

**NORTH PARKES MINES STEP
CHANGE PROJECT
RESPONSE TO SUBMISSIONS –
ADDENDUM**

Part 3A Environmental Assessment

November 2013



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Prepared by
Umwelt (Australia) Pty Limited

on behalf of
North Mining Limited

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Report No. **2949/R18/FINAL**
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1.0 Introduction

The Environmental Assessment (EA) for the Northparkes Mines Step Change Project (Project) (Umwelt 2013) was placed on public exhibition from 11 July 2013 to 15 August 2013. The Project is the continuation of underground block cave mining in two existing ore bodies, the development of underground block cave mining in the E22 resource, additional campaign open cut mining located in existing mining leases, augmentation to approved Tailings Storage Facilities (TSFs) and an extended mine life of seven years until 2032 at the existing Northparkes Mine (NPM) site, located north-west of Parkes. NPM is operated by North Mining Limited (NML) which is seeking project approval for the Project under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

In response to the public exhibition of the EA, a Response to Submissions report was prepared and submitted to the Department of Planning and Infrastructure (DP&I) in September 2013. This report has been prepared as an addendum to the Response to Submissions report to provide a response to an additional submission received from the NSW Office of Agricultural Sustainability and Food Security (OASFS) received during the public exhibition period (refer to **Section 2.0**).

In addition, this report provides additional information in a relation to a number of commitments from NPM outlined in the Response to Submissions report, being:

- Umwelt has completed surveys for Sloanes froglet during appropriate weather conditions of heavy rainfall at the NPM site (refer to **Section 3.1**);
- As provided for in the Statement of Commitments in the EA (refer to Section 6.8.1) Umwelt has undertaken further survey for *Diuris tricolor* across the Project Disturbance Area during the known flowering period of late September/early October 2013 (refer to **Section 3.2**); and
- Umwelt has completed further survey of the proposed Kokoda Offset Site targeting threatened species and to inform further refinement of detailed management strategies, as required (refer to **Section 3.3**).

This report has been prepared by Umwelt on behalf of NPM.

2.0 NSW Office of Agricultural Sustainability and Food Security (OASFS)

This section provides a detailed response to the issues raised in the OASFS submissions on the Project. In the preparation of this section, the issues raised in OASFS submissions have been comprehensively reviewed and considered. Matters raised in this submission are outlined in the bold type below with the response following in normal type.

Considerable reference has been made to Cunningham (2006) Soils Survey and Land Capability Assessment of the Northparkes Mines – E48 Project, yet this document has not been included. Without this information, soils and land capability cannot be properly assessed.

The reference document *Soils Survey and Land Capability Assessment of the Northparkes Mines – E48 Project* (Cunningham 2006) was produced as part of the existing approved E48 Project (PA06_0026). As such, the information contained within Cunningham (2006) was assessed and approved under PA06_0026 (as modified), with this information used to inform the *Northparkes Mines Step Change Project Agricultural Impact Assessment* (WHK Agricultural Consultants 2013) (refer to Appendix 5 of the EA). For reference please find Cunningham (2006) attached as **Appendix 1**.

The assessment of Biophysical Strategic Agricultural Land (BSAL) (in Sections 1.3 and 4.0 of Appendix 5) does not address the BSAL criteria sufficiently. The broad statement (in Section 4.2.3) that ‘soil fertility is not high enough to meet this criteria’ is not sufficient. The fertility criteria contained in the Interim Protocol for Verification of Biophysical Strategic Agricultural Land should be used and the soils of the area should be included or excluded from BSAL through this process.

It is important to note that the consideration of BSAL, and associated assessment processes outlined in the Mining SEPP, apply to applications for SSD under Part 4 of the EP&A Act. As outlined in the EA, the Project is subject to the provisions of Part 3A of the EP&A Act.

