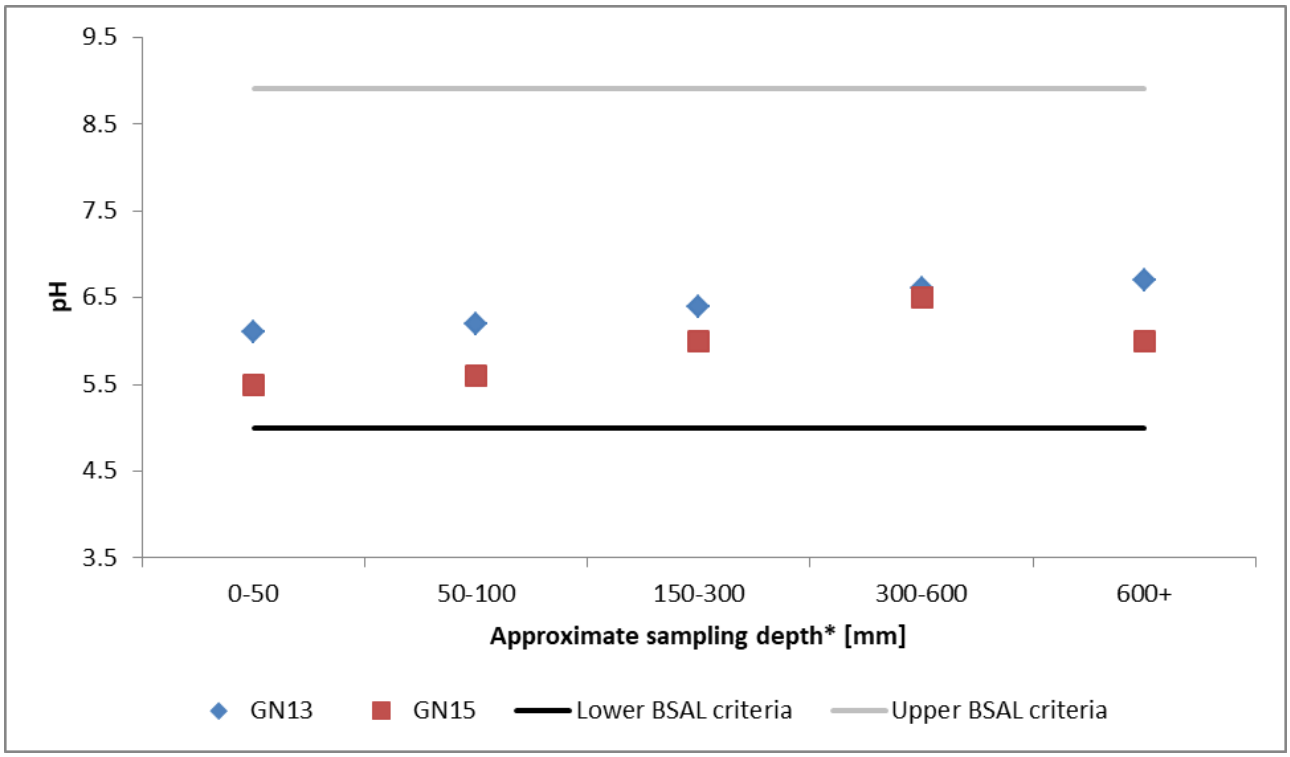


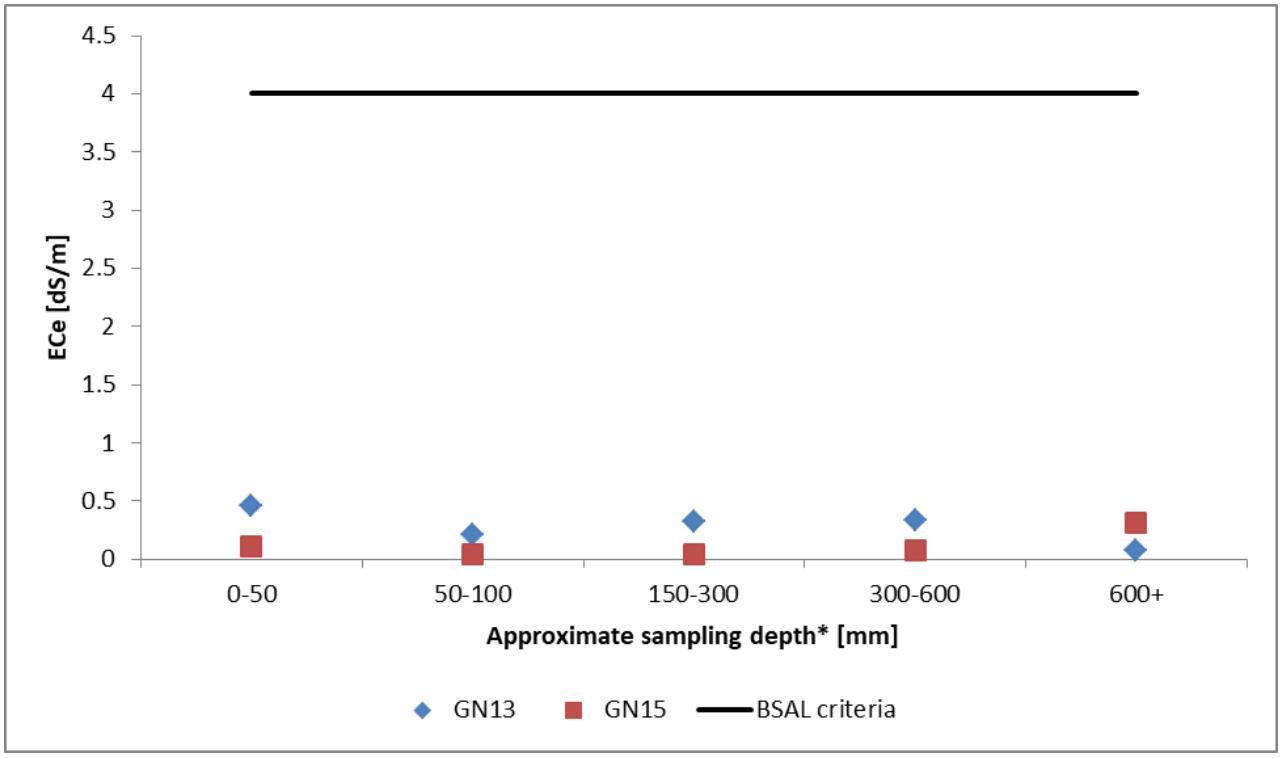
Plate 4.17 Profile description GN15

The pH of the Kandosols is moderately acid to slightly acid, both in the A and B horizons of the analysed sites (**Figure 4.13**). Both profiles are non-saline (**Figure 4.14**) and GN13 is non sodic, while GN15 is sodic below 250 mm and highly sodic below 600 mm (**Figure 4.15**), which may be a result of the influence of the underlying sandstone. GN13 has a moderate CEC throughout the profile, while GN15 has a very low CEC in the upper 600 mm and a moderate CEC below this (**Figure 4.16**). However, this will be due to a high Sodium percentage as shown by the ESP (**Figure 4.15**).



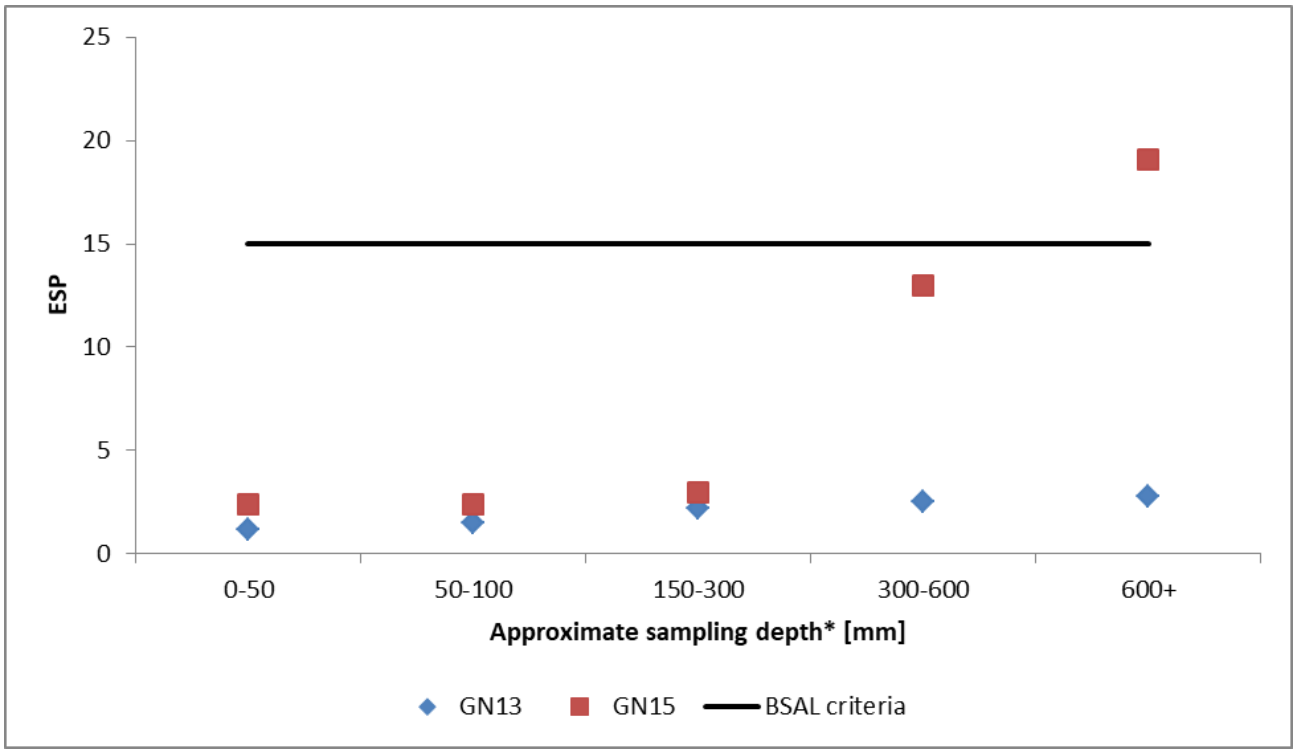
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.13 pH for sampled Kandosols



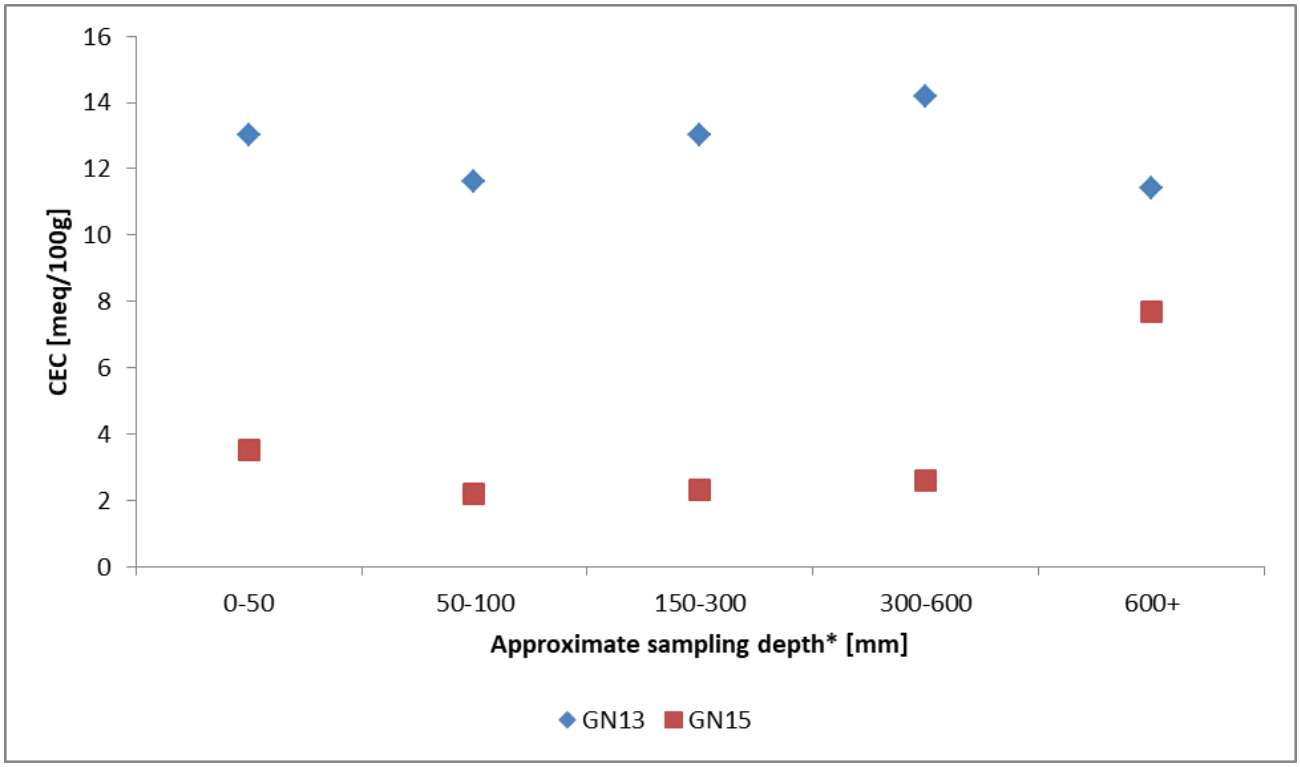
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.14 Saturated paste electrical conductivity (ECe) for sampled Kandosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.15 Exchangeable sodium percentage for sampled Kandosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.16 Cation exchange capacity (CEC) for sampled Kandosols

4.1.5 Chromosol

Brown or Black Chromosols occur on the upper terrace of the creek floodplains (GN6, GN8, GN69, GN71, GN77, GN79) and in one occasion (GN35) on the midslope of the rolling hills (**Plates 4.18** and **4.19**). The Chromosols in the floodplain are derived from *ex situ* material. GN35 is situated in a drainage line, therefore the underlying sandstone or mudstone bedrock as well as *ex situ* material will have contributed to the soil formation. Chromosols cover approximately 19 ha, or 3%, of the Verification Area.

Plate 4.18 GN 71, upper terrace, looking south

Plate 4.19 GN35, midslope, looking north

The A horizon texture of the floodplain Chromosols ranged from Sandy Loam, Sandy Clay Loam and Silty Clay Loam to Clay Loam with a weak to moderate, granular to sub-angular blocky structure. The upper B textures were Coarse Sandy Light Medium Clay, Medium Clay and Medium Heavy Clay, with predominantly moderate sub-angular and angular blocky structures. Coarse fragments were only recorded in GN9, mottling occurred the GN6 B21 and the lower B horizon of some of the other profiles. Few manganiferous soft segregations were recorded in the lower depth of GN77 (+650 mm) and GN79 (+800 mm).

Chromosols on the Bowmans Creek floodplain may be well suited for agricultural use, however the Chromosol mapped near Yorks Creek (GN6) has imperfect drainage and rooting restrictions due to high sodicity (see below).

Table 4.5 presents the soil profile description of GN71 with its profile and landscape context being shown in **Plate 4.20** and **4.21** respectively.

Table 4.5 Soil Profile Description – GN71

GN71	**Datum: GDA 94 Zone 56** **Easting: 316552.76** **Northing: 6412017.90** **Recorded: 11th October 2017**
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 1000 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Moderately well drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol
Profile Characteristics	
A11 0-120 mm	7.5YR 4/3 (moderately moist) Silty Clay Loam. pH 6.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A12 120-350 mm	7.5YR 4/3(moderately moist), sporadically bleached Silty Clay Loam. pH 5.6. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Sharp boundary.
B21 350-650 mm	7.5YR 3/4 (moderately moist) Medium Clay. pH 6.5. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Gradual boundary.
B22 650-800 mm	7.5YR 4/4 (moderately moist) Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common, coarse macropores. Gradual boundary.
B23 800+ mm	7.5YR 2.5/2 (moderately moist) Light Clay. pH 7.0[3]. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Limit of observation.

[3] Field pH, maximum sampling depth 650-800 mm

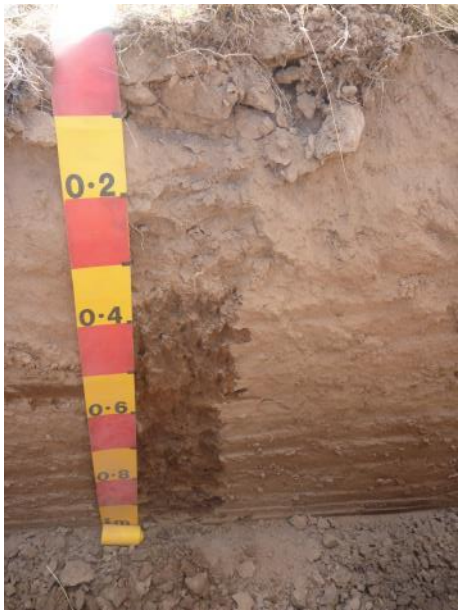


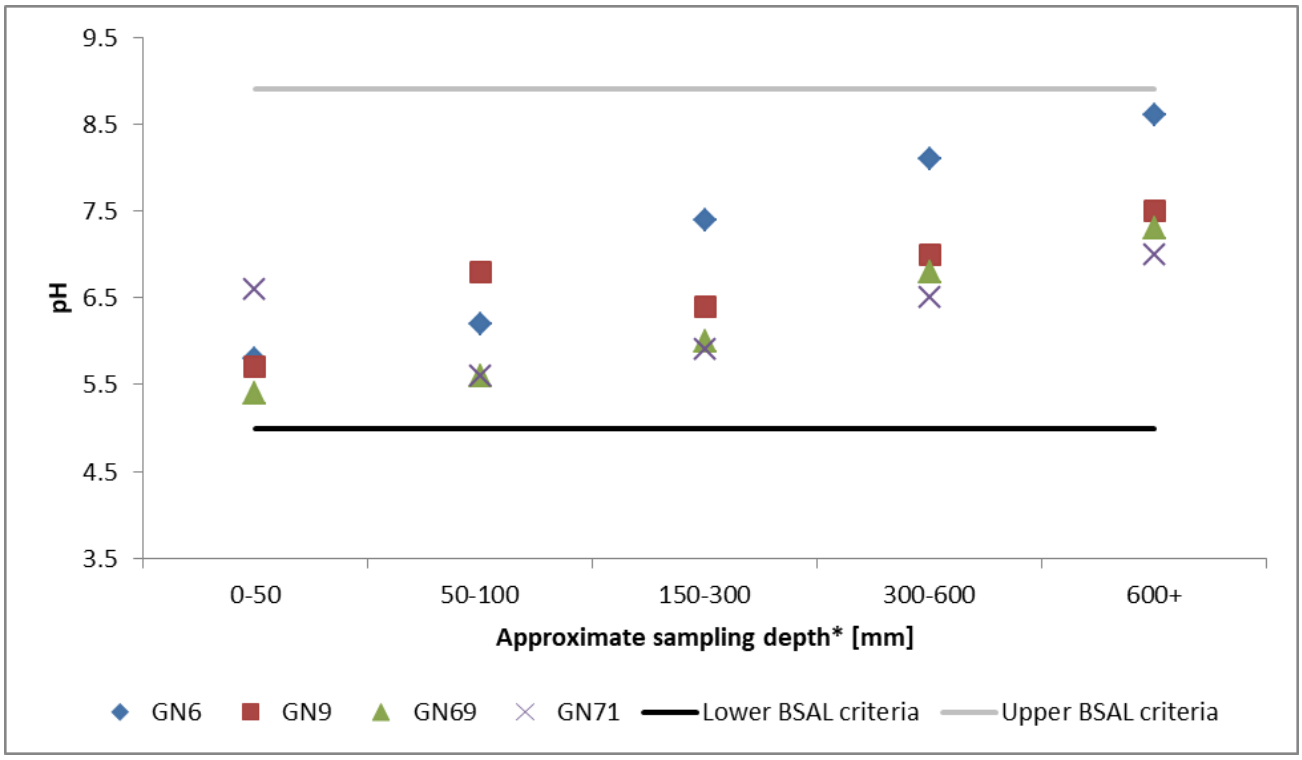
Plate 4.20 Profile description GN71

Plate 4.21 GN71, upper floodplain terrace of Bowmans Creek, looking south

Laboratory analysis of the Chromosol samples showed that A horizon pH ranged from strongly acid (pH 5.54, GN69) to slightly alkaline (pH 7.4, GN6). B horizon pH lay between pH 6.4 (slightly acid) and pH 8.6 (strongly alkaline) (**Figure 4.17**).

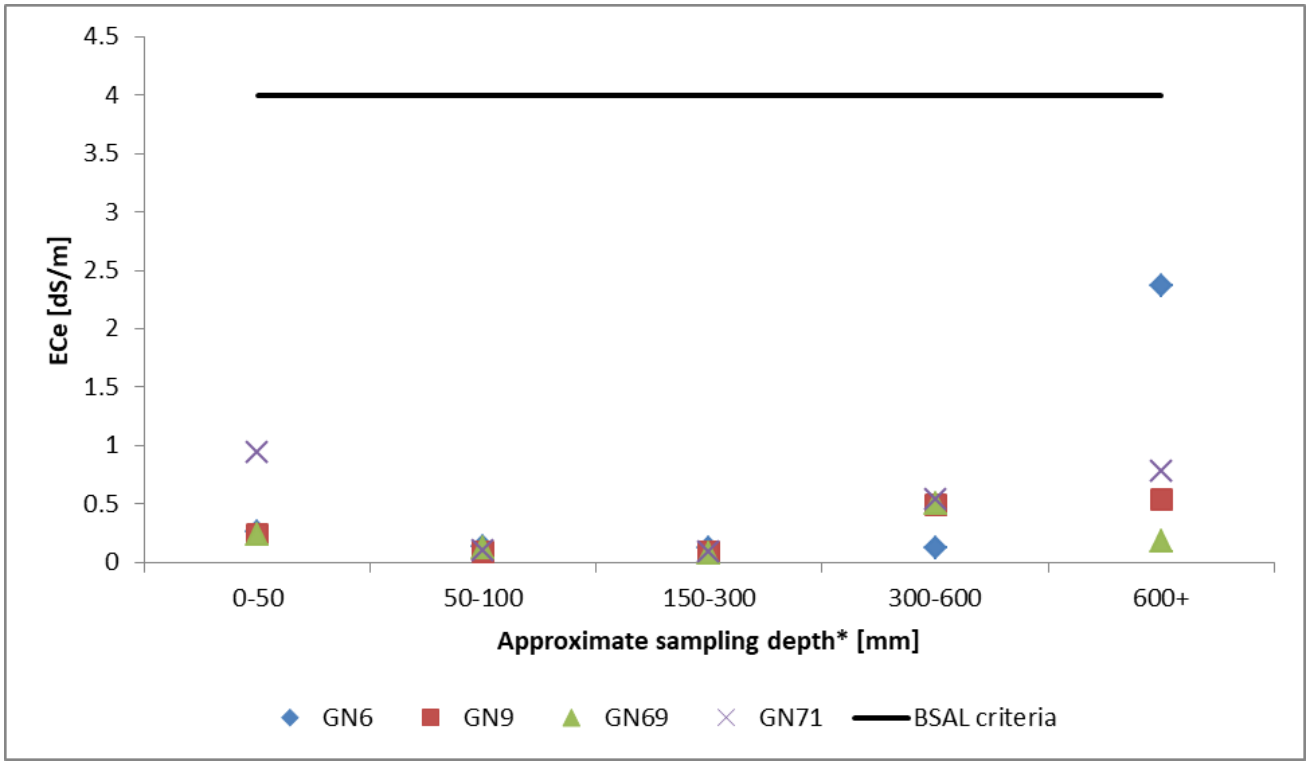
The analysed Chromosol samples were non-saline and non-sodic, with the exception of GN6, which was slightly saline and strongly sodic (ESP 35.5) below 500 mm (**Figures 4.18** and **4.19**). This indicates that the underlying geology strongly influenced the soil formation for GN6 below 500 mm.

The CEC of the A horizons was moderate for all sites, with the exception of the A2 horizon of GN6, which had a low CEC. This may be a result of a slight bleach in this horizon which indicates lateral leaching of nutrients. GN9, GN69 and GN71 had a high CEC rating for the upper B horizon, which may be a result of increased clay contents. The CEC rating of GN6 remained low. The CEC in the lower B decreased to a moderate to low value, with the exception of GN71 (high CEC rating) (**Figure 4.20**).