Notwithstanding, the AIS included as part of the EA was prepared in accordance with the DGRs, which included specific detailed requirements of the NSW Office of Agricultural Security and Food Security (OASFS), as detailed in Table 5.2 of the EA, and the DP&I AIS guidelines (dated October 2012). Neither of these requirements requested a detailed assessment against BSAL criteria. It is noted that the DP&I AIS guidelines (October 2012) requires the description of any land *mapped* as BSAL in the Project area or within 2 kilometres of the Project area.

As discussed in Section 5.2 of the EA, at the time of the preparation of the EA, there was no mapping of BSAL in the Central West region in which the Project is located. In addition, there was no SRLUP prepared for the Central West and there has not been a SRLUP prepared for this region to date.

The broad assessment of BSAL provided in the Agricultural Impact Assessment (AIA), was completed due to a request through consultation with relevant agencies, to broadly examine the agricultural resources within the Project Area in the context of existing SRLUPs for the Upper Hunter and New England North-west. Accordingly, the approach undertaken in the AIA was to identify the key limiting factor, in this case soil fertility, in terms of the Project area potentially conforming to the broad BSAL criteria.

It is noted that the NSW Government have recently released further mapping of BSAL, including within the Central West, which is currently on exhibition. As shown on **Figure 2.1**, there are no areas mapped as BSAL within the Project area or within 2 kilometres of the Project area. The closest area of mapped BSAL in relation to the Project Area is over 50 kilometres to the north (refer to **Figure 2.1**).

The extent of salinity is not clear. In Section 3.2.2 the proponent states that most of the SMU2 profiles tested had moderate to extreme salinity in their deep subsoil yet soil test results referred to in Section 3.2.3 (pertaining to soils broadly consistent with SMU2 soils) states that 'Salinity...and...chloride...were relatively low in all tests'. Clarification on the extent of salinity in the Project area is required.

Soil salinity, as discussed in Section 3.2.2 of Appendix 5 of the EA, was in relation to soil testing undertaken as part of the existing approved E48 Project (PA06_0026), informing the Cunningham's (2006) assessment. The discussion of soil test results in Section 3.2.3 of Appendix 5 of the EA was in relation to soil testing undertaken as part of the ongoing farm management and was considered as part of the preparation of the Northparkes Mines Step Change Project (the Project) Environmental Assessment (EA).

As discussed in Section 3.2.3, salinity and chloride were found to be relatively low in all tests undertaken as part of ongoing soil monitoring; however, it was noted that the depth of sampling in the tests undertaken for the Project were not as great as some horizons of moderate to high salinity found by Cunningham (2006) as part of the E48 Project.