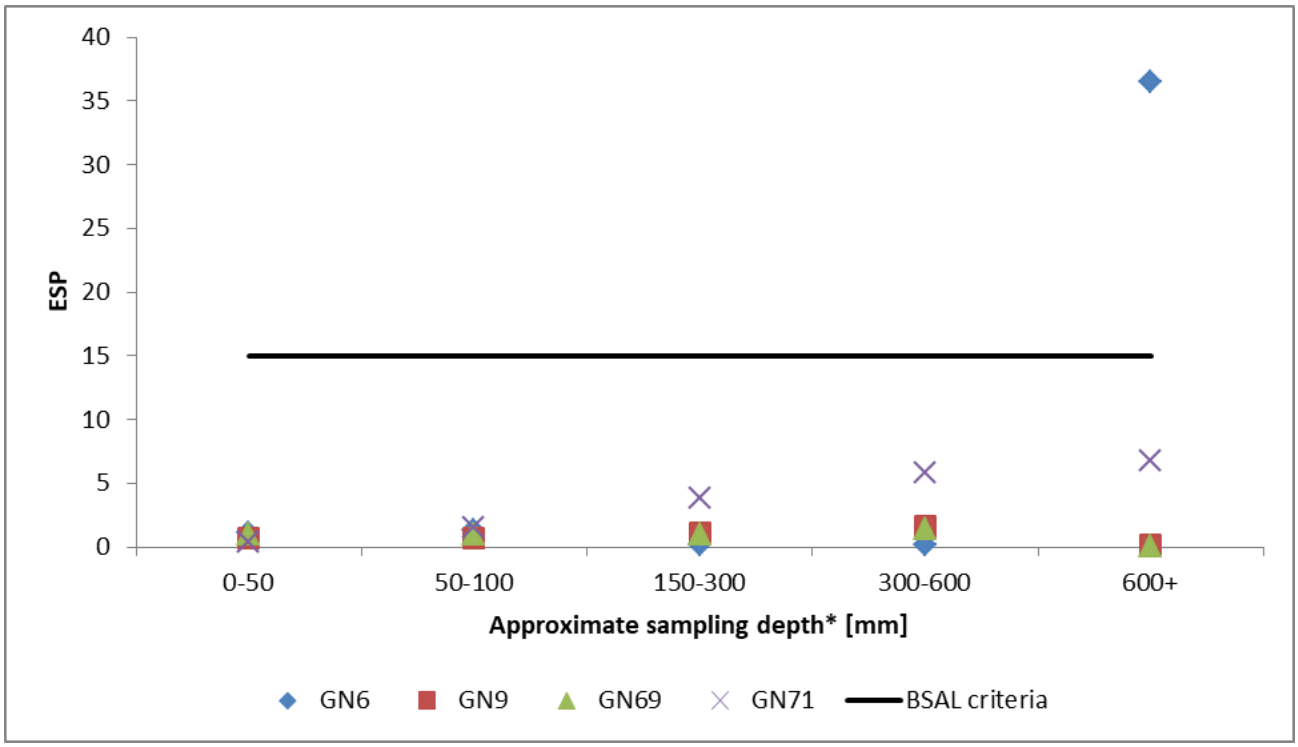
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.17 pH for sampled Chromosols



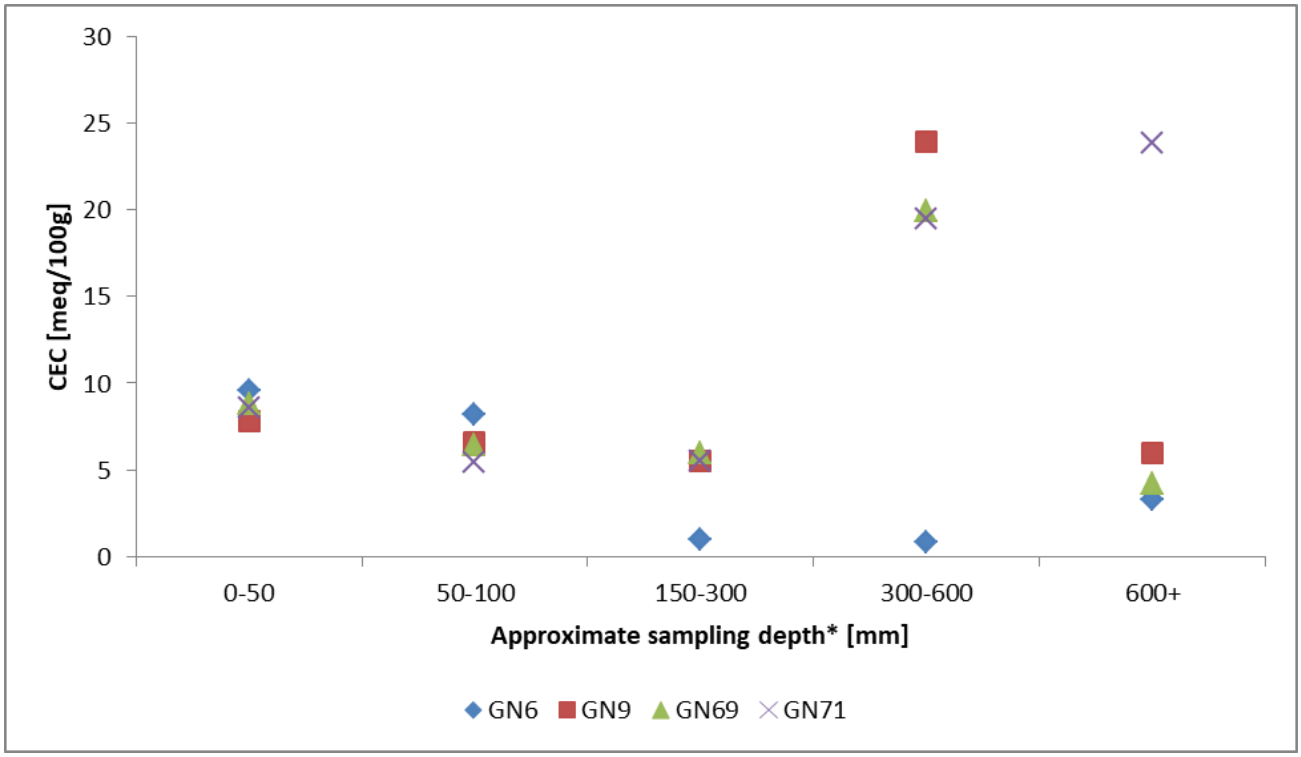
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.18 Saturated paste electrical conductivity (ECe) for sampled Chromosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.19 Exchangeable sodium percentage for sampled Chromosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.20 Cation exchange capacity (CEC) for sampled Chromosols

4.1.6 Dermosol

Red, Black and Brown Dermosols were found in isolation in floodplain areas (GN26, GN67, GN82) and to a limited extent on a mid to lower slope site (GN17) (**Plates 4.22** and **4.23** respectively). As a result of this limited extent, only two detailed sites (GN17, GN67) and two check sites (GN26, GN82) intercepted Dermosols. Dermosols are present on 11 ha, or 2%, of the Verification Area.

Dermosols on the floodplains are formed from *ex-situ* material, while on the mid to lower slope it may be a result of a slight variation of the underlying sedimentary (mudstone) geology.

Plate 4.22 GN 26, floodplain, looking west towards Yorks Creek

Plate 4.23 GN17, midslope, looking north

The A horizon of the observed Dermosols had a Light Clay texture with a moderate granular structure.

On the midslope, B horizons had a Medium Heavy Clay texture which decreased to a Light Clay with depth, with strong, angular blocky structure and 10-20 mm peds. Few fine, faint mottles were observed, increasing to many with depths. Many angular small mudstone pebbles occurred between 600-700 mm and mudstone bedrock was encountered at 700 mm.

On the floodplain, B horizon texture increased from Medium Clay to Heavy Clay with depth, with the occurrence of slickensides in the profile. Soil structure was strong angular blocky with 5-20 mm peds. A few, faint orange mottles were observed in the B Horizon. Vertic properties were observed in the B21 and B22 of both profiles in the floodplain (GN26, GN67), but cracks did not connect to the surface.

For Dermosols, imperfect drainage is a limitation to agriculture. For GN17, coarse fragments and bedrock at 700 mm further impede land use. As discussed below, both analysed profiles were highly sodic below 600 mm, and thus restrict rooting depth.

Exemplary, GN67 profile description is presented in **Table 4.6** and its profile and landscape context is shown in **Plates 4.24** and **4.25** respectively.

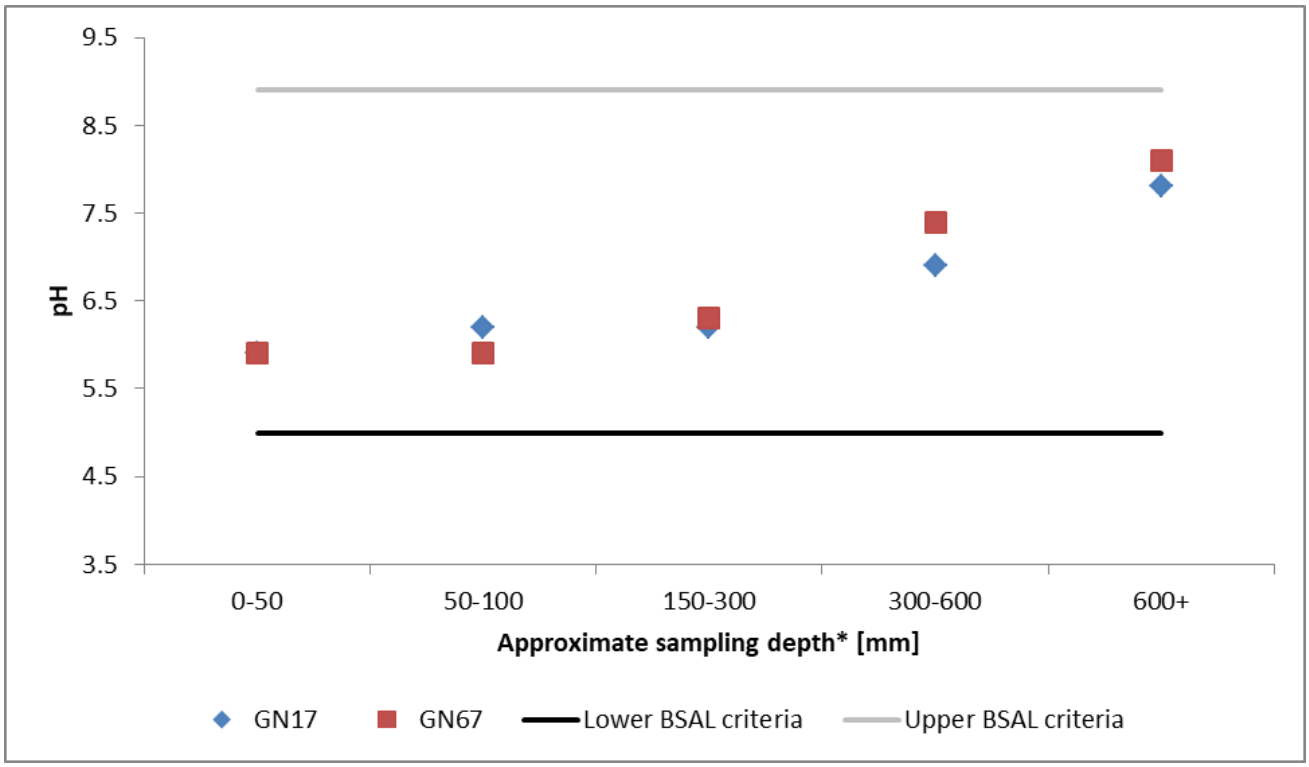
Table 4.6 Soil Profile Description – GN67

GN67	**Datum: GDA 94 Zone 56** **Easting: 317507.04** **Northing: 6411450.76** **Recorded: 12th October 2017**
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 950 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Dermosol
Profile Characteristics	
A1 0-100 mm	7.5YR 4/2 (moderately moist) Light Clay. pH 5.9. Moderate pedality, rough-ped fabric, granular structure, 5-10 mm. Common, medium macropores. Gradual boundary.
B21 100-300 mm	10YR 3/1 (moderately moist) Medium Clay. pH 5.9. Strong pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common (10-20%), fine, faint, orange mottles. Common, medium macropores. Gradual boundary.
B22 300-600 mm	10YR 3/2 (moderately moist) Medium Heavy Clay. pH 7.4. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Few (<10%), distinct slickensides. Few, medium macropores. Diffuse boundary.
B24 600^{+} mm	10YR 3/3 (moderately moist) Heavy Clay. pH 8.1. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%), fine, faint, orange mottles. Limit of observation.

Plate 4.24 Soil Profile GN67

Plate 4.25 GN67, floodplain terrace of Yorks Creek, looking north

Analysed soil samples showed a moderately acid soil pH in the A and upper B horizon, which increased to moderately alkaline with depth (**Figure 4.21**). GN17 was non saline throughout the profile, while GN67 was slightly saline below 600 mm (**Figure 4.22**). Both sites had non sodic A horizons, but became sodic in the B horizon, with a maximum ESP of 24.4 and 19 below 600 mm, for GN17 and GN69, respectively (**Figure 4.23**). GN67 has a low CEC rating throughout the profile, while the CEC of GN17 was moderate to high, decreasing to low below 600 mm (**Figure 4.24**).



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.21 pH for sampled Dermosols

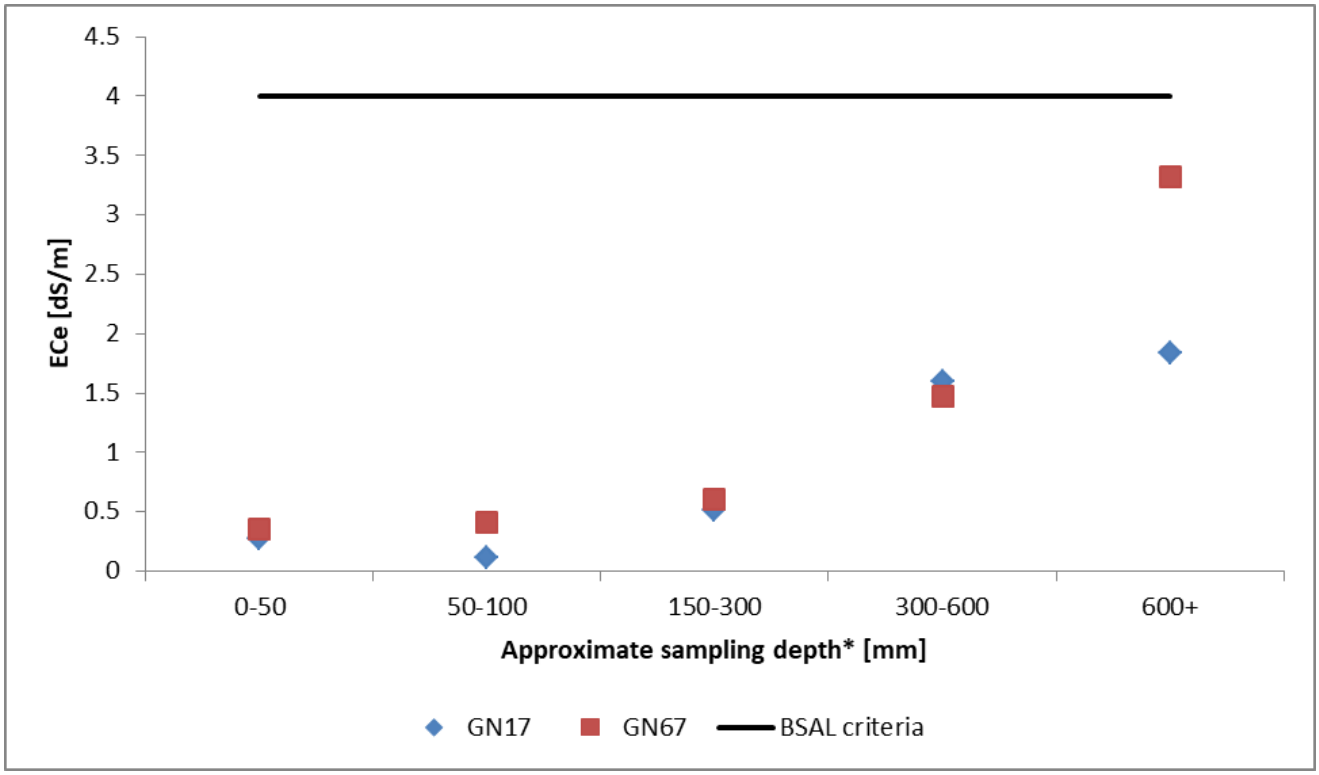


Figure 4.22 Saturated paste electrical conductivity (ECe) for sampled Dermosols

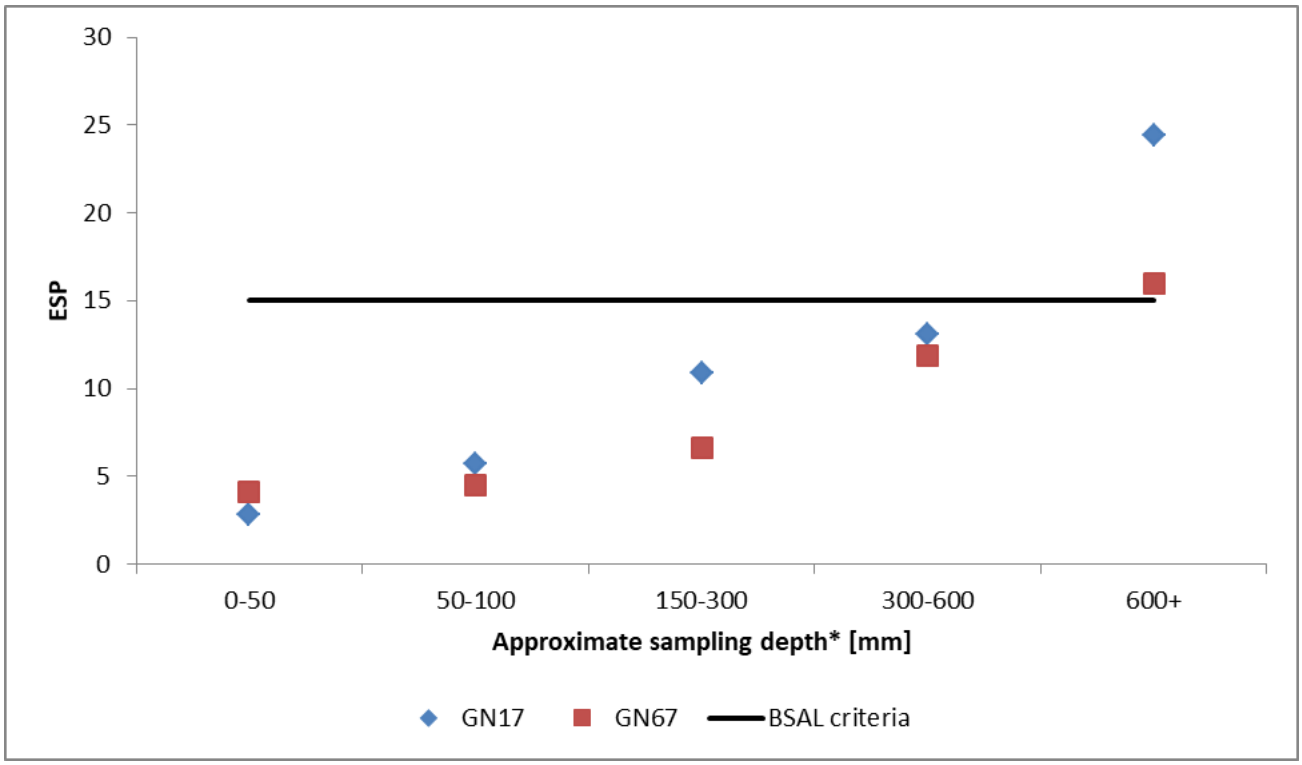


Figure 4.23 **Exchangeable sodium percentage for sampled Dermosols**

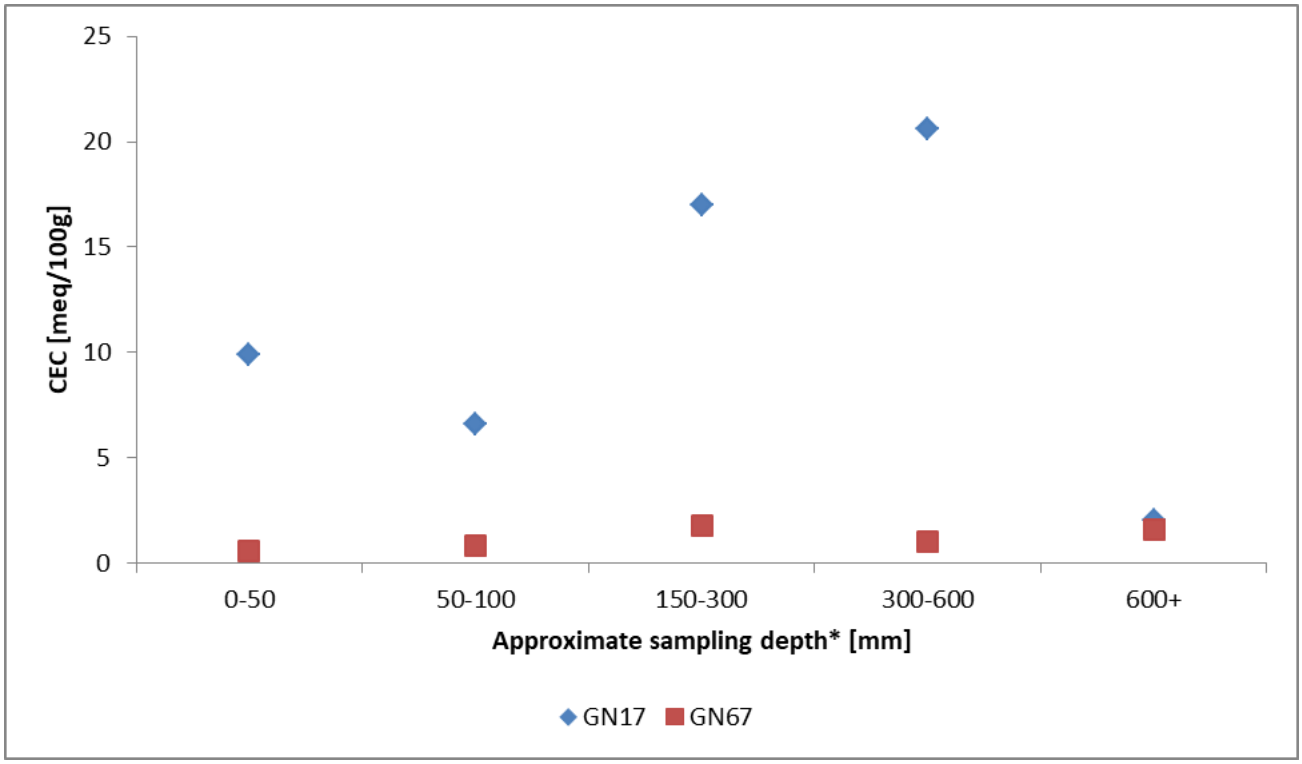


Figure 4.24 **Cation exchange capacity (CEC) for sampled Dermosols**

4.2 Soil Classification and mapping

In accordance with the Interim Protocol, all detailed sites were described to family level following *The Australian Soil Classification* (Isbell, 1996) as presented in **Table 4.7**. **Table 4.8** shows the ASC Order and suborder for the check sites. The distribution of the identified soils in the Verification Area is shown in **Figure 4.25**.

Sodosol is the dominant soil order in the Verification Area, taking up approximately 87% of the area. Tenosols cover approximately 5% of the area, while Chromosols can be found in approximately 3% of the Verification Area. Dermosols and Rudosols cover approximately 2% and 1% of the Verification Area respectively, while Kandosols are present on less than 1% of the area (**Table 4.9**).

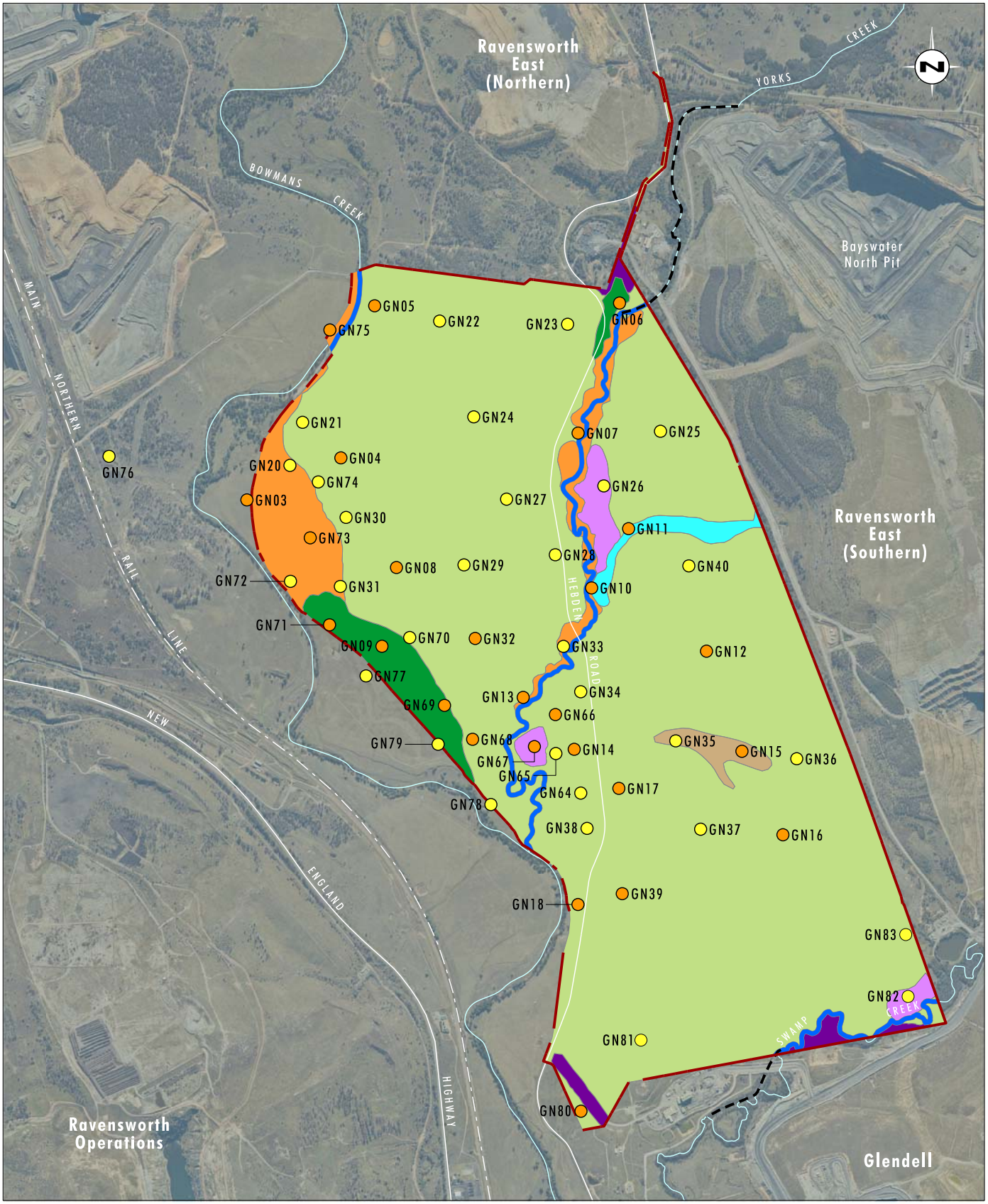


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2017 & 2019)

0 0.25 0.5 1.0km
1:25 000

Legend

- Verification Area
- Disturbed
- Brown/Red/Yellow/Grey/Black Sodosol
- Brown-Orthic Tenosol
- Clastic/Stratic Rudosol
- Brown Kandosol
- Brown/Black Chromosol
- Red/Black Dermosol
- Creek Line
- Soil Sampling Sites – Check Sites
- Soil Sampling Sites - Detailed Sites
- Existing Creek Diversion

FIGURE 4.25

Distribution of Soil Units Across the Verification Area

File Name (A4): R04/4166_023.dgn
20190403 16.20

Table 4.7 Soil classification for detailed sites

Site ID	ASC Order	ASC suborder	Great Group	Sub-Group	Family
GN3*	Tenosol	Brown-Orthic	Regolithic	Basic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Loamy B horizon maximum texture: Clayey Soil depth: Very deep
GN4	Rudosol	Stratic			Gravel of the surface and A1 horizon: Slightly gravelly A1 horizon texture: Loamy Soil depth: Shallow
GN5	Sodosol	Brown	Mesonatric	Mesotrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN6	Chromosol	Brown	Mesotrophic	Bleached-Sodic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Very Deep
GN7	Sodosol	Brown	Mesonatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Very Deep
GN8	Sodosol	Brown	Subnatric	Mesotrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN9	Chromosol	Brown	Eutrophic	Haplic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Deep/Very Deep

Site ID	ASC Order	ASC suborder	Great Group	Sub-Group	Family
GN10	Rudosol	Stratic			Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Loamy Soil depth: Shallow
GN11	Rudosol	Stratic			Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy Soil depth: Shallow
GN12	Sodosol	Brown	Subnatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate
GN13	Kandosol	Brown	Eutrophic	Haplic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN14	Sodosol	Brown	Mesonatric	Mesotrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate
GN15	Kandosol	Brown	Mesotrophic	Sodic	A horizon thickness: Moderate Gravel of the surface and A1 horizon: Slightly gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN16	Sodosol	Red	Subnatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN17	Dermosol	Red	Eutrophic	Sodic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Slightly gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate

Site ID	ASC Order	ASC suborder	Great Group	Sub-Group	Family
GN18	Sodosol	Brown	Mesonatric	Eutrophic	A horizon thickness: Thick Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate/Deep
GN32	Rudosol	Clastic	Lithosolic	Basic	Gravel of the surface and A1 horizon: Slightly gravelly A1 horizon texture: Clay Loamy Soil depth: Shallow
GN39	Sodosol	Brown	Subnatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate
GN66	Sodosol	Black	Mesonatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Deep
GN67	Dermosol	Black	Mesotrophic	Vertic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clayey B horizon maximum texture: Clayey Soil depth: Deep
GN68	Sodosol	Black	Mesonatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Deep
GN69	Chromosol	Brown	Eutrophic	Haplic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Deep

Site ID	ASC Order	ASC suborder	Great Group	Sub-Group	Family
GN71	Chromosol	Brown	Eutrophic	Haplic	A horizon thickness: Thick Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Deep
GN73	Tenosol	Brown-Orthic	Regolothic	Basic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clay Loamy Soil depth: Deep
GN75*	Tenosol	Brown-Orthic	Regolithic	Basic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Deep
GN80	Sodosol	Black	Mesonatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Deep

* located outside the Verification Area

Table 4.8 Soil classification for check sites

Site ID	ASC Order	ASC suborder
GN20	Tenosol	Brown-Orthic
GN21	Tenosol	Brown-Orthic
GN22	Sodosol	Yellow
GN23	Sodosol	Yellow
GN24	Sodosol	Brown
GN25	Sodosol	Grey
GN26	Dermosol	Black
GN27	Sodosol	Brown
GN28	Sodosol	Brown
GN29	Sodosol	Brown
GN30	Sodosol	Brown
GN31	Tenosol	Brown-Orthic
GN33	Tenosol	Brown-Orthic
GN34	Kandosol	Brown
GN35	Chromosol	Brown
GN36	Sodosol	Grey
GN37	Tenosol	Brown-Orthic
GN38	Sodosol	Brown
GN40	Sodosol	Brown
GN64	Sodosol	Black
GN65	Sodosol	Black
GN70	Sodosol	Brown
GN72	Tenosol	Brown-Orthic
GN74	Sodosol	Brown
GN76#	Sodosol	Brown
GN77#	Chromosol	Black
GN78	Sodosol	Brown
GN79#	Chromosol	Black
GN81	Sodosol	Brown
GN82	Dermosol	Brown
GN83	Kandosol	Grey

located outside of the Verification Area

Table 4.9 Approximate area of each ASC Order in the Verification Area

ASC Order	Area (ha)	Area (%)
Sodosol	605	87
Tenosol	35	5
Chromosol	19	3
Dermosol	11	2
Rudosol	7	1
Kandosol	6	<1

5.0 Assessment against BSAL criteria

The following section contains an assessment of each of the detailed sites against the 12 BSAL criteria shown in **Figure 2.2**.

5.1 Criteria 1-9: Landscape and soil physical properties

Criteria 1 Is slope less than or equal to 10%?

Several areas of the Verification Area exceed the 10% slope threshold. These areas are shown in **Figure 3.1**, comprising 113 ha, and were excluded from further detailed assessment. Slope analysis is based on LiDAR data and continuous triangulation.

Criteria 2 Is there less than 30% rock outcrop?

Yes. Rock outcrop in the Verification Area does not exceed 30% at any point.

Criteria 3 Does less than or equal to 20% of the area have unattached rock fragments that are more than 60 mm in diameter?

Yes. Surface occurrence of coarse fragments across the Verification Area does not exceed 20% at any point.

Criteria 4 Does less than or equal to 50% of the area have gilgai greater than 500 mm deep?

Yes. No gilgai are present in the Verification Area.

Criteria 5a Is the slope less than 5%?

Yes. Areas of less than 5% slope (primarily on alluvial plains and some hillslopes) within the Verification Area are shown in **Figure 5.1**. Proceed to Criteria 6.

Criteria 5b Is the slope greater than 5% and less than or equal to 10%.

Yes. Areas of slope greater than 5% and less than or equal to 10% occur within the Verification Area. Proceed to Criteria 7.

Criteria 6 Are there nil rock outcrops on slopes of less than 5%?

Yes. This criterion does not apply for sites with slopes > 5% and less than or equal to 10%.

Criteria 7a On slopes < 5%, does the soil have moderate fertility?

Criteria 7b On slopes > 5% and less than or equal to 10%, does the soil have moderately high or high fertility?

Appendix 2 of the Interim Protocol provides a ranking of relative soil fertility based on ASC Order, ASC Suborder and ASC Great Group. The fertility of all detailed sites has been assessed based on this and is presented in **Table 5.1**. Sites that do not meet the required fertility criteria are highlighted in red.

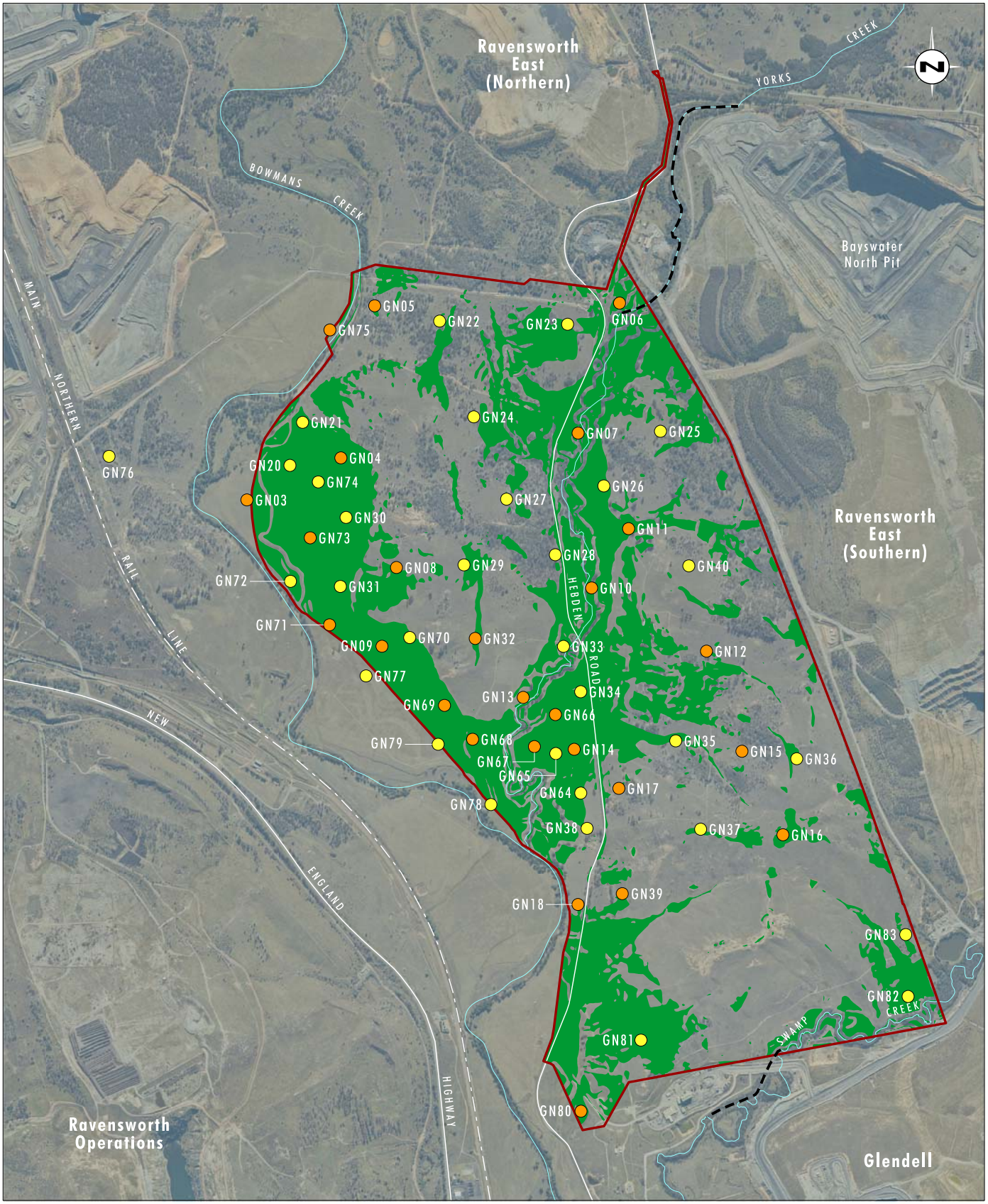


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2017 & 2019)

0 0.25 0.5 1.0km
1:25 000

Legend

- Verification Area
- Slope ≤5%
- Soil Sampling Sites – Check Sites
- Soil Sampling Sites - Detailed Sites
- Existing Creek Diversion

FIGURE 5.1

Area of Slope
Less Than or Equal to 5%

Table 5.1 Assessment of soil fertility

Site ID	ASC Order	ASC suborder	Great Group	Slope (%)	Fertility rating
GN3*	Tenosol	Brown-Orthic	Regolithic	< 5	Moderately low
GN4	Rudosol	Stratic		< 5	Moderately low
GN5	Sodosol	Brown	Mesonatric	< 5	Moderately low
GN6	Chromosol	Brown	Mesotrophic	< 5	Moderately high
GN7	Sodosol	Brown	Mesonatric	< 5	Moderately low
GN8	Sodosol	Brown	Subnatric	< 5	Moderately low
GN9	Chromosol	Brown	Eutrophic	< 5	Moderately high
GN10	Rudosol	Stratic		< 5	Moderately low
GN11	Rudosol	Stratic		< 5	Moderately low
GN12	Sodosol	Brown	Subnatric	< 5	Moderately low
GN13	Kandosol	Brown	Eutrophic	< 5	Moderately low
GN14	Sodosol	Brown	Mesonatric	< 5	Moderately low
GN15	Kandosol	Brown	Mesotrophic	> 5 and <10	Moderately low
GN16	Sodosol	Red	Subnatric	< 5	Moderately low
GN17	Dermosol	Red	Eutrophic	> 5 and <10	Moderately high
GN18	Sodosol	Brown	Mesonatric	< 5	Moderately low
GN32	Rudosol	Clastic	Lithosolic	< 5	Moderately low
GN39	Sodosol	Brown	Subnatric	> 5 and < 10	Moderately low
GN66	Sodosol	Black	Mesonatric	< 5	Moderately low
GN67	Dermosol	Black	Vertic	< 5	Moderately high
GN68	Sodosol	Black	Mesonatric	< 5	Moderately low
GN69	Chromosol	Brown	Eutrophic	< 5	Moderately high
GN71	Chromosol	Brown	Eutrophic	< 5	Moderately high
GN73	Tenosol	Brown-Orthic	Regolothic	< 5	Moderately high
GN75*	Tenosol	Brown-Orthic	Regolithic	< 5	Moderately high
GN80	Sodosol	Black	Mesonatric	< 5	Moderately low

* located outside of the Verification Area

Criteria 8 Is effective rooting depth to a physical barrier greater than or equal to 750 mm?

The Interim Protocol states that "*In the context of BSAL, effective rooting depth to a physical barrier is the depth of soil material from the surface to bedrock, weathered rock, hard pans or continuous gravel layers. These physical barriers may restrict penetration by plant roots and effectively mark the bottom of the soil profile*." The assessment of effective rooting depth for the Verification Area is based on the criteria specified in Table 4 of the Interim Protocol. The results of the assessment are provided in **Table 5.2.**

Table 5.2 Assessment of effective rooting depth to physical barrier

Site ID	Observed rooting depth (mm)	Physical barrier present (>100 mm layer containing >20% coarse fragments and/or segregations >60 mm	Depth (mm)	Effective Rooting depth to physical barrier ≥ 750 mm?
GN3*	700	Yes - 20-50% large pebbles	650	No
GN4	900	No		Yes
GN5	180	No		Yes
GN6	550	No		Yes
GN7	600	No		Yes
GN8	600	Yes – 20-50% large pebbles	600	No
GN9	900	No		Yes
GN10	900	No		Yes
GN11	800	No		Yes
GN12	600	No		Yes
GN13	800	No		Yes
GN14	650	No		Yes
GN15	650	Yes – 20-50% large pebbles	600	No
GN16	580	Yes –Mudstone Bedrock	580	No
GN17	600	Yes –Mudstone Bedrock	700	No
GN18	800	Yes – 20-50% medium pebbles	450	No
GN32	350-600	Yes – Conglomerate bedrock	350-600	No
GN39	680	No		Yes
GN66	800	No		Yes
GN67	950	No		Yes
GN68	1000	No		Yes
GN69	1200	No		Yes
GN71	1000	No		Yes
GN73	1000	No		Yes
GN75*	900	No		Yes
GN80	700	No		Yes

* located outside of the Verification Area

Criteria 9 Is soil drainage better than poor?

The assessment of drainage is based on the criteria specified in Table 2 of the Interim Protocol, which is based on soil colour and also the presence of distinct or prominent mottles > 10% in occurrence. The results of the assessment are provided in **Table 5.3.**

Table 5.3 Assessment of soil drainage

Site ID	Colour Gley, Grey or Bleached?	Mottles > 10% present, either distinct or prominent?	Soil drained better than poor?
GN3*	No	No	Yes
GN4	No	No	Yes
GN5	Yes - Bleached	No	No
GN6	No	Yes	No
GN7	Yes – Bleached	Yes	No
GN8	No	No	Yes
GN9	No	No	Yes
GN10	No	No	Yes
GN11	No	No	Yes
GN12	Yes – Bleached	Yes	No
GN13	No	Yes	No
GN14	Yes – Bleached	Yes	No
GN15	No	Yes	No
GN16	Yes – Bleached	No	No
GN17	No	No	Yes
GN18	No	No	Yes
GN32	No	No	Yes
GN39	Yes – Bleached	No	No
GN66	No	No	Yes
GN67	No	No	Yes
GN68	Yes – Grey	No	No
GN69	No	No	Yes
GN71	No	No	Yes
GN73	No	No	Yes
GN75*	No	No	Yes
GN80	Yes – Bleached	No	No

* located outside of the Verification Area

5.1.1 Soil and landscape BSAL verification criteria – Summary

Several of the assessed sites fail the soil physical and landscape verification criteria (Criteria 1-9) on at least one criterion. A summary is provided below in **Table 5.4.**

Table 5.4 Soil physical and landscape verification criteria results

Site ID	Criteria passed	Criteria failed
GN3*	1,2,3,4,5,6,9	7, 8
GN4	1,2,3,4,5,8,9	7
GN5	1,2,3,4,5,6,8	7, 9
GN6	1,2,3,4,5,6,7,8	9
GN7	1,2,3,4,5,6,8	7, 9
GN8	1,2,3,4,5,6,9	7, 8
GN9	1,2,3,4,5,6,7,8,9	
GN10	1,2,3,4,5,6,8,9	7
GN11	1,2,3,4,5,6,8,9	7
GN12	1,2,3,4,5,6,8	7, 9
GN13	1,2,3,4,5,6,8	7, 9
GN14	1,2,3,4,5,6,8	7, 9
GN15	1,2,3,4,5,6	7, 8, 9
GN16	1,2,3,4,5,6	7,8,9
GN17	1,2,3,4,5,7,9	6, 8
GN18	1,2,3,4,5,6,9	7, 8
GN32	1,2,3,4,5,6,9	7, 8
GN39	1,2,3,4,5,8	7, 9
GN66	1,2,3,4,5,6,8,9	7
GN67	1,2,3,4,5,6,7,8,9	
GN68	1,2,3,4,5,6,8	7, 9
GN69	1,2,3,4,5,6,7,8,9	
GN71	1,2,3,4,5,6,7,8,9	
GN73	1,2,3,4,5,6,7,8,9	
GN75*	1,2,3,4,5,6,7,8,9	
GN80	1,2,3,4,5,6,8	7, 9

* located outside of the Verification Area

5.2 Assessment against BSAL criteria 10-12 – Soil chemical properties

Assessment of the Verification Area has been made against the soil chemistry criteria, which are as follows:

Criteria 10 Does the pH range from 5.0 – 8.9 if measured in water (or 4.5 to 8.1 if measured in calcium chloride), within the uppermost 600 mm of the profile?

Criteria 11 Is salinity (ECe) ≤4 ds/m or are chlorides < 800 mg/kg when gypsum is present, within the uppermost 600 mm of the soil profile?

Criteria 12 Is effective rooting depth to a chemical barrier ≥750 mm?

Criteria for assessing effective rooting depth to a chemical barrier have been taken from Table 4 of the Interim Protocol. These are as follows:

- pH 5.0-8.9, if measured in water
- ECe < 4 dS/m
- ESP < 15%
- Ca:Mg ratio > 0.1

The summary of the results of all detailed soils is presented in **Table 5.5**, the detailed assessment of each sample against Criteria 10 and 11 are presented in **Appendix A**. Laboratory test results taken from the detailed soil test pits are included in **Appendix B.**

Table 5.5 Summary of assessment of Criteria 10-12

Site ID	Pass Criteria 10	Pass Criteria 11	Pass Criteria 12
GN3*	Yes	Yes	Yes
GN4	Yes	Yes	Yes
GN5	Yes	Yes	No
GN6	Yes	Yes	No
GN7	No	Yes	No
GN8	Yes	Yes	No
GN9	Yes	Yes	Yes
GN10	Yes	Yes	Yes
GN11	Yes	Yes	Yes
GN12	Yes	Yes	Yes
GN13	Yes	Yes	Yes
GN14	Yes	Yes	No
GN15	Yes	Yes	No
GN16	Yes	Yes	Yes
GN17	Yes	Yes	No
GN18	Yes	Yes	No
GN32	Yes	Yes	Yes
GN39	Yes	Yes	No

Site ID	Pass Criteria 10	Pass Criteria 11	Pass Criteria 12
GN66	Yes	Yes	No
GN67	Yes	Yes	No
GN68	Yes	No	No
GN69	Yes	Yes	Yes
GN71	Yes	Yes	Yes
GN73	Yes	Yes	Yes
GN75*	Yes	Yes	Yes
GN80	Yes	Yes	Yes

* located outside of the Verification Area

5.2.1 Soil chemistry verification criteria – Summary

Several of the assessed sites fail the soil chemistry verification criteria (Criteria 10-12).

5.3 Mapping of BSAL

GN9, GN69 and GN71 (all Chromosols) as well as, GN73 and GN75 (both Tenosols) meet all 12 BSAL criteria and thus are considered BSAL. The latter (GN75) is now located outside the Verification Area.

All sites are located in Bowmans Creek upper floodplain terrace. The total area of BSAL within the Verification Area is approximately 34 ha, or less than 5% of the Verification Area under assessment. The majority of this is situated to the east of Bowmans Creek, with a small parcel, associated with GN75, sited to the north of the creek. Of this smaller BSAL area less than 1 ha is located within the Verification Area, and thus does not comply with the minimum size criterion of 20 ha. However, it is expected that BSAL continues in the area adjacent to GN75 (**Figure 5.2**). Contiguous BSAL in the area outside of the Verification Area has been estimated based on the original Upper Hunter SRLUP mapping, slope analysis and previous mapping by GSSE (2013). As the total area of contiguous areas of estimated BSAL adjacent to the BSAL area around GN75 within the Verification Area exceeds 20 ha, this area has also been assessed as being BSAL.

Table 5.6 BSAL results

Site ID	BSAL criteria passed	BSAL criteria failed
GN3*	1,2,3,4,5,6,9,10,11,12	7,8
GN4	1,2,3,4,5,8,9,10,11,12	7
GN5	1,2,3,4,5,6,8,10,11	7,9,12
GN6	1,2,3,4,5,6,8,10,11	7,9,12
GN7	1,2,3,4,5,6,7,8,10,11	7,9,12
GN8	1,2,3,4,5,6,9,10,11	7,8,12
GN9	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN10	1,2,3,4,5,6,8,9,10,11,12	7
GN11	1,2,3,4,5,6,8,9,10,11,12	7
GN12	1,2,3,4,5,6,8,10,11,12	7,9
GN13	1,2,3,4,5,6,8,10,11,12	7,9
GN14	1,2,3,4,5,6,8,10,11	7,9,12
GN15	1,2,3,4,5,6,10,11	7,8,9,12

Site ID	BSAL criteria passed	BSAL criteria failed
GN16	1,2,3,4,5,6,10,11,12	7,8,9
GN17	1,2,3,4,5,7,9,10,11	6,8,12
GN18	1,2,3,4,5,6,9,10,11	7,8,12
GN32	1,2,3,4,5,6,9,10,11,12	7,8
GN39	1,2,3,4,5,8,10,11	7,9,12
GN66	1,2,3,4,5,6,8,9,10,11	7,12
GN67	1,2,3,4,5,6,7,8,9,10,11	12
GN68	1,2,3,4,5,6,8,10	7,9,11,12
GN69	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN71	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN73	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN75*	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN80	1,2,3,4,5,6,8,10,11,12	7,9

* located outside of the Verification Area. GN75 is located in the contiguous BSAL: Area adjacent to the Verification Area.