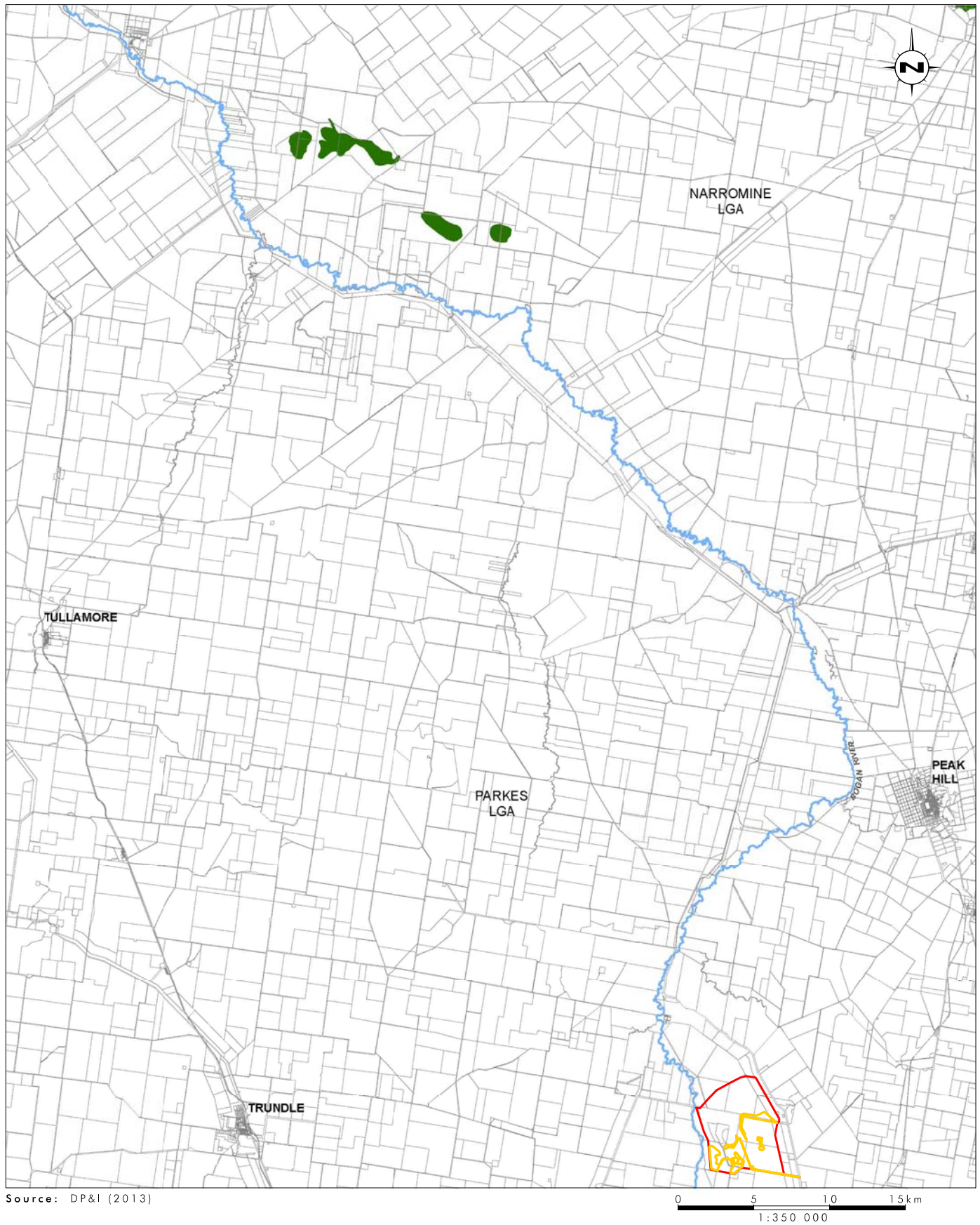
Furthermore, as discussed in Section 5.2.1.3 of the main text of the EA, in general soil salinisation is not a significant land management issue within the NPM landholdings given the low yielding water table within the region, the use of dryland cropping techniques and also the absence of identified soil salinity issues (such as evidence of salts in drain bank or cuttings) in the management of NPM landholdings.

The DGRs specifically requested the consideration of contamination with the land and soil capability in the AIS and this has not been done. Contamination should be considered in the AIS.

As discussed in Section 5.2.1.3 of the main text of the EA, a preliminary contamination assessment was undertaken on the site for the additional disturbance associated with the Project. The assessment included a review by the current Northparkes Farm Manager of the history of agricultural practices in the Proposed Disturbance Areas, visual inspection of the portions of the site to be disturbed by the proposed extensions to operations, as well as undertaking a database search of the NSW EPA Contaminated Land Record of Notices.

The assessment indicated that the area has been subject to cropping and grazing only. The area has not supported any sheep dip sites, fuel or chemical storage areas, or machinery workshops/sheds, aside from what has been identified on the NPM contaminated site register. The results of the database search indicated land affected by the Proposed Disturbance Area have no records of notices relating to orders made under Part 3 of the *Contaminated Land Management Act 1997*. As such, no further assessment has been undertaken in regards to this issue.