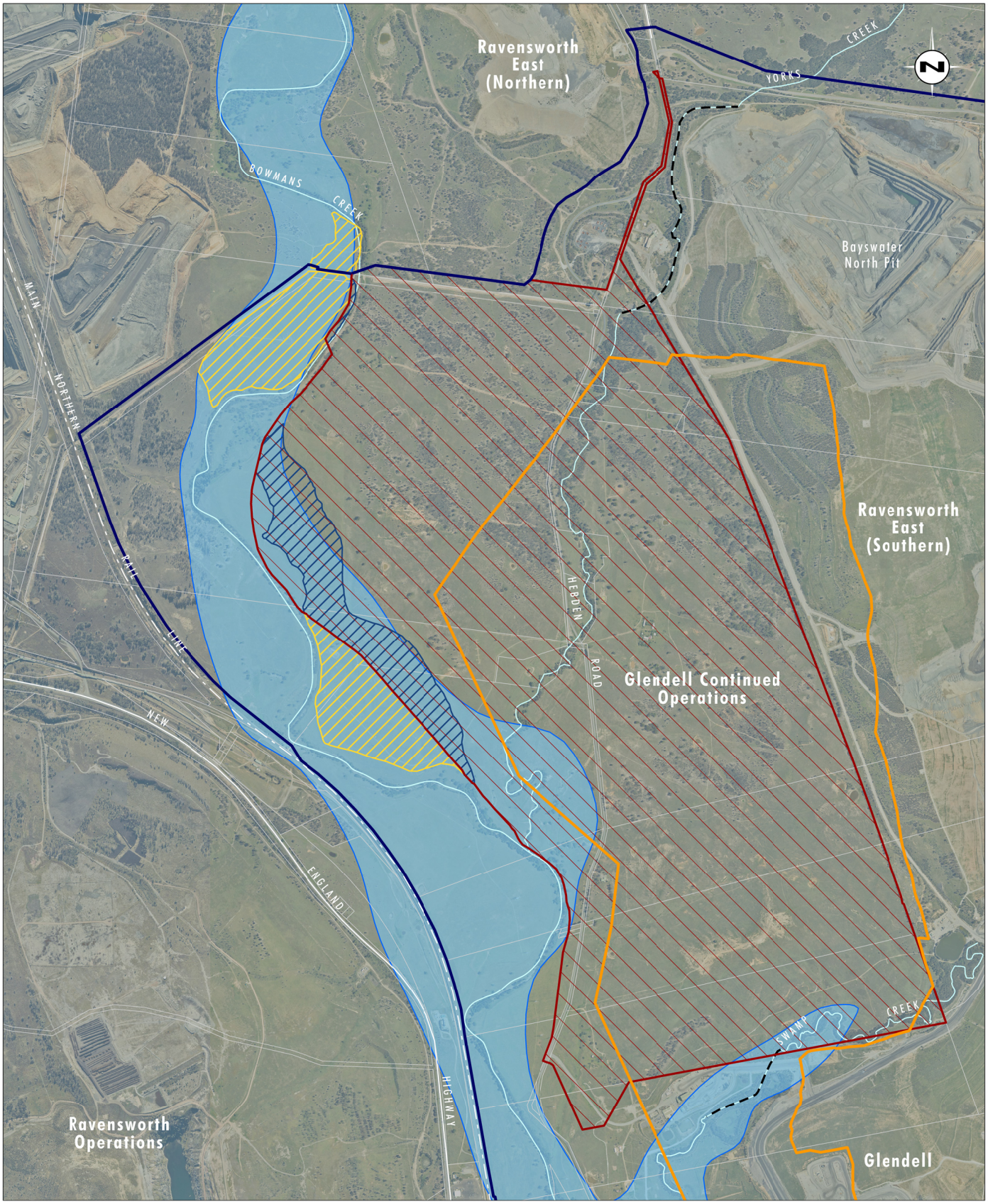


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), NSW Department of Planning and Infrastructure (2013)

0 0.25 0.5 1.0km
1:25 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Verification Area
- Mapped BSAL (Upper Hunter SRLUP, 2013)
- Verified BSAL within Verification Area
- Contiguous BSAL (Extrapolated from Verification Area)
- Existing Creek Diversion

FIGURE 5.2

Upper Hunter SRLUP BSAL mapping and Verified BSAL in Verification Area

File Name (A4): R04/4166_068.dgn
20190129 9.15

6.0 Conclusion

The results of the BSAL verification, using both the Upper Hunter SRLUP assessment methodology and the Interim Protocol, illustrate that there are two parcels of BSAL within the Verification Area. These areas are mapped in **Figure 5.2**. All other areas in the Verification Area fail at least one of the BSAL assessment criteria.

All relevant soil morphological and laboratory data have been uploaded into the NSW Soil and Land Information System database and the approved laboratory data template, as per the Site Verification Certificate guidelines.

7.0 References

Department of Planning and Infrastructure (DP&I) (2012). Strategic Regional Land-use Plan for the Upper Hunter.

GSS Environmental (2013), Liddell Coal Operations Proposed Modification 5. Soil and Land Resource Assessment.

Isbell, R.F. (1996). Australian Soil Classification. CSIRO Publishing, Australia.

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

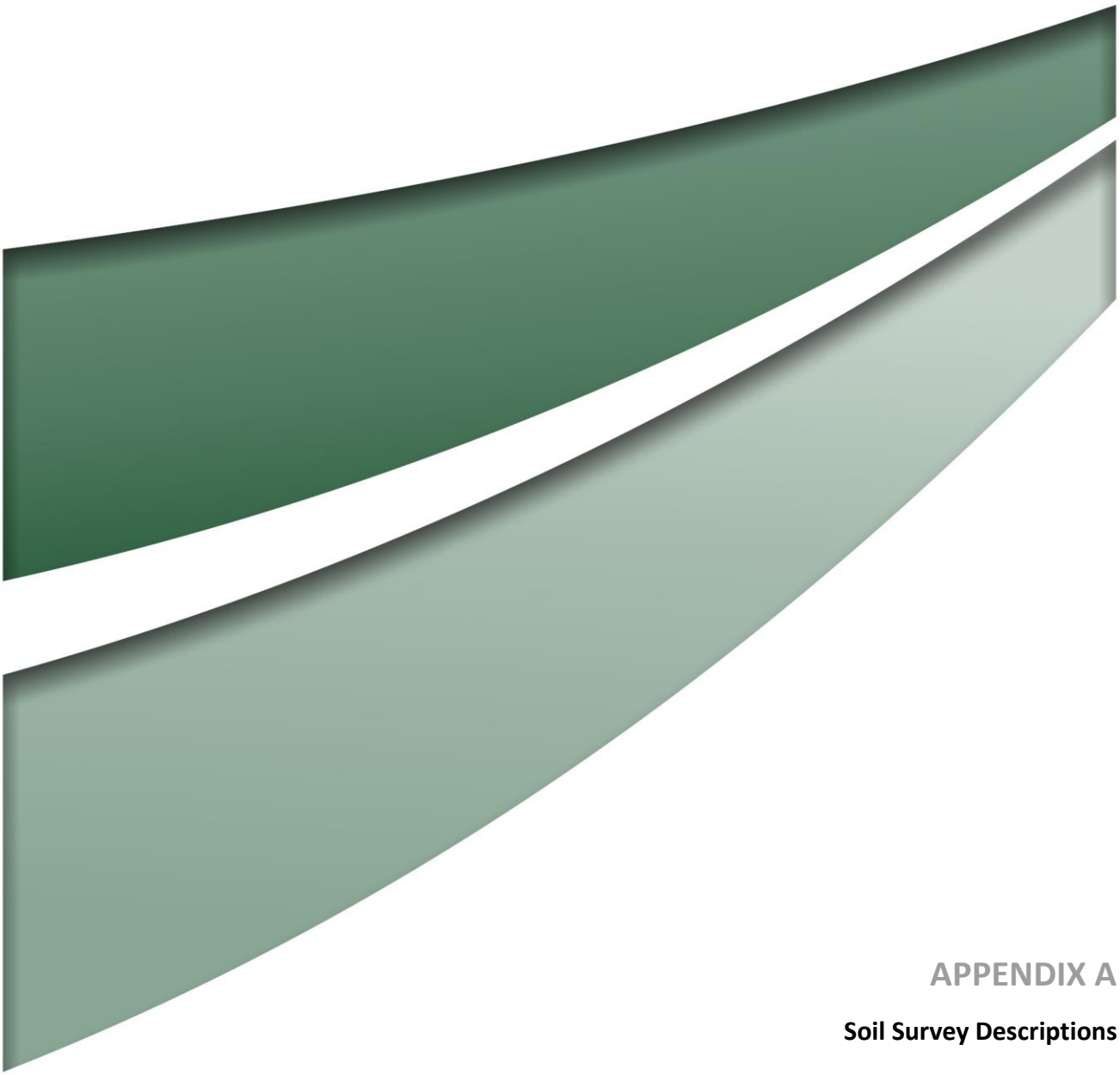
NSW Government (2015). Strategic Regional Land Use Policy – Guideline for Agricultural Impact Statements at the Exploration Stage.

NSW Government (2013), Interim Protocol for site verification mapping of biophysical strategic agricultural land.

Umwelt (Australia) Pty Limited (Umwelt) (2015). Mount Owen Continued Operations Project: Soil Assessment.

Umwelt (Australia) Pty Limited (Umwelt) (2016). Mount Owen Continued Operations Project. Site Verification Certificate Report.

Umwelt (Australia) Pty Limited (Umwelt) (2017). Application for verification of biophysical strategic agricultural land. Mount Owen Continued Operations Modification 2.



APPENDIX A

Soil Survey Descriptions

Appendix A

Detailed sites

Please note for all detailed sites: Laboratory pH was measured in a 1:5 soil water solution. Where more than one sample has been analysed within a horizon, the results have been averaged.

GN1: Site was removed due to change in survey area

GN2: Site was removed due to archaeological concerns

GN3	**Datum: GDA 94 Zone 56** **Easting: 316167.86** **Northing: 6412599.88** **Recorded: 22nd August 2017**
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 650 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Well drained Profile permeability: Highly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics	
A11 0-100 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Loam. pH 5.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A12 100-200 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Loam. pH 5.4. Apedal massive structure, sandy fabric. Sharp boundary.
B21 200-650 mm	7.5YR 4/4 (moderately moist) Coarse Sandy Loam. pH 6.1 Apedal massive structure, sandy fabric. Abrupt boundary.
2B2 650^{+} mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay. pH 7.6 Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Many (20-50%) 20-60 mm sub-rounded conglomerate large pebbles. Limit of observation.

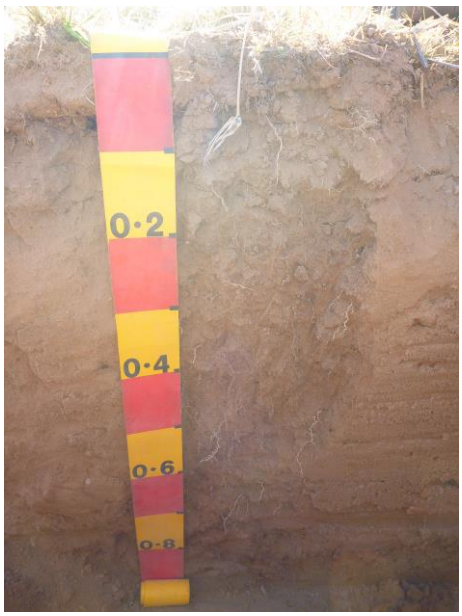
GN3 soil profile

GN 3, lower Bowmans Creek floodplain, looking west towards Bowmans Creek

GN4	Datum: GDA 94 Zone 56 Easting: 316605.64 Northing: 6412795.75 Recorded: 22nd August 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 850+ mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Rapidly drained Profile permeability: Highly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Stratic Rudosol

Profile Characteristics	
A1 0-150 mm	7.5YR 4/4 (moderately moist) Sandy Loam. pH 5.9. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 6-20 mm sub-angular conglomerate pebbles Abrupt boundary.
2A1 150-300 mm	7.5YR 4/4 (moderately moist) Loamy Coarse Sand. pH 6.1. Apedal massive structure, sandy fabric. Few (2-10%) 6-20 mm angular medium pebbles Gradual boundary.
2B2 150-850 mm	7.5YR 4/6 (moderately moist) Loamy Coarse Sand. pH 6.6. Apedal massive structure, sandy fabric. Few (2-10%) 6-20 mm angular medium pebbles Gradual boundary.
D 850^{+} mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay Loam. pH 7.0[1] Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%) 2-6 mm, maganiferous, soft segregations. Limit of observation.

[1] Field pH as maximum sampled depth is 600-800 mm



GN4 soil profile

GN4, upper floodplain terrace, looking west towards Bowmans Creek

GN5	Datum: GDA 94 Zone 56 Easting: 316762.92 Northing: 6413504.17 Recorded: 21st August 2017
Landscape Element: Hillslope Slope: 5% Soil Surface Condition: Hard setting Vegetation: Bulloak regeneration, derived native grassland Estimated effective rooting depth: 180 mm Ground cover: 80% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-10mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay Loam. pH 5.5[2]. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp, broken boundary.
A2 10-180 mm	7.5YR 4/2 (moderately moist), 7.5YR 7/1 (dry) Sandy Loam. pH 6.1. Apedal massive structure, sandy fabric. Many (20-50%) 6-20 mm sub-rounded conglomerate medium pebbles. Abrupt boundary.
B21 180-600 mm	7.5YR 4/3 (moderately moist) Coarse Sandy Medium Clay. pH 8.1 Moderate pedality, rough-ped fabric, sub-angular structure, 5-10 mm. Few (2-10%) medium, faint orange mottles. Few (2-10%) 6-20 mm sub-rounded medium pebbles. Abrupt boundary.
B22 600^{+} mm	7.5YR 5/4 (moderately moist) Coarse Sandy Medium Clay (light). pH 8.8 Moderate pedality, rough-ped fabric, sub-angular structure, 10-20 mm. Few (2-10%) medium, faint orange mottles Few (2-10%) 20-60 mm sub-rounded large pebbles. Limit of observation.

[2] Field pH. This horizon was not sampled as not sufficient material was available for sampling without sample contamination with A2 horizon.

GN5 soil profile

GN5, looking south

GN6	Datum: GDA 94 Zone 56 Easting: 317903.81 Northing: 6413516.94 Recorded: 23rd August 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Swamp oak, derived native grassland Estimated effective rooting depth: 550 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol

Profile Characteristics	
A1 0-150 mm	10YR 2/1 (moderately moist) Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 150-250 mm	10YR 3/4 (moderately moist), 10YR 6/4 (dry) Sandy Clay Loam. pH 7.4. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Clear boundary.
B21 250-550 mm	10YR 4/4 (moderately moist) Medium Heavy Clay. pH 8.1. Moderate pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Common (10-20%), medium, distinct, orange mottles Gradual boundary
B22 550^{+} mm	10YR 4/6 (moderately moist) Coarse Sandy Light Clay. pH 8.6. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Few (2-10%), medium, prominent, brown mottles. Very few (<2%) 6-20 mm, rounded, conglomerate pebbles. Limit of observation.

GN6, soil profile

GN6, looking south

Commencing erosion (left), eroded out coarse fragments (right) to the east GN6 close to Yorks Creek

GN7	Datum: GDA 94 Zone 56 Easting: 317710.71 Northing: 6412911.23 Recorded: 24th August 2017
Landscape Element: Footslope Slope: 1% Soil Surface Condition: Firm Vegetation: Swamp oak, Bulloak, derived, native grassland Estimated effective rooting depth: 280 mm Ground cover: 80% Run on: High	Run-off: Low Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-120 mm	7.5YR 4/4 (moderately moist) Sandy Loam. pH 5.0. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 120-280 mm	7.5YR 6/3 (moderately moist), 7.5YR 7/2 (dry) Sandy Loam. pH 5.9. Apedal massive structure, sandy fabric. Sharp boundary.
B21 280-500 mm	7.5YR 4/4 (moderately moist) Light Medium Clay. pH 7.1 Moderate pedality, rough-ped fabric, columnar breaking to angular blocky structure, 5-10 mm. Common (10-20%), medium, distinct, orange mottles Clear boundary
B22 500-800 mm	7.5YR 5/6 (moderately moist) Coarse Sandy Light Clay. pH 8.2. Moderate pedality, rough-ped fabric, columnar breaking to angular blocky structure, 5-10 mm. Few (2-10%), medium, distinct, orange mottles Gradual boundary
B23 800^{+} mm	7.5YR 5/4 (moderately moist) Coarse Sandy Light Clay. pH 8.5[3]. Moderate pedality, rough-ped fabric, columnar breaking to angular blocky structure, 5-10 mm. Many (20-50%), fine, distinct, orange mottles Limit of observation.

[3] Field pH as maximum sampling depth 500-800 mm

GN7, soil profile

GN7, looking south

GN8	Datum: GDA 94 Zone 56 Easting: 316864.54 Northing: 6412284.91 Recorded: 22nd August 2017
Landscape Element: Hillslope Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 600 mm Ground cover: 100% Run on: High	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-80 mm	7.5YR 3/2 (moderately moist) Coarse Sandy Clay Loam. pH 5.4. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 80-200 mm	7.5YR 4/4 (moderately moist), 7.5YR 6/4 (dry) Coarse Sandy Clay Loam. pH 5.8. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Common (10-20%), 2-6 mm, sub-angular conglomerate pebbles. Abrupt boundary.
B21 200-600 mm	7.5YR 3/4 (moderately moist) Light Medium Clay. pH 7.1. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%), medium, faint, orange mottles. Clear boundary
BC 600^{+} mm	7.5YR 3/4 (moderately moist) Coarse Sandy Light Clay. pH 8.2. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Few (2-10%), medium, faint, orange mottles. Many (20-50%), 20-60 mm, rounded large pebbles. Common (10-20%), 20-60 mm, ferruginous, weak fragments. Limit of observation.

GN8, soil profile

GN8, looking east (uphill)

GN9	Datum: GDA 94 Zone 56 Easting: 316796.97 Northing: 6411918.12 Recorded: 22nd August 2017
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 700+ mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol

Profile Characteristics	
A1 0-100 mm	7.5YR 3/3 (moderately moist) Sandy Clay Loam. pH 6.3. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
B21 100-400 mm	7.5YR 4/4 (moderately moist) Sandy Loam. pH 6.4. Apedal massive structure, sandy fabric. Very few (<2%), 2-6 mm, rounded conglomerate pebbles. Abrupt boundary.
B22 400-700 mm	7.5YR 4/4 (moderately moist) Coarse Sandy Light Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Clear boundary
B23 700^{+} mm	7.5YR 3/4 (moderately moist) Coarse Sandy Light Clay. pH 7.5. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Limit of observation.

GN9, soil profile

GN8, upper terrace of Bowmans Creek floodplain, looking east towards rollomg hills

GN10	**Datum: GDA 94 Zone 56** **Easting: 317773.7** **Northing: 6412189.84** **Recorded: 23rd August 2017**
Landscape Element: Backplain Slope: 0% Soil Surface Condition: Firm Vegetation: Swamp oak Estimated effective rooting depth: 900+ mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Rapidly drained Profile permeability: Highly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Stratic Rudosol

Profile Characteristics	
A1 0-50 mm	7.5YR 3/4 (moderately moist) Silty Clay Loam. pH 6.4. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
B21 50-180 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.4. Apedal massive structure, sandy fabric. Gradual boundary.
B22 180-300 mm	7.5YR 3/2 (moderately moist) Coarse Sandy Clay Loam (heavy). pH 6.6. Apedal massive structure, sandy fabric. Gradual boundary
B23 300^{+} mm	At 300 mm: 7.5YR 3/4 (moderately moist) Loamy Sand. pH 6.5. Apedal massive structure, sandy fabric. At 600 mm: 7.5YR 4/4 (moderately moist) Loamy Sand. pH 6.8. Apedal massive structure, sandy fabric. Limit of observation.

GN10, soil profile

GN10 on Yorks Creek floodplain, looking south

GN11	Datum: GDA 94 Zone 56 Easting: 317945.92 Northing: 6412465.9 Recorded: 18th August 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland, red gum regeneration Estimated effective rooting depth: 800 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Well drained Profile permeability: Highly permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Stratic Rudosol

Profile Characteristics	
A1 0-100 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.4. Moderate rough-ped fabric, granular structure, 5-10 mm. Abrupt boundary.
2D 100-250 mm	10YR 4/3 (moderately moist) Fine Sandy Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Abrupt boundary.
3D 250-350 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.1. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary
4D 350-500 mm	10YR 5/3 (moderately moist) Silty Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary
5D 500^{+} mm	10YR 3/2 (moderately moist) Silty Clay. pH 5.9. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Limit of observation.

GN11, soil profile

GN11, looking west towards Bowmans Creek

GN12	Datum: GDA 94 Zone 56 Easting: 318308.87 Northing: 6411895.18 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 2% Soil Surface Condition: Firm Vegetation: Derived native grassland, box ironbark Estimated effective rooting depth: 600 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-20 mm	10YR 4/3 (moderately moist) Silty Clay Loam. pH 5.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 20-100 mm	10YR 6/2 (moderately moist), 10YR 7/2 (dry) Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (10-20%), 6-20 mm sub-rounded ironstone pebbles. Abrupt boundary.
B21 100-600 mm	10YR 5/4 (moderately moist) Medium Clay. pH 6.2. Moderate pedality, rough-ped fabric, angular blocky structure, 20-50 mm. Few (2-10%), fine, distinct, orange mottles. Gradual boundary
B22 600-700 mm	10YR 5/6 (moderately moist) Sandy Light Clay. pH 6.6. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Many (20-50%), fine, distinct, orange mottles. Gradual boundary
B23 700-800 mm	10YR 4/6 (moderately moist) Light Clay. pH 7.0[4]. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Gradual boundary
C1 800^{+} mm	10YR 5/6 (moderately moist) Coarse Sandy Clay Loam. pH 7.0[5]. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Limit of observation.

[4] Field pH, maximum laboratory sampling depth 600-700 mm

GN12, soil profile

GN12, looking north

GN13	**Datum: GDA 94 Zone 56** **Easting: 317454.85** **Northing: 6411679.84** **Recorded: 21st August 2017**
Landscape Element: Backplain Slope: 0% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 800 mm Ground cover: 100% Run on: High	Run-off: Low Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Kandosol

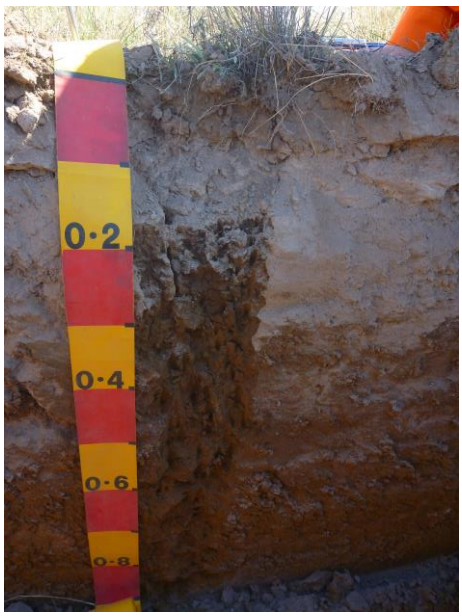
Profile Characteristics	
A11 0-100 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.1. Strong pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
B21 100-400 mm	7.5YR 3/3 (moderately moist) Silty Clay Loam. pH 6.2. Apedal massive structure, sandy fabric. Common (10-20%), medium, distinct, orange mottles. Gradual boundary
B21 400-500 mm	10YR 3/4 (moderately moist) Light Clay Fine Sandy. pH 6.6. Apedal massive structure, sandy fabric. Common (10-20%), medium, distinct, brown mottles. Abrupt boundary
B23 500^{+} mm	10YR 2/1 (moderately moist) Silty Clay Loam. pH 6.7. Moderate pedality, rough-ped fabric, angular blocky structure, 10-50 mm. Limit of observation.

GN13, soil profile

GN13, Yorks Creek floodplain, looking south

GN14	Datum: GDA 94 Zone 56 Easting: 317692.56 Northing: 6411438.11 Recorded: 23rd August 2017
Landscape Element: Footslope Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 650 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-50 mm	7.5YR 4/4 (moderately moist) Silty Clay Loam. pH 5.3. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 50-150	7.5YR 6/1 (moderately moist), 7.5YR 7/1 (dry) Coarse Sandy Clay Loam. pH 5.9. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Abrupt boundary.
B21 150-400 mm	7.5YR 3/4 (moderately moist) Light Medium Clay. pH 6.8. Strong pedality, rough-ped fabric, columnar breaking to sub-angular blocky, 20-50 mm. Common, fine, macropores. Clear boundary
B22 400-600 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Light Clay. pH 7.6. Strong pedality, rough-ped fabric, sub-angular blocky structure, 10-20 mm. Gradual boundary
B23 600^{+} mm	7.5YR 4/6 (moderately moist) Coarse Sandy Light Clay. pH 6.7. Strong pedality, rough-ped fabric sub-angular blocky structure, 10-20 mm. Common (10-20%), medium, distinct, brown mottles. Limit of observation.



GN14, soil profile

GN14, looking west towards York Creek

GN15	Datum: GDA 94 Zone 56 Easting: 318473.97 Northing: 6411428.96 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 2% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 650 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Conglomerate Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Kandosol

Profile Characteristics	
A1 0-100 mm	10YR 5/3 (moderately moist) Sandy Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 2-6 mm, rounded conglomerate pebbles. Clear boundary.
B21 100-250	10YR 4/3 (moderately moist) Sandy Clay Loam. pH 5.8. Apedal massive structure, sandy fabric. Common (10-20%) 6-20 mm, rounded conglomerate pebbles. Gradual boundary.
B22 250-600 mm	10YR 5/3 (moderately moist) Coarse Sandy Clay Loam. pH 6.3. Apedal massive structure, sandy fabric. Many (20-50%) 20-60 mm, rounded conglomerate large pebbles. Gradual boundary
BC 600^{+} mm	10YR 5/3 (moderately moist) Light Clay. pH 6.5[5]. Apedal massive structure, sandy fabric. Many (20-50%), very coarse, distinct brown mottles. Many (20-50%) 6-20 mm, rounded conglomerate pebbles. Limit of observation.

[5] Field pH, maximum soil sampling depth 600-650 mm

GN15, soil profile

GN15, looking east

GN16	Datum: GDA 94 Zone 56 Easting: 318664.87 Northing: 6411039.89 Recorded: 17th August 2017
Landscape Element: Hillcrest Slope: 2% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 580 mm Ground cover: 100% Run on: Low	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Mudstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Red Chromosol

Profile Characteristics	
A1 0-30 mm	10YR 4/4 (moderately moist) Sandy Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Clear boundary.
A2 30-250 mm	7.5YR 5/2 (moderately moist), 7.5YR 7/2 (dry) Sandy Clay Loam. pH 5.8. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Abrupt boundary.
B21 250-480 mm	5YR 4/6 (moderately moist) Medium Heavy Clay. pH 6.6. Moderate pedality, smooth-ped fabric, sub-angular blocky structure, 5-10 mm. Diffuse boundary.
B22 480-580 mm	7.5YR 4/6 (moderately moist) Light Medium Clay. pH 6.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm Diffuse boundary
Cv 580^{+} mm	Soft Mudstone breaking into 10-50 mm, angular-blocky fragments. Limit of observation.

GN16, soil profile

GN16, looking north

GN17	Datum: GDA 94 Zone 56 Easting: 317900.59 Northing: 6411256.12 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 4% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 600 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Mudstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Red Dermosol

Profile Characteristics	
A1 0-150 mm	7.5YR 3/4 (moderately moist) Silty Light Clay. pH 6.1. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 2-6 mm, rounded conglomerate pebbles. Diffuse boundary.
B21 150-450	5YR 4/6 (moderately moist) Medium Heavy Clay. pH 6.2. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%) fine, faint, yellow mottles. Clear boundary.
B22 450-600 mm	10YR 4/6 (moderately moist) Medium Clay. pH 6.9. Strong pedality rough-ped fabric, angular blocky structure, 10-20 mm. Many (20-50%) fine, faint, orange mottles. Clear boundary
B23 600-700 mm	2.5YR 4/4 (moderately moist) Light Clay. pH 7.8. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Many (20-50%) 2-6 mm, angular, mudstone small pebbles. Sharp boundary
Cv 700^{+} mm	Soft Mudstone breaking into 10-50 mm, angular-blocky fragments. Limit of observation.

GN17, soil profile

GN17, looking west towards Hebden Road

GN18	Datum: GDA 94 Zone 56 Easting: 317710.16 Northing: 6410715.06 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 800 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Mudstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A11 0-100 mm	7.5YR 3/4 (moderately moist) Silty Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Very few (<2%) 2-6 mm, sub-rounded pebbles. Abrupt boundary.
A12 100-300 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Clear boundary.
B21 300-450 mm	7.5YR 2.5/3 (moderately moist) Medium Heavy Clay (Heavy). pH 6.6. Moderate pedality, smooth-ped fabric, angular blocky structure, 5-10 mm. Very few (<2%) fine, faint, orange mottles. Abrupt boundary
B22 450-750 mm	7.5YR 4/6 (moderately moist) Medium Heavy Clay (Heavy). pH 7.0. Strong pedality, smooth-ped fabric, angular blocky structure, 5-10 mm. Many (20-50%) 6-20 mm, angular medium pebbles. Gradual boundary
B23 750^{+} mm	7.5YR 5/8 (moderately moist) Medium Heavy Clay (Heavy). pH 7.0[6]. Strong pedality, smooth-ped fabric, angular blocky structure, 5-10 mm. Many (20-50%) 2-60 mm, angular small pebbles. Limit of observation.

[6] Field pH, maximum sampling depth 450-750 mm.

GN18, soil profile

GN18, looking north

GN32	**Datum: GDA 94 Zone 56** **Easting: 317231.37** **Northing: 6411954.52** **Recorded: 21st August 2017**
Landscape Element: Hillcrest Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 350/600 mm Ground cover: 100% Run on: Low	Run-off: Moderate Profile drainage: Well drained Profile permeability: Highly permeable Evidence of erosion: No Lithology: Conglomerate Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Clastic Rudosol

Profile Characteristics	
A1 0-100 mm	10YR 3/3 (moderately moist) Coarse Sandy Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 2-6 mm, sub-rounded, small pebbles. Abrupt boundary.
B21 100-350/600 mm	10YR 4/3 (moderately moist) Coarse Sandy Clay Loam. pH 5.8. Strong pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%) 6-20 mm, sub-rounded, medium pebbles. Clear, wavy boundary.
BC 350/600^{+} mm	Weathered conglomerate Limit of observation.

GN32, soil profile

GN32, looking west

Sandstone outcrop downhill of GN32

GN39	Datum: GDA 94 Zone 56 Easting: 317916.48 Northing: 6410765.52 Recorded: 23rd August 2017
Landscape Element: Hillslope Slope: 5% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 680 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Sandstone/Mudstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-100 mm	7.5YR 3/3 (moderately moist) Silty Clay Loam. pH 5.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 100-150 mm	7.5YR 3/3 (moderately moist), 7.5YR 7/1 (dry) Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Sharp boundary.
B21 150-300 mm	7.5YR 2.5/2 (moderately moist) Medium Heavy Clay (Light). pH 6.5. Moderate pedality rough-ped fabric, angular blocky structure, 10-20 mm. Common (10-20%), fine, faint, red mottles. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Clear boundary.
B22 300-680 mm	7.5YR 4/4 (moderately moist) Medium Heavy Clay. pH 6.9. Strong pedality, smooth-ped fabric, angular blocky structure, 20-40mm. Common (10-20%), medium, distinct, brown biological mixing. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Common, medium, macropores. Abrupt boundary
B23 680^{+} mm	10YR 4/6 (moderately moist) Medium Heavy Clay (Heavy). pH 6.6. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%) 2-6 mm, sub-rounded, small pebbles. Very few (<2%) medium, manganiferous, soft segregations. Common, medium, macropores Limit of observation.

GN39, soil profile

GN39, looking south

Surface rock near GN39 site

GN66	Datum: GDA 94 Zone 56 Easting: 317605.07 Northing: 6411599.96 Recorded: 12th October 2017
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 580 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Sodosol

Profile Characteristics	
A1 0-20 mm	10YR 3/3 (moderately moist) Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Broken boundary.
A2 20-150 mm	10YR 4/2 (moderately moist), 10YR 6/2 (dry) Clay Loam. pH 5.7. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Very few (<2%) 6-20 mm, sub-rounded, medium pebbles. Sharp boundary.
B21 150-400 mm	10YR 3/1 (moderately moist) Medium Clay. pH 6.6. Strong pedality, rough-ped fabric, prismatic structure, 10-20 mm. Common, fine macropores. Gradual boundary.
B22 400-580 mm	10YR 3/2 (moderately moist) Medium Clay. pH 6.8. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Few (2-10%) 6-20 mm, sub-angular, medium pebbles. Common, fine macropores. Gradual boundary.
B23 580-800 mm	10YR 3/3 (moderately moist) Medium Clay. pH 6.9. Moderate pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Gradual boundary.
B24 800^{+} mm	10YR 3/3 (moderately moist) Light Clay. pH 7.0[7]. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (2-10%) 2-6 mm, sub-angular, medium pebbles. Limit of observation.

[7] Field pH, maximum sampling depth 580-800 mm

GN66, soil profile

GN66, looking north

GN67	Datum: GDA 94 Zone 56 Easting: 317507.04 Northing: 6411450.76 Recorded: 12th October 2017
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 950 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Dermosol

Profile Characteristics	
A1 0-100 mm	7.5YR 4/2 (moderately moist) Light Clay. pH 5.9. Moderate pedality, rough-ped fabric, granular structure, 5-10 mm. Common, medium macropores. Gradual boundary.
B21 100-300 mm	10YR 3/1 (moderately moist) Medium Clay. pH 5.9. Strong pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common (10-20%), fine, faint, orange mottles. Common, medium macropores. Gradual boundary.
B22 300-600 mm	10YR 3/2 (moderately moist) Medium Heavy Clay. pH 7.4. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Few (<10%), distinct slickensides. Few, medium macropores. Diffuse boundary.
B23 600^{+} mm	10YR 3/3 (moderately moist) Heavy Clay. pH 8.1. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%), fine, faint, orange mottles. Limit of observation.

GN67, soil profile

GN67, looking north

Slickenside in GN67 soil profile

GN68	Datum: GDA 94 Zone 56 Easting: 317219.21 Northing: 6411484.79 Recorded: 12th October 2017
Landscape Element: Footslope Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth:150 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Sodosol

Profile Characteristics	
A1 0-10 mm	7.5YR 2.5/3 (moderately moist) Clay Loam. pH 6.0[8]. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Broken boundary.
A2 10-180 mm	10YR 4/2 (moderately moist), 10YR 6/2 (dry) Silty Clay Loam. pH 5.9 Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Sharp boundary.
B21 180-400 mm	10YR 3/2 (moderately moist) Medium Clay. pH 6.8. Strong pedality, rough-ped fabric, prismatic structure, 5-10 mm. Few (2-10%), fine, faint, orange mottles. Gradual boundary.
B22 400-700 mm	10YR 3/4 (moderately moist) Light Clay. pH 8.1. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%), fine, faint, orange mottles. Few (2-10%), fine, manganiferous weak nodules and soft segregations. Diffuse boundary.
B23 700^{+} mm	10YR 3/6 (moderately moist) Light Clay. pH 8.7. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Common (10-20%), medium –coarse manganiferous weak nodules and soft segregations. Limit of observation.

[8] Field pH, A1horizon too thin and broken to sample for laboratory analysis without contamination with A2

GN68, soil profile

GN68, looking north

GN69	Datum: GDA 94 Zone 56 Easting: 317088.29 Northing: 6411642.67 Recorded: 12th October 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 1100 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol

Profile Characteristics	
A1 0-100 mm	7.5YR 2.5/3 (moderately moist) Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 100-400 mm	7.5YR 3/2 (moderately moist), 7.5YR 5/2 (dry) Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Abrupt boundary.
B21 400-630 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Medium Heavy Clay. pH 6.8. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%), medium, manganiferous soft segregations. Clear boundary.
2D 630-850 mm	7.5YR 3/4 (moderately moist) Sand. pH 7.3. Apedal massive structure, sandy fabric. Abrupt boundary.
3D 850-950 mm	7.5YR 4/4 (moderately moist), Coarse Sandy Clay Loam. pH 7.0[9]. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Abrupt boundary
4D 950^{+} mm	7.5YR 2.5/2 (moderately moist) Light Clay (light). pH 7.0[10]. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%), fine, distinct, orange mottles. Very few (<2%), fine, manganiferous soft segregations. Limit of observation.

[9] Field pH, maximum sampling depth 630-850 mm

[10] Field pH, maximum sampling depth 630-850 mm

GN69, soil profile

GN69, looking west towards Bowmans Creek

GN71	Datum: GDA 94 Zone 56 Easting: 316552.76 Northing: 6412017.90 Recorded: 11th October 2017
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 1000 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol

Profile Characteristics	
A11 0-120 mm	7.5YR 4/3 (moderately moist) Silty Clay Loam. pH 6.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A12 120-350 mm	7.5YR 4/3(moderately moist), sporadically bleached Silty Clay Loam. pH 5.6. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Sharp boundary.
B21 350-650 mm	7.5YR 3/4 (moderately moist) Medium Clay. pH 6.5. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Gradual boundary.
B22 650-800 mm	7.5YR 4/4 (moderately moist) Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common, coarse macropores. Gradual boundary.
B23 800^{+} mm	7.5YR 2.5/2 (moderately moist) Light Clay. pH 7.0[11]. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Limit of observation.

[11] Field pH, maximum sampling depth650-800 mm

GN71, soil profile

GN71, looking north

GN73	Datum: GDA 94 Zone 56 Easting: 316462.82 Northing: 6412423.32 Recorded: 11th October 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 1000 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics	
A1 0-100 mm	7.5YR 6/3 (moderately moist) Silty Clay Loam. pH 5.4. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
B21 100-280 mm	7.5YR 4/3 (moderately moist) Coarse Sandy Clay Loam. pH 5.4. Apedal massive structure, sandy fabric. Gradual boundary.
B22 280-480 mm	7.5YR 4/3 (moderately moist) Coarse Sandy Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Very few (<2%) 6-20 mm, sub-angular, medium pebbles. Sharp boundary.
2D1 480-750 mm	10YR3/6 (moderately moist) Sandy Light Clay. pH 6.4. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Clear boundary.
2D2 750^{+} mm	10YR 3/4 (moderately moist) Sandy Light Clay. pH 7.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Very few (<2%) 2-6 mm, angular, small pebbles. Limit of observation.

GN73, soil profile

GN73, Bowmans Creek upper floodplain, looking west towards creek

GN75	Datum: GDA 94 Zone 56 Easting: 316554.43 Northing: 6413391.67 Recorded: 21st December 2017
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 900 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics	
A1 0-100 mm	10YR 4/3 (moderately moist) Silty Clay Loam. pH 5.7. Moderate pedality, rough-ped fabric, granular structure, 10-20 breaking to 2-5 mm. Clear boundary.
B21 100-350 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 5.8. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary.
B22 350-600 mm	7.5YR 3/4 (moderately moist) Sandy Clay Loam. pH 6.3. Weak pedality, rough-ped fabric, sub-angular blocky, 2-5 mm. Clear boundary.
2D 600^{+} mm	10YR 2.5/3 (moderately moist) Light Clay Coarse Sandy. pH 6.9. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Limit of observation.

GN75, soil profile

GN75, Bowmans Creek floodplain, looking north

GN80	**Datum: GDA 94 Zone 56** **Easting: 317724.15** **Northing: 6409752.10** **Recorded: 22nd December 2017**
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 700 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Sodosol

Profile Characteristics	
A1 0-180 mm	7.5YR 3/4 (moderately moist) Silty Clay Loam. pH 5.9. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 180-300 mm	7.5YR 5/4 (moderately moist), 7.5YR 7/3 (dry) Silty Clay Loam. pH 6.4. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Abrupt boundary.
B21 300-600 mm	7.5YR 2.5/2 (moderately moist) Medium Clay. pH 7.0. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Gradual boundary.
B22 600-750 mm	7.5YR 3/4 (moderately moist) Light Clay. pH 7.0. Strong pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Common (10-20%) medium, faint, brown mottles. Gradual boundary.
B23 750^{+} mm	7.5YR 2.5/2 (moderately moist) Light Clay light. pH 7.0[12]. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common (10-20%), fine, faint, orange mottles. Limit of observation.

[12] Field pH, maximum sampling depth 600-750 mm

GN80, soil profile

GN80, looking south

Check sites

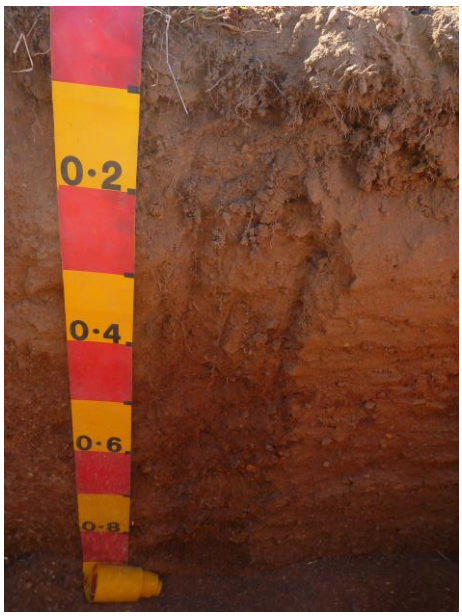
GN19 removed due to change in disturbance boundary

GN20	**Datum: GDA 94 Zone 56** **Easting: 316368.38** **Northing: 6412760.55** **Recorded: 22nd August 2017**
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown-Orthic Tenosol
Profile Characteristics	
A1 0-80 mm	7.5YR 3/3 (moderately moist) Sandy Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Clear boundary.
B21 80-180 mm	7.5YR 3/4 (moderately moist) Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Sharp boundary.
B22 180-400 mm	7.5YR 4/4 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Apedal massive structure, sandy fabric. Clear boundary.
D 400^{+} mm	Clay with visible sand Limit of observation.

GN20, soil profile

GN20, looking west towards Bowmans Creek

GN21	**Datum: GDA 94 Zone 56** **Easting: 316427.17** **Northing: 6412961.44** **Recorded: 22nd August 2017**
Landscape Element: Plain Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown-Orthic Tenosol
Profile Characteristics	
A1 0-100 mm	7.5YR 3/2 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
B21 100-400 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Many (20-50%) 6-20 mm, sub-rounded, medium pebbles. Clear boundary
B22 400-700 mm	7.5YR 4/6 (moderately moist) Light Clay Coarse Sandy. pH 7.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm Abundant (50-90%) 20-60 mm, sub-rounded, large pebbles. Clear boundary
B23 700-800 mm	Increase in clay content
Cv 800^{+} mm	Highly weathered sandstone Limit of observation.



GN21, soil profile

GN21, looking south

GN22	Datum: GDA 94 Zone 56 Easting: 317065.64 Northing: 6413432.98 Recorded: 21st August 2017
Landscape Element: Hillslope Slope: 5% Soil Surface Condition: Hard setting	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Yellow Sodosol

Profile Characteristics	
A1 0-30 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Loam. pH 5.0. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 30-200 mm	7.5YR 5/4 (moderately moist), 7.5YR 7/2 (dry) Loam Fine Sandy. pH 6.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Very few (<2%) 2-6 mm, sub-rounded, medium pebbles. Clear boundary
B21 200-400 mm	7.5YR 6/6 (moderately moist) Light Clay Fine Sandy. pH 6.5. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Many (20-50%), medium, faint, orange and grey mottles. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Clear boundary
B22 400-600 mm	
BC 600^{+} mm	Limit of observation.

GN22, soil profile

GN22, looking south

GN23	**Datum: GDA 94 Zone 56** **Easting: 317661.77** **Northing: 6413418.15** **Recorded: 21st August 2017**
Landscape Element: Hillslope Slope: 3% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Yellow Sodosol
Profile Characteristics	
A1 0-100 mm	7.5YR 3/1 (moderately moist) Clay Loam Fine Sandy. pH 5.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Clear boundary.
A2 100-200 mm	7.5YR 6/2 (moderately moist), 7.5YR 7/1 (dry) Coarse Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Common (10-20%) 6-20 mm, angular, medium pebbles. Abrupt boundary
B21 200-450 mm	7.5YR 4/4 (moderately moist) Medium Heavy Clay. pH 7.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Limit of observation.

GN23, soil profile

GN23, looking east

GN24	Datum: GDA 94 Zone 56 Easting: 317224.72 Northing: 6412986.74 Recorded: 21st August 2017
Landscape Element: Hillslope Slope: 6% Soil Surface Condition: Hard setting	Vegetation: Derived native grassland, bulloak regeneration Lithology: Sandstone Australian Soil Classification (ASC):Brown Sodosol
Profile Characteristics	
A1 0-20 mm	7.5YR 3/2 (moderately moist) Loamy Sand. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp, broken boundary.
A2 20-180 mm	7.5YR 3/3 (moderately moist), 7.5YR 6/2 (dry) Coarse Sandy Clay Loam. pH 6.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Many (20-50%) 6-20 mm, sub-rounded, medium pebbles. Sharp boundary
B21 180-400 mm	7.5YR 5/4 (moderately moist) Medium Clay (light). pH 6.5. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Many (20-50%), coarse, distinct, orange mottles. Very few (<2%) 2-6 mm, sub-rounded, medium pebbles. Limit of observation.
B22 400^{+} mm	

GN24, soil profile

GN24, looking west

GN25	**Datum: GDA 94 Zone 56** **Easting: 318094.44** **Northing: 6412919.49** **Recorded: 18th August 2017**
Landscape Element: Hillslope Slope: 3% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Grey Sodosol
Profile Characteristics	
A1 0-50 mm	10YR 3/2 (moderately moist) Coarse Sandy Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Sharp boundary.
A2 50-300 mm	10YR 5/3 (moderately moist), 10YR 7/2 (dry) Coarse Sandy Clay Loam. pH 5.5. Apedal massive structure, sandy fabric. Many (20-50%) 6-20 mm, sub-rounded, medium pebbles. Sharp boundary
B21 300^{+} mm	7.5YR 4/2 (moderately moist) Sandy Light Clay. pH 6.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%), small, distinct, orange mottles. Many (20-50%) 6-20 mm, sub-rounded, medium pebbles. Limit of observation.

GN25, soil profile

GN25, looking north

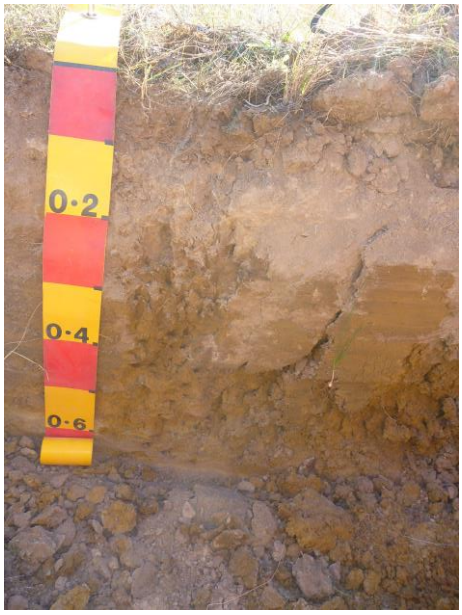
GN26	Datum: GDA 94 Zone 56 Easting: 317830.54 Northing: 6412665.08 Recorded: 18th August 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Black Dermosol

Profile Characteristics	
A1 0-100 mm	7.5YR 2.5/1 (moderately moist) Silty Light Clay. pH 6.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Clear boundary.
B21 100-200 mm	7.5YR 2.5/1 (moderately moist) Medium Clay. pH 6.5. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Common, medium macropores in moist profile. Gradual boundary Limit of observation.
B22 200^{+} mm	

GN26, soil profile

GN26, looking south

GN27	**Datum: GDA 94 Zone 56** **Easting: 317377.36** **Northing: 6412603.47** **Recorded: 22nd August 2017**
Landscape Element: Hillslope Slope: 7% Soil Surface Condition: Hard setting	Vegetation: Derived native grassland, bulloak regeneration Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol
Profile Characteristics	
A1 0-50 mm	7.5YR 3/2 (moderately moist) Sandy Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Very few (<2%) 6-20 mm, sub-rounded, medium pebbles. Abrupt boundary.
A2 50-200 mm	7.5YR 4/2 (moderately moist), 7.5YR 6/2 (dry) Coarse Sandy Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Abrupt boundary
B21 200-500 mm	7.5YR 4/4 (moderately moist) Medium Clay (light). pH 7.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Clear boundary Limit of observation.



GN27, soil profile

GN27, looking north

GN28	**Datum: GDA 94 Zone 56** **Easting: 317604.55** **Northing: 6412344.35** **Recorded: 22nd August 2017**
Landscape Element: Footslope Slope: 5% Soil Surface Condition: Hard setting	Vegetation: Derived native grassland, bulloak regeneration Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol
Profile Characteristics	
A1 0-20 mm	7.5YR 4/2 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp, broken boundary.
A2 20-210 mm	7.5YR 6/3 (moderately moist), 7.5YR 7/1 (dry) Coarse Sandy Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, angular-blocky structure, 5-10 mm. Few (2-10%) 2-6 mm, sub-angular, small pebbles. Abrupt boundary
B21 210^{+} mm	7.5YR 4/6 (moderately moist) Light Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular-blocky structure, 5-10 mm. Few (2-10%) 2-6 mm, sub-angular, small pebbles Few (2-10%) 6-20 mm, ferruginous concretions. Limit of observation.

GN28, soil profile

GN28, looking east towards Hebden Road and Yorks Creek in the far background

GN29	Datum: GDA 94 Zone 56 Easting: 317179.09 Northing: 6412297.07 Recorded: 22nd August 2017
Landscape Element: Hillcrest Slope: 2% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-100 mm	7.5YR 4/4 (moderately moist) Silty Clay Loam. pH 6.5. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Sharp boundary.
A2 100-200 mm	7.5YR 4/4 (moderately moist), 7.5YR 5/4 (dry) Silty Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (2-10%) 6-20 mm, sub-rounded, medium pebbles. Abrupt boundary
B21 200-350 mm	7.5YR 5/8 (moderately moist) Medium Clay. pH 6.5. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%) 2-6 mm, angular, small pebbles Gradual boundary.

GN29, soil profile

GN29, looking west

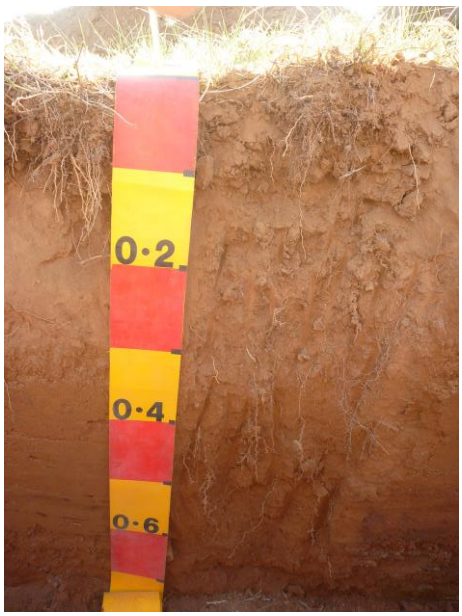
GN29, surface rock (left) and sandstone outcrop (right)

GN30	Datum: GDA 94 Zone 56 Easting: 316629.8 Northing: 6412518.39 Recorded: 22nd August 2017
Landscape Element: Plain Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown Sodosol
Profile Characteristics	
A1 0-150 mm	7.5YR 4/4 (moderately moist) Silty Clay Loam. pH 6.5. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 10-20 mm. Abrupt boundary.
A2 150-350 mm	7.5YR 4/4 (moderately moist), 7.5YR 6/3 (dry) Coarse Sandy Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Abrupt boundary
B21 350-600 mm	7.5YR 4/4 (moderately moist) Medium Heavy Clay. pH 7.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Clear boundary.

GN30, soil profile

GN30, looking east

GN31	**Datum: GDA 94 Zone 56** **Easting: 316603.2** **Northing: 6412196.78** **Recorded: 22nd August 2017**
Landscape Element: Plain Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown-Orthic Tenosol
Profile Characteristics	
A1 0-100 mm	7.5YR 3/3 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Abrupt boundary.
B21 100-330 mm	7.5YR 4/4 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Apedal massive structure, sandy fabric. Gradual boundary
B22 330^{+} mm	7.5YR 4/4 (moderately moist) Coarse Sandy Clay Loam. pH 7.0. Apedal massive structure, sandy fabric. Common (10-20%) 6-20, rounded medium pebbles. Limit of observation.