In addition, NPM maintains a register that records, among other things, the location, establishment, activities, contaminants, records of sampling/inspection, a risk assessment and preventative measures/remedial actions for each site that stores potentially hazardous/contaminating materials with the NPM operations area. At present a total of 59 sites are recorded and managed under the register.



Legend

- ▭ Project Area
- ▭ Proposed Disturbance Area
- ▭ Biophysical Strategic Agricultural Land

FIGURE 2.1

Draft SEPP BSAL Central West, NSW

3.0 Additional Targeted Ecological Surveys

The following sections document the outcomes of targeted ecological surveys undertaken during spring 2013 for the Project. The following surveys were undertaken:

- Surveys for *Crinia sloanei* across the Project Area during September 2013 following heavy rainfall.
- Surveys for *Diuris tricolor* across the Project Area and proposed Kokoda Offset Site during September 2013 following the flowering of the species at a known reference site close to the Project Area.
- Seasonal fauna survey and supplementary vegetation mapping of the proposed Kokoda Offset Site during September 2013 to further inform mapping of ecological features of this site and to further inform refinement of management zones as relevant.

Each of the above surveys is described in detail below.

3.1 Sloanes froglet Survey

3.1.1 Introduction

As part of the detailed assessment of potential impacts on this species outlined in EA, the presence of Sloanes froglet within the Proposed Disturbance Area could not be discounted. On this basis, the ecological assessment supporting the EA indicated that the Project could have a significant impact on this species should it be confirmed as being present within the Proposed Disturbance Area. Accordingly, NPM committed to completing targeted surveys across the Proposed Disturbance Area during periods of suitable weather conditions to confirm, or otherwise, the presence of Sloanes froglet within the Proposed Disturbance Area.

Sloanes froglet is listed as a vulnerable species under the *Threatened Species Conservation Act 1995* (TSC Act). This species was not recorded within the Proposed Disturbance Area, however it was identified by call and brief capture during nocturnal amphibian surveys in February 2012 (during cool conditions) following a period of prolonged and heavy rainfall adjacent to the Bogan River within the Wider Study Area. This species was recorded within an inundated area of farmland to the south of McClintocks Lane approximately 500 metres west of the Proposed Disturbance Area (refer to **Figure 3.1**).

Sloanes froglet is a small ground-dwelling frog that is typically associated with periodically inundated areas in grasslands, woodland and disturbed habitats (OEH 2013). Sloanes froglet shelters under logs and other debris, usually in moist depressions or near water (Frogs of Australia 2013). This species is known to call throughout the cooler months and generally following heavy rain where they call whilst floating in inundated areas (Cogger 2000).

The EA identified that the Proposed Disturbance Area could provide up to 130 hectares of potential habitat (grassland, woodland and disturbed habitats [excluding cultivated land] that is associated with nearby water sources, and that becomes inundated during rainfall events) for the species throughout the Proposed Disturbance Area, especially in low lying areas which may become inundated during rainfall events. The precise area of potentially suitable habitat for the species is likely restricted to areas prone to inundation during moderate to heavy rainfall events, within the 130 hectares.



Source: Boundaries and Aerial - NPM (2013), Aerial - Google Earth (2006,2010)

0 0.5 1.0 2.0km
1:40 000

Legend

- ▬ Project Area
- ▬ Proposed Disturbance Area
- ▬ Drainage Line
- ▬ Sloanes froglet Survey (Driving and Walking)
- Sloanes froglet Survey Point
- 2012 Sloanes froglet Record

FIGURE 3.1

Sloanes froglet (*Crinia sloanei*)
Survey Locations

3.1.2 Methods

Rainfall records for the NPM site and weather forecasts for the Parkes area were monitored during mid 2013 to identify potentially suitable conditions to survey for Sloanes froglet within the Proposed Disturbance Area.