GN31, soil profile

GN31, Bowmans Creek upper floodplain terrace, looking north

GN33	Datum: GDA 94 Zone 56 Easting: 317642.52 Northing: 6411917.62 Recorded: 24th August 2017
Landscape Element: Backplain Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown-Orthic Tenosol
Profile Characteristics	
A1 0-200 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Clear boundary.
B21 200-500 mm	10YR 4/4 (moderately moist) Silty Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Gradual boundary
B22 500^{+} mm	10YR 3/3 (moderately moist) Sandy Clay Loam. pH 6.5. Apedal massive structure, sandy fabric. Limit of observation.

GN33, soil profile

GN33, looking west

GN34	**Datum: GDA 94 Zone 56** **Easting: 317722.9** **Northing: 6411706.27** **Recorded: 22nd August 2017**
Landscape Element: Footslope Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvial/Sandstone Australian Soil Classification (ASC): Brown Kandosol
Profile Characteristics	
A1 0-150 mm	7.5YR 3/3 (moderately moist) Silty Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Clear boundary.
B21 150-450 mm	7.5YR 3/4 (moderately moist) Silty Clay Loam. pH 6.5. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Common, medium macropores. Gradual boundary
B22 450^{+} mm	7.5YR 3/4 (moderately moist) Coarse Sandy Light Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Common, medium, faint orange mottles. Limit of observation.

GN34, soil profile

GN34, looking west

GN35	Datum: GDA 94 Zone 56 Easting: 318165.62 Northing: 6411477.37 Recorded: 17th August 2017
Landscape Element: Footslope Slope: 1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone/Mudstone Australian Soil Classification (ASC): Brown Chromosol
Profile Characteristics	
A1 0-50 mm	10YR 4/4 (moderately moist) Silty Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 50-200 mm	10YR 5/3 (moderately moist), 10YR 7/1 (dry) Fine Sandy Loam. pH 6.5. Apedal massive structure, sandy fabric. Few (10-20%), 6-20 mm sub-rounded ironstone pebbles. Clear boundary
B21 200-400 mm	10YR 5/2 (moderately moist) Sandy Light Clay. pH 7.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (2-10%)6-20 mm, sub-rounded, medium ironstone pebbles Few, fine, faint, brown mottles. Limit of observation.

GN35, soil profile

GN35, looking north

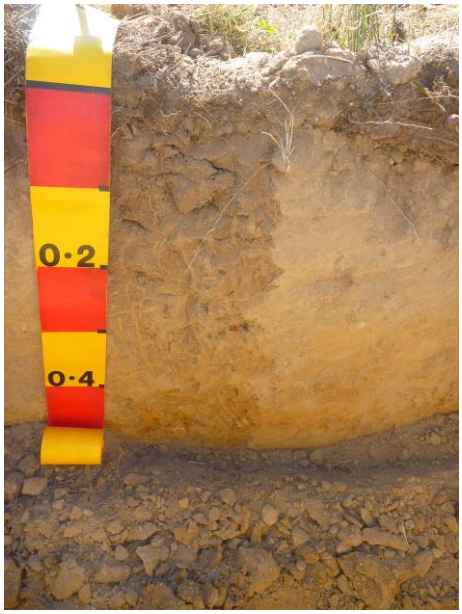
GN36	**Datum: GDA 94 Zone 56** **Easting: 318729.19** **Northing: 6411394.13** **Recorded: 17th August 2017**
Landscape Element: Hillslope Slope: 4% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone/Mudstone Australian Soil Classification (ASC): Grey Sodosol

Profile Characteristics	
A1 0-80 mm	7.5YR 5/3 (moderately moist) Silty Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 80-400 mm	10YR 6/2 (moderately moist), 10YR 7/1 (dry) Fine Sandy Loam. pH 6.5. Apedal massive structure, sandy fabric. Very few (<2%), 20-60 mm sub-angular ironstone pebbles. Clear boundary
B22 400^{+} mm	10YR 4/2 (moderately moist) Heavy Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Common, fine, distinct, brown mottles. Limit of observation.

GN36, soil profile

GN36, looking south

GN37	Datum: GDA 94 Zone 56 Easting: 318281.53 Northing: 6411065.84 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 3% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown-Orthic Tenosol
Profile Characteristics	
A1 0-50 mm	7.5YR 4/2 (moderately moist) Loamy Sand. pH 6.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
B21 50-300 mm	7.5YR 6/3 (moderately moist) Loamy Sand. pH 6.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (2-10%), 20-60 mm sub-rounded ironstone pebbles. Gradual boundary
B22 300-420 mm	10YR 5/4 (moderately moist) Coarse Sandy Loam. pH 6.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary
BC 420^{+} mm	10YR 5/6 (moderately moist) Sandy Light Clay. pH 7.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few, coarse, distinct, brown mottles. Limit of observation.



GN37, soil profile

GN37, looking north

GN38	**Datum: GDA 94 Zone 56** **Easting: 317752.38** **Northing: 6411069.77** **Recorded: 24th August 2017**
Landscape Element: Hillslope Slope: 7% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol
Profile Characteristics	
A11 0-150 mm	7.5YR 3/2 (moderately moist) Sandy Clay Loam. pH 5.5. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Abrupt boundary.
A12 150-300 mm	10YR 2/2 (moderately moist) Sandy Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (2-10%), 20-60 mm sub-rounded ironstone pebbles. Gradual boundary
A2 300-480 mm	7.5YR 5/2 (moderately moist), 7.5YR 6/2 (dry) Coarse Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Very few (<2%) 6-20 mm sub-rounded, medium pebbles. Gradual boundary
B21 480^{+} mm	Greyish, brown Coarse Sandy Light Clay with many faint orange mottles. pH 7.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Limit of observation.

GN38, soil profile

GN38, looking north

GN40	Datum: GDA 94 Zone 56 Easting: 318226.57 Northing: 6412292.52 Recorded: 18th August 2017
Landscape Element: Hillslope Slope: 4% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-200 mm	10YR 2/2 (moderately moist) Sandy Clay Loam. pH 5.5. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Sharp boundary.
A2 200-350 mm	10YR 4/3 (moderately moist), 10YR 6/2 (dry) Coarse Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm Many (20-50%) 6-20 mm, sub-angular, medium pebbles. Sharp boundary
B21 300-500 mm	7.5YR 4/2 (moderately moist) Coarse Sandy Medium Clay. pH 6.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Many (20-50%) small, distinct, brown mottles. Sharp boundary

GN40, soil profile

GN40, looking west

GN64	**Datum: GDA 94 Zone 56** **Easting: 317723.12** **Northing: 6411234.17** **Recorded: 12th October 2017**
Landscape Element: Hillslope Slope: 3% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Black Sodosol
Profile Characteristics	
A1 0-20 mm	7.5YR 2.5/3 (moderately moist) Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 20-250 mm	7.5YR 3/2 (moderately moist), sporadically bleached Silty Clay Loam. pH 6.5. Strong pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common, medium macropores. Sharp boundary.
B21 250-550 mm	10YR 3/1 (moderately moist) Medium Clay. pH 7.0. Strong pedality, rough-ped fabric, columnar structure, 5-10 mm. Common (10-20%), medium, distinct, orange mottles. Many, fine macropores. Gradual boundary.
B22 550^{+} mm	10YR 4/6 (moderately moist) Medium Clay. pH 7.5. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Many (20-50%), fine, distinct, grey mottles Common (10-20%) 6-20 mm sub-angular medium pebbles. Limit of observation.

GN64, soil profile

GN64, looking south

GN65	Datum: GDA 94 Zone 56 Easting: 317606.96 Northing: 6411418.31 Recorded: 12nd October 2017
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Black Sodosol
Profile Characteristics	
A1 0-30 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Broken boundary.
A2 30-200 mm	10YR 5/2 (moderately moist), 10YR 6/1 (dry) Sandy Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Common (10-20%) 6-20 mm, sub-angular, medium pebbles. Sharp boundary.
B21 200-400^{+} mm	10YR 3/2 (moderately moist) Sandy Light Medium Clay. pH 7.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Common (10-20%), fine, faint orange mottles. Many (20-50%) 6-20 mm, angular, medium pebbles. Limit of observation.

GN65, soil profile

GN65, looking east

GN70	Datum: GDA 94 Zone 56 Easting: 316926.38 Northing: 6411958.75 Recorded: 12th October 2017
Landscape Element: Footslope Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-50 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.5. Apedal massive structure, sandy fabric. Sharp boundary.
A2 50-220 mm	10YR 5/2 (moderately moist), 10YR 7/1 (dry) Silty Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Abrupt boundary.
B1 220-300 mm	10YR 4/2 (moderately moist) Light Clay (heavy). pH 7.0. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Common (10-20%), medium, manganiferous weak nodules and soft segregations. Gradual boundary.
B21 300-500 mm	10YR 4/3 (moderately moist) Medium Heavy Clay. pH 7.0. Strong pedality, smooth-ped fabric, prismatic breaking to angular blocky structure, 20-50 mm. Many (20-50%), medium, distinct, orange mottles. Few (2-10%), fine, manganiferous soft segregations. Common, coarse macropores. Gradual boundary.
B22 500-850 mm	10YR 4/2 (moderately moist), Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Many (20-50%), medium, distinct, orange mottles. Very few (<2%) 6-20 mm, sub-rounded, medium pebbles. Common, coarse macropores. Abrupt boundary
2D 850^{+} mm	10YR 4/6 (moderately moist) Coarse Sand. pH 7.0. Apedal massive structure, sandy fabric. Common (10-20%), medium, distinct, grey mottles. Common (10-20%) 60-20 mm, sub-rounded, large pebbles. Many (20-50%), coarse, manganiferous soft segregations. Limit of observation.

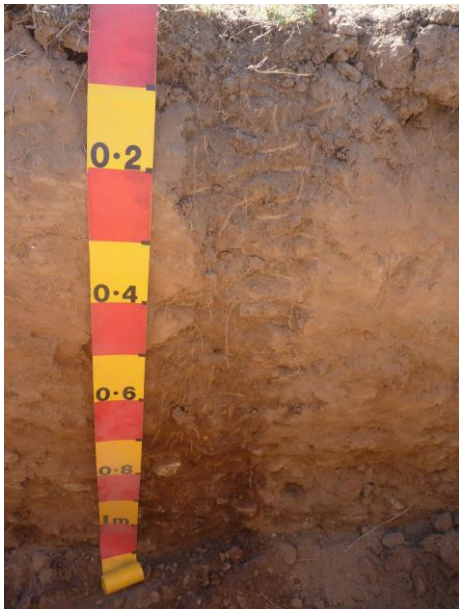
GN70, soil profile

GN70, looking south

GN70, manganiferous, weak nodule

GN72	Datum: GDA 94 Zone 56 Easting: 316370.86 Northing: 6412220.61 Recorded: 11th October 2017
Landscape Element: Backplain Slope: 1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics	
A1 0-100 mm	7.5YR 3/3 (moderately moist) Silty Clay Loam. pH 7.0. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
B21 100-300 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary.
B22 300-550 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Clear boundary.
2D1 550-800 mm	10YR3/6 (moderately moist) Clayey Sand. pH 7.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (2-10%) 20-60 mm, sub-rounded, large pebbles. Sharp boundary.
2D2 800^{+} mm	10YR 3/6(moderately moist) Clayey Sand. pH 7.0. Apedal massive structure, sandy fabric. Very abundant (>90%) 20-60 mm to 200-600 mm, rounded large pebbles to stones. Limit of observation.



GN72, soil profile

GN72, looking south

GN74	Datum: GDA 94 Zone 56 Easting: 316500.40 Northing: 6412683.76 Recorded: 11th October 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A11 0-100 mm	7.5YR 4/3 (moderately moist) Coarse Sandy Loam. pH 7.0. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Very few (<2%) 2-6 mm, sub-angular, small pebbles. Sharp boundary.
A12 100-500 mm	At 150 mm: 7.5YR 4/3 (moderately moist) Coarse Sandy Loam. pH 6.0. Apedal massive structure, sandy fabric. Common (10-20%) 6-20 mm, sub-rounded, medium pebbles. At 450 mm: 7.5YR 4/4 (moderately moist) Coarse Sandy Loam. pH 6.5. Apedal massive structure, sandy fabric. Many (20-50%) 20-60 mm, sub-rounded, large pebbles. Sharp, wavy boundary.
B21 500-850 mm	At 600 mm: 7.5YR 4/6 (moderately moist) Sandy Light Clay. pH 6.5. Strong pedality, rough-ped fabric, prismatic breaking to angular blocky, 200-500 mm. Very few (<2%) 2-6 mm, sub-angular, small pebbles. At 800 mm: 7.5YR 4/6 (moderately moist) Sandy Light Clay. pH 6.5. Strong pedality, rough-ped fabric, angular blocky, 20-50 mm. Very few (<2%) 2-6 mm, sub-angular, small pebbles. Very few (<2%), fine, manganiferous soft segregations. Sharp boundary.
2D 850^{+} mm	10YR 3/6 (moderately moist) Coarse Sand. pH 7.0. Apedal massive structure, sandy fabric. Very abundant (>90%) 10-60 mm to 200-600 mm, rounded large pebbles to stones. Limit of observation.

GN74, soil profile

GN74, looking west

GN74, columns in trench

GN76	Datum: GDA 94 Zone 56 Easting: 315525.65 Northing: 6412802.88 Recorded: 21st December 2017
Landscape Element: Hillslope Slope: 6% Soil Surface Condition: Firm	Vegetation: Derived native grassland and Bulloak Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol
Profile Characteristics	
A2[13] 0-100 mm	7.5YR 8/2 (dry), 10YR 6/3 (moderately moist) Sandy Loam. pH 6.5. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Abundant (50-90%) 20-60 mm, rounded large pebbles. Sharp boundary.
B21 100-320 mm	10YR 5/3 (moderately moist) Medium Heavy Clay. pH 7.0. Moderate pedality, smooth-ped fabric, prismatic breaking to angular blocky structure, 10-20 mm. Many (20-50%), medium, distinct, orange mottles. Many (20-50%) 20-60 mm to 6-20 mm, rounded large to medium pebbles. Common, fine macropores. Gradual boundary.
B22 320-500 mm	10YR 5/6 (moderately moist) Medium Heavy Clay. pH 7.5. Strong pedality, smooth-ped fabric, angular blocky, 10-20 mm. Many (20-50%), coarse, distinct, grey mottles. Very few (<2%) 2-6 mm, sub-angular, small pebbles. Gradual boundary.
B23 500-700 mm	10YR 6/1 (moderately moist) Medium Heavy Clay. pH 7.0. Moderate pedality, smooth-ped fabric, sub-angular blocky structure, 10-20 mm. Many (20-50%), very coarse, distinct, orange mottles. Very few (<2%) manganiferous, fine, soft segregations. Gradual boundary.
B24 700[+] mm	10YR 7/1 (moderately moist) Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Common (10-20%), medium, distinct, orange mottles. Few (2-10%), manganiferous, fine, soft segregations. Limit of observation.

[13] A1 completely eroded

GN76, soil profile

GN76, looking south

Erosion downhill from GN76

GN77	Datum: GDA 94 Zone 56 Easting: 316722.83 Northing: 6411779.98 Recorded: 21st December 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Black Chromosol

Profile Characteristics	
A11 0-150 mm	7.5YR 2.5/3 (moderately moist) Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A12 150-400 mm	7.5YR 3/4 (moderately moist) Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Sharp boundary.
B21 450-650 mm	5YR 2.5/2 (moderately moist) Medium Clay. pH 7.0. Strong pedality, rough-ped fabric, prismatic breaking to angular blocky, 20-50 mm. Common, fine macropores. Clear boundary.
B22 650-850 mm	7.5YR 3/4 (moderately moist) Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Few (2-10%) manganiferous, fine, soft segregations. Gradual boundary.
B23 850^{+} mm	7.5YR 3/3 (moderately moist) Light Clay Coarse Sandy. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common (10-20%), medium, distinct, orange mottles. Few (2-10%), manganiferous, medium, soft segregations. Limit of observation.

GN77, soil profile

GN77, looking west towards a lower terrace and Bowmans Creek

GN78	**Datum: GDA 94 Zone 56** **Easting: 317304.52** **Northing: 6411180.66** **Recorded: 22nd December 2017**
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol
Profile Characteristics	
A1 0-10 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, granular2-5 mm. Broken boundary.
A2 10-200 mm	10YR 7/2 (moderately moist), 7.5YR 8/1 (dry) Silty Clay Loam. pH 6.5. Strong pedality, rough-ped fabric, angular blocky structure, 20-50 mm. Sharp boundary.
B21 200^{+} mm	10YR 4/3 (moderately moist) Medium Clay. pH 6.0. Strong pedality, rough-ped fabric, angular blocky structure, 20-50 mm. Limit of observation.

GN78, soil profile

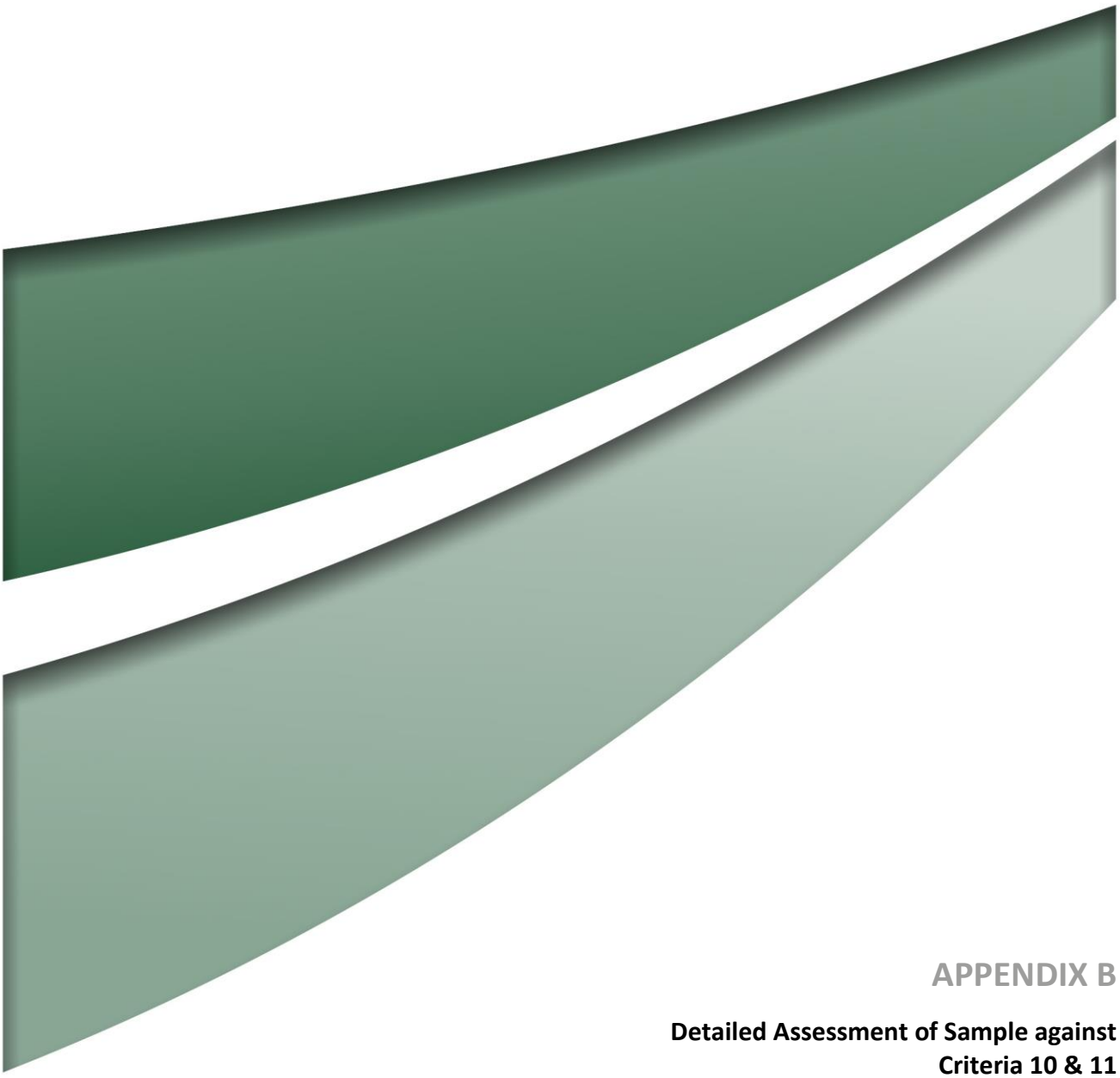
Looking north

GN79	Datum: GDA 94 Zone 56 Easting: 317058.60 Northing: 6411461.51 Recorded: 21st December 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Black Chromosol

Profile Characteristics	
A11 0-100 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 6.5. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Gradual boundary.
A12 100-300 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 6.0. Moderate pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Sharp boundary.
B21 300-550 mm	10YR 2/2 (moderately moist) Medium Clay. pH 7.0. Strong pedality, rough-ped fabric, prismatic breaking to angular blocky, 10-20 mm. Gradual boundary.
B22 550-800 mm	10YR 3/4 (moderately moist) Medium Clay. pH 7.5. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%) fine, faint, orange mottles. Common, fine macropores. Gradual boundary.
B23 800^{+} mm	7.5YR 3/3 (moderately moist) Light Clay. pH 7.5. Moderate pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Common (10-20%), medium, distinct, orange mottles. Few (2-10%), manganiferous, medium, soft segregations. Limit of observation.

GN79, soil profile

GN79, looking east



APPENDIX B

Detailed Assessment of Sample against Criteria 10 & 11

Site ID	Sample depth	pH Threshold values In water 5.0-8.9	ECe <4dS/m	ESP% <15	Ca:Mg ratio >0.1	Pass BSAL Criteria 10	Pass BSAL Criteria 11	Pass BSAL Criteria 12
GN3	0-50	5.6	0.269	0.9	2.4	Yes	Yes	Yes
	100-200	5.4	0.086	0.8	3	Yes	Yes	
	200-300	5.7	0.076	0.8	3.7	Yes	Yes	
	300-600	6.1	0.074	1.3	4.1	Yes	Yes	
	650+	7.6	0.476	<0.2	3.8	Yes	Yes	
GN4	0-50	5.9	0.149	1.4	2.5	Yes	Yes	Yes
	50-150	5.9	0.072	1.4	2.8	Yes	Yes	
	150-300	6.1	0.027	2	3	Yes	Yes	
	300-600	6.6	0.052	2.8	2.8	Yes	Yes	
	600-800	7	0.069	2.8	7.5	Yes	Yes	
GN5	0-50	*Not sampled, insufficient topsoil due to sheet erosion*				NA	NA	No
	50-150	6.1	0.055	5.6	1	Yes	Yes	
	180-300	7.7	0.125	17.1	< 0.2*	Yes	Yes	
	300-600	8.4	1.13	19.8	< 0.2*	Yes	Yes	
	600-800	8.8	2.05	24.6	< 0.2*	Yes	Yes	

Site ID	Sample depth	pH Threshold values In water 5.0-8.9	ECe <4dS/m	ESP% <15	Ca:Mg ratio >0.1	Pass BSAL Criteria 10	Pass BSAL Criteria 11	Pass BSAL Criteria 12
GN6	0-50	5.8	0.264	1.1	2.9	Yes	Yes	No
	50-150	6.2	0.14	1.3	2.8	Yes	Yes	
	150-250	7.4	0.123	<0.2	1.1	Yes	Yes	
	300-550	8.1	0.131	<0.2		Yes	Yes	
	550+	8.6	2.37	36.5	< 0.2*	Yes	Yes	
GN7	0-50	4.8	0.086	4.1	1.5	No	Yes	No
	50-120	5.2	0.032	2.7	2	Yes	Yes	
	120-280	5.9	0.057	9.8	1.2	Yes	Yes	
	300-500	7.1	1.66	17.7	0.3	Yes	Yes	
	500-800	8.2	2.34	35.2	0.2	Yes	Yes	
GN8	0-50	5.4	0.125	1.9	1.2	Yes	Yes	No
	50-150	5.8	0.049	3.9	0.8	Yes	Yes	
	200-300	6.3	0.152	13.5	0.1	Yes	Yes	
	300-600	7.8	1.46	24.5	< 0.2*	Yes	Yes	
	600+	8.2	2.16	26.8	< 0.2*	Yes	Yes	

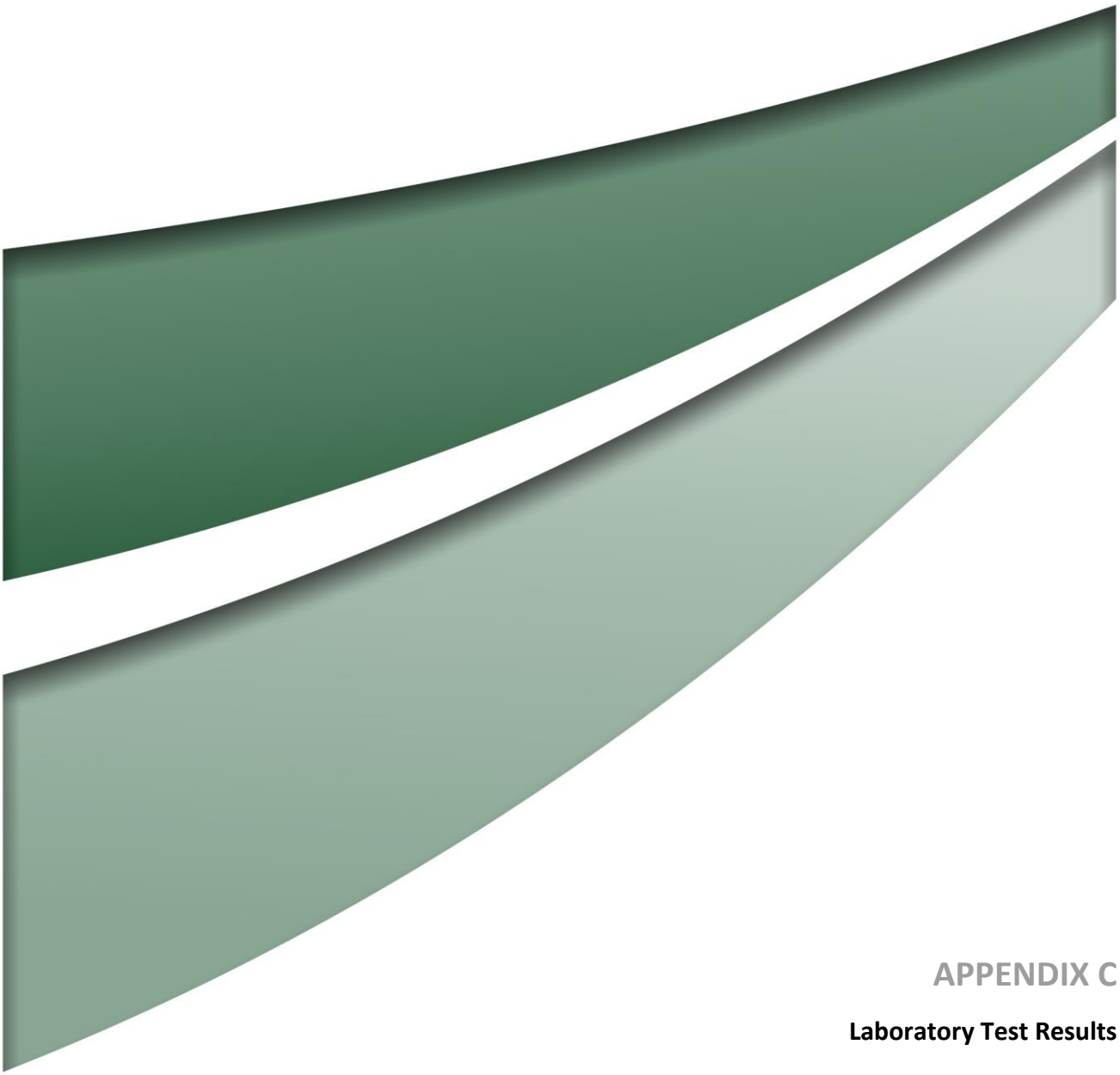
Site ID	Sample depth	pH Threshold values In water 5.0-8.9	ECe <4dS/m	ESP% <15	Ca:Mg ratio >0.1	Pass BSAL Criteria 10	Pass BSAL Criteria 11	Pass BSAL Criteria 12
GN9	0-50	5.7	0.24	0.7	2.9	Yes	Yes	Yes
	50-100	6.8	0.095	0.7	3.5	Yes	Yes	
	150-300	6.4	0.089	1.1	6.8	Yes	Yes	
	400-600	7	0.493	1.6	5	Yes	Yes	
	700+	7.5	0.538	<0.2	6.3	Yes	Yes	
GN10	0-50	6.4	1.01	7.4	1.2	Yes	Yes	Yes
	50-150	6.4	0.267	1.9	1.2	Yes	Yes	
	180-300	6.6	0.207	2.4	1.2	Yes	Yes	
	300-600	6.5	0.108	2.7	1.4	Yes	Yes	
	600+	6.8	0.068	3.2	1.7	Yes	Yes	
GN11	0-50	6.4	0.356	3.3	0.7	Yes	Yes	Yes
	100-150	6	0.3	4.5	0.4	Yes	Yes	
	250-300	6.1	0.125	8.4	0.3	Yes	Yes	
	350-500	5.7	0.331	7.1	1.6	Yes	Yes	
	500+	5.9	2.27	0.5	0.1	Yes	Yes	

Site ID	Sample depth	pH Threshold values In water 5.0-8.9	ECe <4dS/m	ESP% <15	Ca:Mg ratio >0.1	Pass BSAL Criteria 10	Pass BSAL Criteria 11	Pass BSAL Criteria 12
GN12	0-20	5.6	0.411	3.6	0.8	Yes	Yes	Yes
	20-100	6	0.114	4.3	0.7	Yes	Yes	
	100-300	6.3	0.456	7.5	0.3	Yes	Yes	
	300-600	6.1	1.6	9.4	0.2	Yes	Yes	
	600-700	6.6	2.16	11.1	0.2	Yes	Yes	
GN13	0-50	6.1	0.463	1.2	1.3	Yes	Yes	Yes
	100-150	6.2	0.208	1.5	1.2	Yes	Yes	
	150-300	6.4	0.322	2.2	1.2	Yes	Yes	
	400-500	6.6	0.337	2.5	1.3	Yes	Yes	
	500-800	6.7	0.08	2.8	1.4	Yes	Yes	
GN14	0-50	5.3	0.292	4.8	1.2	Yes	Yes	No
	50-150	5.9	0.098	7.3	0.5	Yes	Yes	
	150-300	6.8	1.13	17.8	< 0.1	Yes	Yes	
	400-600	7.6	1.87	31.8	< 0.2*	Yes	Yes	
	600+	6.7	2.38	24.1	< 0.1	Yes	Yes	

Site ID	Sample depth	pH Threshold values In water 5.0-8.9	ECe <4dS/m	ESP% <15	Ca:Mg ratio >0.1	Pass BSAL Criteria 10	Pass BSAL Criteria 11	Pass BSAL Criteria 12
GN15	0-50	5.5	0.111	2.4	1.2	Yes	Yes	No
	100-150	5.6	0.044	2.4	1	Yes	Yes	
	150-250	6	0.038	3	0.8	Yes	Yes	
	250-600	6.5	0.076	13	0.2	Yes	Yes	
	600+	6	0.309	19.1	< 0.1	Yes	Yes	
GN16	0-30	5.7	0.433	1.5	1.5	Yes	Yes	Yes
	50-150	5.8	0.138	1.4	1.6	Yes	Yes	
	150-300	6.6	0.181	3.7	1	Yes	Yes	
	300-600	6	0.81	6.4	0.4	Yes	Yes	
GN17	0-50	5.9	0.274	2.8	0.8	Yes	Yes	No
	50-150	6.2	0.12	5.7	0.6	Yes	Yes	
	150-300	6.2	0.513	10.9	0.4	Yes	Yes	
	450-600	6.9	1.6	13.1	0.3	Yes	Yes	
	600-700	7.8	1.84	24.4	0.3	Yes	Yes	

Site ID	Sample depth	pH Threshold values In water 5.0-8.9	ECe <4dS/m	ESP% <15	Ca:Mg ratio >0.1	Pass BSAL Criteria 10	Pass BSAL Criteria 11	Pass BSAL Criteria 12
GN18	0-50	5.7	0.38	2.8	0.9	Yes	Yes	No
	100-150	5.9	0.16	5.4	0.8	Yes	Yes	
	150-300	6.1	0.159	10.8	0.6	Yes	Yes	
	300-450	6.6	0.941	20	0.2	Yes	Yes	
	450-750	7	1.75	24.5	0.1	Yes	Yes	
GN32	0-50	5.5	0.229	3.9	2.1	Yes	Yes	Yes
	50-100	5.5	0.238	3.8	2	Yes	Yes	
	100-150	5.8	0.062	1.8	1.8	Yes	Yes	
	150-300	5.8	0.057	1.8	1.9	Yes	Yes	
GN39	0-50	5.6	0.239	1.7	0.9	Yes	Yes	No
	100-150	6	0.328	4	0.6	Yes	Yes	
	150-300	6.5	0.511	10.3	0.2	Yes	Yes	
	400-600	6.9	2.22	12.7	< 0.1	Yes	Yes	
	650+	6.6	3.56	16.2	0.1	Yes	Yes	

Site ID	BSAL criteria passed	BSAL criteria failed
GN3	10,11,12	
GN4	10,11,12	
GN5	10,11	12
GN6	10,11	12
GN7	11	10,12
GN8	10,11	12
GN9	10,11,12	
GN10	10,11,12	
GN11	10,11,12	
GN12	10,11,12	
GN13	10,11,12	
GN14	10,11	12
GN15	10,11	12
GN16	10,11,12	
GN17	10,11	12
GN18	10,11	12
GN32	10,11,12	
GN39	10,11	12
GN66		
GN67		
GN68		
GN69		
GN71		
GN73		



APPENDIX C

Laboratory Test Results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1717430**	Page	: 1 of 23
Client	: **UMWELT (AUSTRALIA) PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ANNE SCHNEIDER	Contact	: Customer Services EB
Address	: 75 York street Teralba 2284	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: 3986C	Date Samples Received	: 25-Aug-2017 13:10
Order number	: ----	Date Analysis Commenced	: 29-Aug-2017
C-O-C number	: ----	Issue Date	: 11-Sep-2017 18:43
Sampler	: ANNE SCHNEIDER		
Site	: ----		
Quote number	: SYBQ/277/16		
No. of samples received	: 87		
No. of samples analysed	: 87		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ED006(Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ED007(Exchangeable Cations): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ED006(Exchangeable Cations on Alkaline Soils): Unable to calculate Calcium/Magnesium Ratio for some samples as the required results for Calcium/Magnesium are below LOR.
- ED008 (Exchangeable Cations with pre-treatment by ICP-AES): Unable to calculate Magnesium/Potassium Ratio results for Some samples as required Exchangeable Potassium results are less than the limit of reporting.
- EA031 (Saturated Paste pH): NATA accreditation does not cover the performance of this service.
- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- ED006 (Exchangeable Cations on Alkaline Soils): Sample EB1717430-034 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN3 0-50	GN3 100-200	GN3 200-300	GN3 300-600	GN3 650+
			Client sampling date / time	22-Aug-2017 13:30	22-Aug-2017 13:30	22-Aug-2017 13:30	22-Aug-2017 13:30	22-Aug-2017 13:30
Compound	CAS Number	LOR	Unit	EB1717430-001	EB1717430-002	EB1717430-003	EB1717430-004	EB1717430-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.6	5.4	5.7	6.1	7.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	54	24	15	11	56
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.9	5.2	5.3	5.7	6.8
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	269	86	76	74	476
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.1	0.6	0.3	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	0.5	0.2	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	2.2
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	0.6
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	<0.2
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	<0.2
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	2.8
Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	<0.2
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	----	3.8
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.6	2.1	2.6	3.7	----
Exchangeable Magnesium	----	0.1	meq/100g	1.5	0.7	0.7	0.9	----
Exchangeable Potassium	----	0.1	meq/100g	1.6	1.5	1.1	0.5	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	----
Cation Exchange Capacity	----	0.1	meq/100g	6.8	4.9	4.7	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	5.1	----
Exchangeable Sodium Percent	----	0.1	%	0.9	0.8	0.8	1.3	----
Calcium/Magnesium Ratio	----	0.1	-	2.4	3.0	3.7	4.1	----
Magnesium/Potassium Ratio	----	0.1	-	1.0	0.4	0.6	1.8	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN4 0-50	GN4 50-150	GN4 150-300	GN4 300-600	GN4 600-800
			Client sampling date / time	22-Aug-2017 15:30	22-Aug-2017 15:30	22-Aug-2017 15:30	22-Aug-2017 15:30	22-Aug-2017 15:30
Compound	CAS Number	LOR	Unit	EB1717430-006	EB1717430-007	EB1717430-008	EB1717430-009	EB1717430-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.9	5.9	6.1	6.6	7.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	55	15	10	7	10
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.8	5.6	5.5	5.9	6.4
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	149	72	27	52	69
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.1	0.2	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.3	2.8	2.7	3.1	4.5
Exchangeable Magnesium	----	0.1	meq/100g	1.3	1.0	0.9	1.1	0.6
Exchangeable Potassium	----	0.1	meq/100g	1.1	1.1	0.8	0.2	0.1
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	0.1	0.2
Cation Exchange Capacity	----	0.1	meq/100g	5.8	5.1	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	4.5	4.6	5.4
Exchangeable Sodium Percent	----	0.1	%	1.4	1.4	2.0	2.8	2.8
Calcium/Magnesium Ratio	----	0.1	-	2.5	2.8	3.0	2.8	7.5
Magnesium/Potassium Ratio	----	0.1	-	1.2	0.9	1.2	4.9	5.9

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN5 50-150	GN5 180-300	GN5 300-600	GN5 600-800	GN6 0-50
			Client sampling date / time	21-Aug-2017 12:30	21-Aug-2017 12:30	21-Aug-2017 12:30	21-Aug-2017 12:30	23-Aug-2017 08:30
Compound	CAS Number	LOR	Unit	EB1717430-011	EB1717430-012	EB1717430-013	EB1717430-014	EB1717430-015
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.1	7.7	8.4	8.8	5.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	11	106	217	402	25
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.3	6.5	7.2	7.3	5.6
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	55	125	1130	2050	264
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	<0.1
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	<0.1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	<0.2	0.3	0.3	----
Exchangeable Magnesium	----	0.2	meq/100g	----	2.3	3.1	3.9	----
Exchangeable Potassium	----	0.2	meq/100g	----	<0.2	<0.2	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	0.5	0.8	1.4	----
Cation Exchange Capacity	----	0.2	meq/100g	----	2.8	4.2	5.6	----
Exchangeable Sodium Percent	----	0.2	%	----	17.1	19.8	24.6	----
Calcium/Magnesium Ratio	----	0.2	-	----	<0.2	<0.2	<0.2	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.9	----	----	----	6.6
Exchangeable Magnesium	----	0.1	meq/100g	0.9	----	----	----	2.3
Exchangeable Potassium	----	0.1	meq/100g	0.2	----	----	----	0.5
Exchangeable Sodium	----	0.1	meq/100g	0.1	----	----	----	0.1
Cation Exchange Capacity	----	0.1	meq/100g	2.2	----	----	----	9.6
Exchangeable Sodium Percent	----	0.1	%	5.6	----	----	----	1.1
Calcium/Magnesium Ratio	----	0.1	-	1.0	----	----	----	2.9
Magnesium/Potassium Ratio	----	0.1	-	4.2	----	----	----	4.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN6 50-150	GN6 150-250	GN6 300-550	GN6 550+	GN7 0-50
			Client sampling date / time	23-Aug-2017 08:30	23-Aug-2017 08:30	23-Aug-2017 08:30	23-Aug-2017 08:30	24-Aug-2017 09:00
Compound	CAS Number	LOR	Unit	EB1717430-016	EB1717430-017	EB1717430-018	EB1717430-019	EB1717430-020
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.2	7.4	8.1	8.6	4.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	14	16	205	544	26
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.8	6.2	5.9	7.3	4.5
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	140	123	131	2370	86
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	2.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	1.2
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	0.5	0.8	<0.2	----
Exchangeable Magnesium	----	0.2	meq/100g	----	0.4	<0.2	2.1	----
Exchangeable Potassium	----	0.2	meq/100g	----	<0.2	<0.2	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	<0.2	<0.2	1.2	----
Cation Exchange Capacity	----	0.2	meq/100g	----	1.0	0.8	3.3	----
Exchangeable Sodium Percent	----	0.2	%	----	<0.2	<0.2	36.5	----
Calcium/Magnesium Ratio	----	0.2	-	----	1.1	----	<0.2	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	5.7	----	----	----	1.2
Exchangeable Magnesium	----	0.1	meq/100g	2.0	----	----	----	0.8
Exchangeable Potassium	----	0.1	meq/100g	0.4	----	----	----	0.3
Exchangeable Sodium	----	0.1	meq/100g	0.1	----	----	----	0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	4.7
Cation Exchange Capacity	----	0.1	meq/100g	8.2	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	1.3	----	----	----	4.1
Calcium/Magnesium Ratio	----	0.1	-	2.8	----	----	----	1.5
Magnesium/Potassium Ratio	----	0.1	-	5.1	----	----	----	2.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN7 50-120	GN7 120-280	GN7 300-500	GN7 500-800	GN8 0-50
			Client sampling date / time	24-Aug-2017 09:00	24-Aug-2017 09:00	24-Aug-2017 09:00	24-Aug-2017 09:00	22-Aug-2017 11:00
Compound	CAS Number	LOR	Unit	EB1717430-021	EB1717430-022	EB1717430-023	EB1717430-024	EB1717430-025
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.2	5.9	7.1	8.2	5.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	5	11	360	603	19
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	4.8	4.9	5.9	6.7	5.4
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	32	57	1660	2340	125
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.9	0.4	----	----	0.3
Exchangeable Aluminium	----	0.1	meq/100g	0.8	0.3	----	----	0.2
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	0.4	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	1.6	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	1.1	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	3.2	----
Exchangeable Sodium Percent	----	0.2	%	----	----	----	35.2	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	0.2	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.6	1.4	----	----	2.0
Exchangeable Magnesium	----	0.1	meq/100g	0.8	1.2	----	----	1.7
Exchangeable Potassium	----	0.1	meq/100g	0.1	<0.1	----	----	0.5
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.3	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	3.4	3.3	----	----	4.5
Exchangeable Sodium Percent	----	0.1	%	2.7	9.8	----	----	1.9
Calcium/Magnesium Ratio	----	0.1	-	2.0	1.2	----	----	1.2
Magnesium/Potassium Ratio	----	0.1	-	8.3	----	----	----	3.2
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	2.0	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	6.9	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	<0.1	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	2.0	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	11.0	----	----
Exchangeable Sodium Percent	----	0.1	%	----	----	17.7	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	GN7 50-120	GN7 120-280	GN7 300-500	GN7 500-800	GN8 0-50
				Client sampling date / time	24-Aug-2017 09:00	24-Aug-2017 09:00	24-Aug-2017 09:00	24-Aug-2017 09:00	22-Aug-2017 11:00
Compound	CAS Number	LOR	Unit		EB1717430-021	EB1717430-022	EB1717430-023	EB1717430-024	EB1717430-025
					Result	Result	Result	Result	Result
ED008: Exchangeable Cations - Continued									
Calcium/Magnesium Ratio	----	0.1	-		**----**	**----**	**0.3**	**----**	**----**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN8 50-150	GN8 200-300	GN8 300-600	GN8 600+	GN9 0-50
			Client sampling date / time	22-Aug-2017 11:00	22-Aug-2017 11:00	22-Aug-2017 11:00	22-Aug-2017 11:00	22-Aug-2017 12:00
Compound	CAS Number	LOR	Unit	EB1717430-026	EB1717430-027	EB1717430-028	EB1717430-029	EB1717430-030
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.8	6.3	7.8	8.2	5.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	8	65	421	674	46
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.4	5.2	6.6	7.1	6.0
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	49	152	1460	2160	240
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.4	----	----	----	0.2
Exchangeable Aluminium	----	0.1	meq/100g	0.3	----	----	----	<0.1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	<0.2	<0.2	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	3.3	2.9	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	1.1	1.1	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	4.4	4.0	----
Exchangeable Sodium Percent	----	0.2	%	----	----	24.5	26.8	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	<0.2	<0.2	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.8	1.6	----	----	4.3
Exchangeable Magnesium	----	0.1	meq/100g	1.0	11.6	----	----	1.5
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	----	----	1.8
Exchangeable Sodium	----	0.1	meq/100g	<0.1	2.1	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	2.4	----	----	----	7.8
Cation Exchange Capacity	----	0.1	meq/100g	----	15.5	----	----	----
Exchangeable Sodium Percent	----	0.1	%	3.9	13.5	----	----	0.7
Calcium/Magnesium Ratio	----	0.1	-	0.8	0.1	----	----	2.9
Magnesium/Potassium Ratio	----	0.1	-	4.7	50.6	----	----	0.8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN9 50-100	GN9 150-300	GN9 400-600	GN9 700+	GN10 0-50
			Client sampling date / time	22-Aug-2017 12:00	22-Aug-2017 12:00	22-Aug-2017 12:00	22-Aug-2017 12:00	23-Aug-2017 11:00
Compound	CAS Number	LOR	Unit	EB1717430-031	EB1717430-032	EB1717430-033	EB1717430-034	EB1717430-035
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.8	6.4	7.0	7.5	6.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	24	12	62	47	469
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.5	5.8	6.3	6.8	6.5
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	95	89	493	538	1010
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	5.1	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	0.8	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	<0.2	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	6.0	----
Exchangeable Sodium Percent	----	0.2	%	----	----	----	<0.2	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	6.3	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.8	3.4	18.9	----	----
Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.5	3.8	----	----
Exchangeable Potassium	----	0.1	meq/100g	3.0	1.5	0.8	----	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.4	----	----
Cation Exchange Capacity	----	0.1	meq/100g	6.6	5.5	23.9	----	----
Exchangeable Sodium Percent	----	0.1	%	0.7	1.1	1.6	----	----
Calcium/Magnesium Ratio	----	0.1	-	3.5	6.8	5.0	----	----
Magnesium/Potassium Ratio	----	0.1	-	0.3	0.4	4.8	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	7.4
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	6.0
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	1.6
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	15.2
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	0.5
Calcium/Magnesium Ratio	----	0.1	-	----	----	----	----	1.2
Magnesium/Potassium Ratio	----	0.1	-	----	----	----	----	3.7

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN10 50-150	GN10 180-300	GN10 300-600	GN10 600+	GN11 0-50
			Client sampling date / time	23-Aug-2017 11:00	23-Aug-2017 11:00	23-Aug-2017 11:00	23-Aug-2017 11:00	18-Aug-2017 12:00
Compound	CAS Number	LOR	Unit	EB1717430-036	EB1717430-037	EB1717430-038	EB1717430-039	EB1717430-040
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.4	6.6	6.5	6.8	6.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	21	16	11	12	78
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.4	6.2	6.4	6.7	6.6
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	267	207	108	68	356
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	6.8	5.0	3.1	2.4	7.0
Exchangeable Magnesium	----	0.1	meq/100g	5.8	4.1	2.2	1.4	10.5
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.3	0.2	0.3	0.7
Exchangeable Sodium	----	0.1	meq/100g	0.2	0.2	0.2	0.1	0.6
Cation Exchange Capacity	----	0.1	meq/100g	13.3	9.7	5.7	4.2	18.8
Exchangeable Sodium Percent	----	0.1	%	1.9	2.4	2.7	3.2	3.3
Calcium/Magnesium Ratio	----	0.1	-	1.2	1.2	1.4	1.7	0.7
Magnesium/Potassium Ratio	----	0.1	-	14.3	12.1	9.4	5.5	15.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN11 100-150	GN11 250-300	GN11 350-500	GN11 500+	GN12 0-20
			Client sampling date / time	18-Aug-2017 12:00	18-Aug-2017 12:00	18-Aug-2017 12:00	18-Aug-2017 12:00	17-Aug-2017 15:45
Compound	CAS Number	LOR	Unit	EB1717430-041	EB1717430-042	EB1717430-043	EB1717430-044	EB1717430-045
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.0	6.1	5.7	5.9	5.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	41	23	77	530	97
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.5	6.0	5.2	5.2	6.2
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	300	125	331	2270	411
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	0.5	0.2	0.1
Exchangeable Aluminium	----	0.1	meq/100g	----	----	0.4	<0.1	<0.1
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.6	0.9	2.5	----	4.2
Exchangeable Magnesium	----	0.1	meq/100g	3.7	2.7	1.6	----	4.9
Exchangeable Potassium	----	0.1	meq/100g	0.3	0.2	1.0	----	0.9
Exchangeable Sodium	----	0.1	meq/100g	0.3	0.3	0.4	----	0.4
Cation Exchange Capacity	----	0.1	meq/100g	----	----	6.0	----	10.5
Cation Exchange Capacity	----	0.1	meq/100g	5.8	4.2	----	----	----
Exchangeable Sodium Percent	----	0.1	%	4.5	8.4	7.1	----	3.6
Calcium/Magnesium Ratio	----	0.1	-	0.4	0.3	1.6	----	0.8
Magnesium/Potassium Ratio	----	0.1	-	10.8	13.6	1.5	----	5.5
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	0.5	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	4.0	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	1.4	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	6.2	----
Exchangeable Sodium Percent	----	0.1	%	----	----	----	23.0	----
Calcium/Magnesium Ratio	----	0.1	-	----	----	----	0.1	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN12 20-100	GN12 100-300	GN12 300-600	GN12 600-700	GN13 0-50
			Client sampling date / time	17-Aug-2017 15:45	17-Aug-2017 15:45	17-Aug-2017 15:45	17-Aug-2017 15:45	21-Aug-2017 16:00
Compound	CAS Number	LOR	Unit	EB1717430-046	EB1717430-047	EB1717430-048	EB1717430-049	EB1717430-050
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.0	6.3	6.1	6.6	6.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	18	74	436	521	44
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.9	5.6	5.4	5.9	6.4
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	114	456	1600	2160	463
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.1	3.7	----	----	6.6
Exchangeable Magnesium	----	0.1	meq/100g	3.0	13.4	----	----	5.2
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.3	----	----	1.0
Exchangeable Sodium	----	0.1	meq/100g	0.2	1.4	----	----	0.2
Cation Exchange Capacity	----	0.1	meq/100g	5.7	18.9	----	----	13.0
Exchangeable Sodium Percent	----	0.1	%	4.3	7.5	----	----	1.2
Calcium/Magnesium Ratio	----	0.1	-	0.7	0.3	----	----	1.3
Magnesium/Potassium Ratio	----	0.1	-	8.5	45.3	----	----	5.2
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	3.2	2.1	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	15.6	10.8	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	0.1	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	2.0	1.6	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	21.0	14.7	----
Exchangeable Sodium Percent	----	0.1	%	----	----	9.4	11.1	----
Calcium/Magnesium Ratio	----	0.1	-	----	----	0.2	0.2	----
Magnesium/Potassium Ratio	----	0.1	-	----	----	137	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN13 100-150	GN13 150-300	GN13 400-500	GN13 500-800	GN14 0-50
			Client sampling date / time	21-Aug-2017 16:00	21-Aug-2017 16:00	21-Aug-2017 16:00	21-Aug-2017 16:00	23-Aug-2017 12:00
Compound	CAS Number	LOR	Unit	EB1717430-051	EB1717430-052	EB1717430-053	EB1717430-054	EB1717430-055
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.2	6.4	6.6	6.7	5.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	17	14	14	14	47
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.8	5.7	5.8	6.0	6.0
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	208	322	337	80	292
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	0.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	0.2
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	5.9	6.7	7.6	6.3	2.3
Exchangeable Magnesium	----	0.1	meq/100g	4.9	5.5	5.9	4.5	1.9
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.4	0.3	0.2	0.6
Exchangeable Sodium	----	0.1	meq/100g	0.2	0.3	0.4	0.3	0.2
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	5.3
Cation Exchange Capacity	----	0.1	meq/100g	11.6	13.0	14.2	11.4	----
Exchangeable Sodium Percent	----	0.1	%	1.5	2.2	2.5	2.8	4.8
Calcium/Magnesium Ratio	----	0.1	-	1.2	1.2	1.3	1.4	1.2
Magnesium/Potassium Ratio	----	0.1	-	7.8	13.9	19.9	25.2	3.3

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN14 50-150	GN14 150-300	GN14 400-600	GN14 600+	GN15 0-50
			Client sampling date / time	23-Aug-2017 12:00	23-Aug-2017 12:00	23-Aug-2017 12:00	23-Aug-2017 12:00	17-Aug-2017 13:30
Compound	CAS Number	LOR	Unit	EB1717430-056	EB1717430-057	EB1717430-058	EB1717430-059	EB1717430-060
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.9	6.8	7.6	6.7	5.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	17	146	511	764	25
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.7	6.0	6.9	6.0	5.9
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	98	1130	1870	2380	111
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.4	----	----	----	0.4
Exchangeable Aluminium	----	0.1	meq/100g	0.3	----	----	----	0.3
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	<0.2	----	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	2.6	----	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	----	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	1.2	----	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	3.8	----	----
Exchangeable Sodium Percent	----	0.2	%	----	----	31.8	----	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	<0.2	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.8	1.2	----	----	1.5
Exchangeable Magnesium	----	0.1	meq/100g	1.6	12.8	----	----	1.2
Exchangeable Potassium	----	0.1	meq/100g	0.3	0.2	----	----	0.4
Exchangeable Sodium	----	0.1	meq/100g	0.2	3.1	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	3.3	----	----	----	3.5
Cation Exchange Capacity	----	0.1	meq/100g	----	17.4	----	----	----
Exchangeable Sodium Percent	----	0.1	%	7.3	17.8	----	----	2.4
Calcium/Magnesium Ratio	----	0.1	-	0.5	<0.1	----	----	1.2
Magnesium/Potassium Ratio	----	0.1	-	5.9	58.0	----	----	2.8
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	<0.1	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	3.2	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	1.1	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	4.4	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	GN14 50-150	GN14 150-300	GN14 400-600	GN14 600+	GN15 0-50
				Client sampling date / time	23-Aug-2017 12:00	23-Aug-2017 12:00	23-Aug-2017 12:00	23-Aug-2017 12:00	17-Aug-2017 13:30
Compound	CAS Number	LOR	Unit		EB1717430-056	EB1717430-057	EB1717430-058	EB1717430-059	EB1717430-060
					Result	Result	Result	Result	Result
ED008: Exchangeable Cations - Continued									
Exchangeable Sodium Percent	----	0.1	%		**----**	**----**	**----**	**24.1**	**----**
Calcium/Magnesium Ratio	----	0.1	-		**----**	**----**	**----**	<0.1	**----**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN15 100-150	GN15 150-250	GN15 250-600	GN15 600+	GN16 0-30
			Client sampling date / time	17-Aug-2017 13:30	17-Aug-2017 13:30	17-Aug-2017 13:30	17-Aug-2017 13:30	17-Aug-2017 10:55
Compound	CAS Number	LOR	Unit	EB1717430-061	EB1717430-062	EB1717430-063	EB1717430-064	EB1717430-065
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.6	6.0	6.5	6.0	5.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	6	6	16	51	103
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.9	6.3	6.4	5.7	6.8
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	44	38	76	309	433
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.4	----	----	0.3	0.2
Exchangeable Aluminium	----	0.1	meq/100g	0.3	----	----	0.2	<0.1
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.8	0.9	0.3	0.1	7.9
Exchangeable Magnesium	----	0.1	meq/100g	0.8	1.1	1.8	5.7	5.4
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	0.1	0.2	1.8
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.3	1.4	0.2
Cation Exchange Capacity	----	0.1	meq/100g	2.2	----	----	7.7	15.5
Cation Exchange Capacity	----	0.1	meq/100g	----	2.3	2.6	----	----
Exchangeable Sodium Percent	----	0.1	%	2.4	3.0	13.0	19.1	1.5
Calcium/Magnesium Ratio	----	0.1	-	1.0	0.8	0.2	<0.1	1.5
Magnesium/Potassium Ratio	----	0.1	-	3.2	4.2	16.2	32.6	3.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN16 50-150	GN16 150-300	GN16 300-600	GN17 0-50	GN17 50-150
			Client sampling date / time	17-Aug-2017 10:55	17-Aug-2017 10:55	17-Aug-2017 10:55	18-Aug-2017 09:30	18-Aug-2017 09:30
Compound	CAS Number	LOR	Unit	EB1717430-066	EB1717430-067	EB1717430-068	EB1717430-069	EB1717430-070
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.8	6.6	6.0	5.9	6.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	23	24	144	42	17
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.2	6.4	6.0	6.4	6.0
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	138	181	810	274	120
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	----	----	0.1	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	<0.1	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.2	3.4	6.0	3.8	2.3
Exchangeable Magnesium	----	0.1	meq/100g	2.7	3.5	14.1	5.0	3.6
Exchangeable Potassium	----	0.1	meq/100g	1.0	0.8	1.6	0.7	0.3
Exchangeable Sodium	----	0.1	meq/100g	0.1	0.3	1.5	0.3	0.4
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	9.9	----
Cation Exchange Capacity	----	0.1	meq/100g	8.1	8.0	23.3	----	6.6
Exchangeable Sodium Percent	----	0.1	%	1.4	3.7	6.4	2.8	5.7
Calcium/Magnesium Ratio	----	0.1	-	1.6	1.0	0.4	0.8	0.6
Magnesium/Potassium Ratio	----	0.1	-	2.6	4.5	8.8	6.7	11.6

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN17 150-300	GN17 450-600	GN17 600-700	GN18 0-50	GN18 100-150
			Client sampling date / time	18-Aug-2017 09:30	18-Aug-2017 09:30	18-Aug-2017 09:30	23-Aug-2017 15:00	23-Aug-2017 15:00
Compound	CAS Number	LOR	Unit	EB1717430-071	EB1717430-072	EB1717430-073	EB1717430-074	EB1717430-075
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.2	6.9	7.8	5.7	5.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	73	343	436	46	21
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.0	6.9	7.4	6.8	6.3
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	513	1600	1840	380	160
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	0.2	0.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	<0.1	0.2
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	0.3	----	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	1.2	----	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	----	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	0.5	----	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	2.0	----	----
Exchangeable Sodium Percent	----	0.2	%	----	----	24.4	----	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	0.3	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.9	----	----	4.0	3.1
Exchangeable Magnesium	----	0.1	meq/100g	11.0	----	----	4.4	3.7
Exchangeable Potassium	----	0.1	meq/100g	0.2	----	----	0.5	0.1
Exchangeable Sodium	----	0.1	meq/100g	1.8	----	----	0.3	0.4
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	9.4	7.6
Cation Exchange Capacity	----	0.1	meq/100g	17.0	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	10.9	----	----	2.8	5.4
Calcium/Magnesium Ratio	----	0.1	-	0.4	----	----	0.9	0.8
Magnesium/Potassium Ratio	----	0.1	-	46.7	----	----	8.7	26.3
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	3.7	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	13.7	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	0.2	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	2.7	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	20.6	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	GN17 150-300	GN17 450-600	GN17 600-700	GN18 0-50	GN18 100-150
				Client sampling date / time	18-Aug-2017 09:30	18-Aug-2017 09:30	18-Aug-2017 09:30	23-Aug-2017 15:00	23-Aug-2017 15:00
Compound	CAS Number	LOR	Unit		EB1717430-071	EB1717430-072	EB1717430-073	EB1717430-074	EB1717430-075
					Result	Result	Result	Result	Result
ED008: Exchangeable Cations - Continued									
Exchangeable Sodium Percent	----	0.1	%		**----**	**13.1**	**----**	**----**	**----**
Calcium/Magnesium Ratio	----	0.1	-		**----**	**0.3**	**----**	**----**	**----**
Magnesium/Potassium Ratio	----	0.1	-		**----**	**75.7**	**----**	**----**	**----**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN18 150-300	GN18 300-450	GN18 450-750	GN32 0-50	GN32 50-100
			Client sampling date / time	23-Aug-2017 15:00	23-Aug-2017 15:00	23-Aug-2017 15:00	21-Aug-2017 15:00	21-Aug-2017 15:00
Compound	CAS Number	LOR	Unit	EB1717430-076	EB1717430-077	EB1717430-078	EB1717430-079	EB1717430-080
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.1	6.6	7.0	5.5	5.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	37	164	1040	51	49
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.3	6.3	6.7	5.8	6.5
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	159	941	1750	229	238
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	0.3	0.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	0.2	0.2
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.2	2.4	----	3.0	2.8
Exchangeable Magnesium	----	0.1	meq/100g	3.9	12.4	----	1.4	1.4
Exchangeable Potassium	----	0.1	meq/100g	0.1	0.2	----	0.8	0.8
Exchangeable Sodium	----	0.1	meq/100g	0.8	3.8	----	0.2	0.2
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	5.7	5.5
Cation Exchange Capacity	----	0.1	meq/100g	7.1	18.8	----	----	----
Exchangeable Sodium Percent	----	0.1	%	10.8	20.0	----	3.9	3.8
Calcium/Magnesium Ratio	----	0.1	-	0.6	0.2	----	2.1	2.0
Magnesium/Potassium Ratio	----	0.1	-	35.9	57.6	----	1.6	1.7
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	1.8	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	15.6	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	0.2	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	5.8	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	23.4	----	----
Exchangeable Sodium Percent	----	0.1	%	----	----	24.5	----	----
Calcium/Magnesium Ratio	----	0.1	-	----	----	0.1	----	----
Magnesium/Potassium Ratio	----	0.1	-	----	----	101	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN32 100-150	GN32 150-300	GN39 0-50	GN39 100-150	GN39 150-300
			Client sampling date / time	21-Aug-2017 15:00	21-Aug-2017 15:00	23-Aug-2017 14:00	23-Aug-2017 14:00	23-Aug-2017 14:00
Compound	CAS Number	LOR	Unit	EB1717430-081	EB1717430-082	EB1717430-083	EB1717430-084	EB1717430-085
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.8	5.8	5.6	6.0	6.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	14	14	39	27	69
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.3	6.2	6.8	6.5	6.4
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	62	57	239	328	511
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.4	0.4	0.2	0.2	----
Exchangeable Aluminium	----	0.1	meq/100g	0.3	0.3	<0.1	<0.1	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.8	1.9	4.0	2.9	2.3
Exchangeable Magnesium	----	0.1	meq/100g	1.0	1.0	4.4	4.8	9.0
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.6	1.0	0.3	0.2
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.2	0.3	1.3
Cation Exchange Capacity	----	0.1	meq/100g	3.8	3.9	9.8	8.5	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	12.8
Exchangeable Sodium Percent	----	0.1	%	1.8	1.8	1.7	4.0	10.3
Calcium/Magnesium Ratio	----	0.1	-	1.8	1.9	0.9	0.6	0.2
Magnesium/Potassium Ratio	----	0.1	-	1.6	1.7	4.3	15.8	47.2

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN39 400-600	GN39 650+	----	----	----
			Client sampling date / time	23-Aug-2017 14:00	23-Aug-2017 14:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1717430-086	EB1717430-087	--------	--------	--------
				Result	Result	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**6.9**	**6.6**	**----**	**----**	**----**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**439**	**813**	**----**	**----**	**----**
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	**6.7**	**6.4**	**----**	**----**	**----**
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	**2220**	**3560**	**----**	**----**	**----**
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**1.3**	**0.8**	**----**	**----**	**----**
Exchangeable Magnesium	----	0.1	meq/100g	**17.3**	**19.6**	**----**	**----**	**----**
Exchangeable Potassium	----	0.1	meq/100g	**0.2**	**0.2**	**----**	**----**	**----**
Exchangeable Sodium	----	0.1	meq/100g	**2.8**	**4.0**	**----**	**----**	**----**
Cation Exchange Capacity	----	0.1	meq/100g	**21.8**	**24.5**	**----**	**----**	**----**
Exchangeable Sodium Percent	----	0.1	%	**12.7**	**16.2**	**----**	**----**	**----**
Calcium/Magnesium Ratio	----	0.1	-	<0.1	<0.1	**----**	**----**	**----**
Magnesium/Potassium Ratio	----	0.1	-	**76.2**	**105**	**----**	**----**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1721190**	Page	: 1 of 8
Client	: **UMWELT (AUSTRALIA) PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ANNE SCHNEIDER	Contact	: Customer Services EB
Address	: 75 York street Teralba 2284	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: 3986C	Date Samples Received	: 17-Oct-2017 11:30
Order number	: ----	Date Analysis Commenced	: 17-Oct-2017
C-O-C number	: ----	Issue Date	: 30-Oct-2017 10:15
Sampler	: ANNE SCHNEIDER		
Site	: ----		
Quote number	: SYBQ/277/16		
No. of samples received	: 29		
No. of samples analysed	: 29		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Greg Vogel	Laboratory Manager	Brisbane Acid Sulphate Soils, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN66 0-20mm	GN66 20-150mm	GN66 150-300mm	GN66 400-580mm	GN66 580-800mm
			Client sampling date / time	12-Oct-2017 17:30	12-Oct-2017 17:30	12-Oct-2017 17:30	12-Oct-2017 17:30	12-Oct-2017 17:30
Compound	CAS Number	LOR	Unit	EB1721190-001	EB1721190-002	EB1721190-003	EB1721190-004	EB1721190-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.7	5.7	6.6	6.8	6.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	102	67	337	770	894
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	386	332	1940	3280	3400
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	0.3	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	0.2	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.2	1.7	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	4.2	3.3	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	1.7	0.7	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.6	0.8	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	10.7	6.8	----	----	----
Exchangeable Sodium Percent	----	0.1	%	5.3	12.1	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	3.0	1.3	0.7
Exchangeable Magnesium	----	0.1	meq/100g	----	----	10.5	5.8	3.7
Exchangeable Potassium	----	0.1	meq/100g	----	----	0.4	<0.1	<0.1
Exchangeable Sodium	----	0.1	meq/100g	----	----	2.8	2.5	1.8
Cation Exchange Capacity	----	0.1	meq/100g	----	----	16.8	9.8	6.4
Exchangeable Sodium Percent	----	0.1	%	----	----	16.8	25.4	28.2

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN67 0-50mm	GN67 50-100mm	GN67 150-300mm	GN67 300-600mm	GN67 600-800mm
			Client sampling date / time	12-Oct-2017 16:15	12-Oct-2017 16:15	12-Oct-2017 16:15	12-Oct-2017 16:15	12-Oct-2017 16:15
Compound	CAS Number	LOR	Unit	EB1721190-006	EB1721190-007	EB1721190-008	EB1721190-009	EB1721190-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.9	5.9	6.3	7.4	8.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	48	33	54	193	680
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	352	408	610	1470	3320
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.1	0.3	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	0.1	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	2.0	2.1
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	5.2	6.2
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	<0.1	<0.1
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	1.0	1.6
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	8.3	9.9
Exchangeable Sodium Percent	----	0.1	%	----	----	----	11.9	16.0
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.6	5.1	7.4	----	----
Exchangeable Magnesium	----	0.1	meq/100g	7.9	10.7	17.8	----	----
Exchangeable Potassium	----	0.1	meq/100g	1.1	1.1	0.7	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.6	0.8	1.8	----	----
Cation Exchange Capacity	----	0.1	meq/100g	14.3	18.0	27.7	----	----
Exchangeable Sodium Percent	----	0.1	%	4.1	4.5	6.6	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN68 50-150mm	GN68 150-300mm	GN68 400-700mm	GN68 700-1000mm	GN69 0-50mm
			Client sampling date / time	12-Oct-2017 13:15	12-Oct-2017 13:15	12-Oct-2017 13:15	12-Oct-2017 13:15	12-Oct-2017 10:30
Compound	CAS Number	LOR	Unit	EB1721190-011	EB1721190-012	EB1721190-013	EB1721190-014	EB1721190-015
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.9	6.8	8.1	8.7	5.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	33	253	685	1080	106
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	164	1450	2500	4330	240
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.5	----	----	----	<0.1
Exchangeable Aluminium	----	0.1	meq/100g	0.3	----	----	----	<0.1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.1	meq/100g	----	----	1.1	0.7	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	2.9	2.3	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	<0.1	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	1.8	1.5	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	5.8	4.4	----
Exchangeable Sodium Percent	----	0.1	%	----	----	30.3	33.3	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.5	4.6	----	----	5.1
Exchangeable Magnesium	----	0.1	meq/100g	1.3	9.6	----	----	1.7
Exchangeable Potassium	----	0.1	meq/100g	0.8	0.3	----	----	2.0
Exchangeable Sodium	----	0.1	meq/100g	0.3	4.1	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	4.4	18.6	----	----	8.8
Exchangeable Sodium Percent	----	0.1	%	7.6	22.1	----	----	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN69 50-100mm	GN69 150-300mm	GN69 400-600mm	GN69 630-850mm	GN71 0-50mm
			Client sampling date / time	12-Oct-2017 10:30	12-Oct-2017 10:30	12-Oct-2017 10:30	12-Oct-2017 10:30	11-Oct-2017 16:50
Compound	CAS Number	LOR	Unit	EB1721190-016	EB1721190-017	EB1721190-018	EB1721190-019	EB1721190-020
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**5.6**	**6.0**	**6.8**	**7.3**	**6.6**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**30**	**11**	**28**	**24**	**353**
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	**130**	**80**	**503**	**178**	**938**
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	**0.2**	<0.1	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	**0.1**	<0.1	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	**3.1**	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	**0.9**	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	**0.1**	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	<0.1	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	**4.2**	----
Exchangeable Sodium Percent	----	0.1	%	----	----	----	<0.1	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**3.6**	**3.9**	**14.1**	----	----
Exchangeable Magnesium	----	0.1	meq/100g	**1.0**	**0.9**	**4.8**	----	----
Exchangeable Potassium	----	0.1	meq/100g	**1.6**	**1.2**	**0.7**	----	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	**0.3**	----	----
Cation Exchange Capacity	----	0.1	meq/100g	**6.4**	**6.0**	**19.9**	----	----
Exchangeable Sodium Percent	----	0.1	%	**1.0**	**1.0**	**1.4**	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	**4.2**
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	**1.4**
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	**2.9**
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	**8.6**
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	**0.4**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN71 50-120mm	GN71 150-300mm	GN71 350-600mm	GN71 650-800mm	GN73 0-50mm
			Client sampling date / time	11-Oct-2017 16:50	11-Oct-2017 16:50	11-Oct-2017 16:50	11-Oct-2017 16:50	11-Oct-2017 14:40
Compound	CAS Number	LOR	Unit	EB1721190-021	EB1721190-022	EB1721190-023	EB1721190-024	EB1721190-025
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.6	5.9	6.5	7.0	5.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	20	10	76	136	28
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	99	86	542	777	96
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	<0.1	----	----	0.6
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	----	----	0.3
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.3	3.9	13.4	16.2	2.3
Exchangeable Magnesium	----	0.1	meq/100g	1.2	1.1	4.6	5.4	0.7
Exchangeable Potassium	----	0.1	meq/100g	0.9	0.3	0.4	0.4	1.4
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.2	1.1	1.6	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	5.4	5.5	19.5	23.8	5.0
Exchangeable Sodium Percent	----	0.1	%	1.5	3.8	5.8	6.8	1.3

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN73 100-200mm	GN73 300-450mm	GN73 500-700mm	GN73 700-1000mm	----
			Client sampling date / time	11-Oct-2017 14:40	11-Oct-2017 14:40	11-Oct-2017 14:40	11-Oct-2017 14:40	----
Compound	CAS Number	LOR	Unit	EB1721190-026	EB1721190-027	EB1721190-028	EB1721190-029	--------
				Result	Result	Result	Result	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.4	6.0	6.4	7.0	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	14	13	73	72	----
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	56	69	531	462	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	1.0	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	0.6	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.0	3.6	12.4	10.0	----
Exchangeable Magnesium	----	0.1	meq/100g	0.5	1.2	6.0	4.3	----
Exchangeable Potassium	----	0.1	meq/100g	1.2	0.4	0.3	0.2	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.2	1.4	1.5	----
Cation Exchange Capacity	----	0.1	meq/100g	4.7	5.4	20.1	16.0	----
Exchangeable Sodium Percent	----	0.1	%	1.3	3.3	6.9	9.3	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1727426**	Page	: 1 of 11
Client	: **UMWELT (AUSTRALIA) PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ANNE SCHNEIDER	Contact	: Customer Services EB
Address	: 75 York street Teralba 2284	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: 4166	Date Samples Received	: 28-Dec-2017 09:15
Order number	: ----	Date Analysis Commenced	: 28-Dec-2017
C-O-C number	: ----	Issue Date	: 19-Jan-2018 14:56
Sampler	: ANNE SCHNEIDER		
Site	: ----		
Quote number	: SYBQ/277/16		
No. of samples received	: 43		
No. of samples analysed	: 43		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN75 0-50mm	GN75 50-100mm	GN75 100-300mm	GN75 350-600mm	GN75 600-1000mm
			Client sampling date / time	21-Dec-2017 13:00	21-Dec-2017 13:00	21-Dec-2017 13:00	21-Dec-2017 13:00	21-Dec-2017 13:00
Compound	CAS Number	LOR	Unit	EB1727426-001	EB1727426-002	EB1727426-003	EB1727426-004	EB1727426-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.7	5.7	5.8	6.3	6.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	51	44	22	18	30
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	180	187	141	168	379
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Brown	Dark Brown	Dark Brown	Brown	Dark Brown
Texture	----	-	-	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Loam	Sandy Clay Loam
Emerson Class Number	EC/TC	-	-	4	4	3	3	4
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.2	0.1	<0.1	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	<0.1	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	5.4	4.4	5.1	5.8	10.8
Exchangeable Magnesium	----	0.1	meq/100g	1.7	1.1	0.9	1.0	3.1
Exchangeable Potassium	----	0.1	meq/100g	1.1	1.2	0.5	0.2	0.4
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	0.2	0.2
Cation Exchange Capacity	----	0.1	meq/100g	8.4	6.8	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	6.6	7.2	14.6
Exchangeable Sodium Percent	----	0.1	%	1.2	0.8	0.8	2.5	1.7
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	30	23	9	15	65
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	3.38	0.99	0.53	0.27	0.33

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN80 0-50mm	GN80 50-150mm	GN80 180-300mm	GN80 300-600mm	GN80 600-250mm
			Client sampling date / time	22-Dec-2017 10:00	22-Dec-2017 10:00	22-Dec-2017 10:00	22-Dec-2017 10:00	22-Dec-2017 10:00
Compound	CAS Number	LOR	Unit	EB1727426-006	EB1727426-007	EB1727426-008	EB1727426-009	EB1727426-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.7	6.0	6.4	7.0	7.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	62	20	22	112	407
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	211	107	168	810	1740
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Brown	Brown	Brown	Very Dark Greyish Brown	Dark Brown
Texture	----	-	-	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Clay Loam	Sandy Clay Loam
Emerson Class Number	EC/TC	-	-	4	4	3	3	3
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.3	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.4	3.8	4.7	12.9	----
Exchangeable Magnesium	----	0.1	meq/100g	1.8	1.3	1.6	5.6	----
Exchangeable Potassium	----	0.1	meq/100g	1.4	0.7	0.2	0.5	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.1	0.4	2.0	----
Cation Exchange Capacity	----	0.1	meq/100g	7.9	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	5.8	7.1	21.1	----
Exchangeable Sodium Percent	----	0.1	%	0.9	1.8	6.3	9.8	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	10.8
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	3.8
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	0.4
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	1.0
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	16.0
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	6.3
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	167	17	16	19	25
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	2.44	0.68	0.48	0.53	0.46

umwelt
Environmental & Social Consultants

Newcastle
75 York Street
Teralba NSW 2284

Perth
First Floor
12 Prowse Street
West Perth WA 6005
PO Box 783
West Perth WA 6872

Canberra
2/99 Northbourne Avenue
Turner ACT 2612
PO Box 6135
O'Connor ACT 2602

Sydney
50 York Street
Sydney NSW 2000

Brisbane
Level 13
500 Queen Street
Brisbane QLD 4000

Orange
Office 1
3 Hampden Street
Orange NSW 2800

T| 1300 793 267 E| info@umwelt.com.au www.umwelt.com.au