Rainfall records from the weather station at NPM were reviewed to identify the amount of rain for the area that was likely to represent a significant local rainfall event that could result in the inundation of potential habitat areas for Sloanes froglet (refer to **Table 3.1**). As shown in **Table 3.1**, between 30 March 2012 and 1 September 2013 only two rainfall events greater than 30 millimetres occurred.

Table 3.1 – Frequency and Intensity of Daily Rainfall Records

Rainfall (millimetres)	Number of Days
Zero	420
< 1	35
1 to 5	34
5.1 to 10	12
10.1 to 15	9
15.1 to 20	2
20.1 to 25	4
25.1 to 30	0
30.1 to 35	1
> 35	1

A rainfall event of greater than 30 millimetres in a 24 hour period was identified as a likely amount of rainfall to result in the inundation of potential habitat areas for Sloanes froglet.

On Monday 16 September 39 millimetres of rainfall were recorded (from 9.00 am Monday to 9.00 am Tuesday) at the NPM site. A further 4 millimetres were recorded on Tuesday 17 September prior to sunset.

Surveys for Sloanes froglet were undertaken across the Proposed Disturbance Area on the evening of Tuesday 17 September 2013. Inundated areas occurred adjacent to McClintocks Lane, Northparkes Lane (located within the Proposed Disturbance Area) and Adavale Lane. All roadside drains were inundated and in several areas adjacent paddocks contained inundated areas. Areas of potentially suitable habitat included inundated areas (excluding inundated cropland) which were surveyed. The nearby Bogan River was not flowing at the time of the survey.

Surveys for Sloanes froglet comprised walking searches in inundated areas and on the banks of flooded areas or water bodies using LED headlamps and/or 30 watt Lightforce spotlights. Searches, including listening for calls, were undertaken opportunistically, wherever potentially suitable habitat was identified. Searches at individual locations varied in duration from 5 minutes to 30 minutes depending on the suitability of the habitat and the activity of other frog species at each site. Call playback surveys were also undertaken at each of the walking survey sites. The call of the species was played for a minimum of approximately 1 minute, and up to 5 minutes, followed by listening for responses during active searches.

Driving surveys were also undertaken along McClintocks Lane, Northparkes Lane, Adavale Lane and Bogan Road. Driving surveys comprised spotlighting the road surface, scanning for frogs, while travelling at less than 20 kilometres per hour. A total of 12 person hours of nocturnal amphibian searches were undertaken across suitable habitat for Sloanes froglet (*Crinia sloanei*) within the Proposed Disturbance Area (refer to **Figure 3.1**).

3.1.3 Results

The targeted survey did not result in the identification of Sloanes froglet within any areas of suitable habitat within the Proposed Disturbance Area. No individuals were seen, heard calling or responded to call playback. The following non threatened frog species were recorded during the survey:

- Perons tree frog (*Litoria peroni*).
- Spotted marsh frog (*Limnodynastes tasmaniensis*).
- Brown froglet (*Crinia parsignifera*).
- Common spadefoot (*Neobatrachus sudelli*).
- Banjo frog (*Limnodynastes dumerilii*).
- Wrinkled burrowing toadlet (*Uperoleia rugosa*).

3.1.4 Conclusion

The absence of Sloanes froglet during the targeted survey suggests one of the following possibilities:

- Sloanes froglet no longer occurs in the areas previously identified and therefore the Project is unlikely to have a significant impact on the species; or
- Sloanes froglet may occur (most likely along the Bogan River) but was not detected within suitable habitat in the Proposed Disturbance Area during the targeted survey. The species may require a larger rainfall event or a rainfall event that results in the Bogan River flooding (where it has previously been recorded as shown on **Figure 3.1**). Given the lack of identification in inundated areas of the Proposed Disturbance Area it is unlikely that the Project would have a significant impact on the species.

It is concluded that Sloanes froglet may possibly occur along the Bogan River, located outside of the Proposed Disturbance Area, and the species is unlikely to be significantly impacted by the Project.

3.2 Pine Donkey Orchid (*Diuris tricolor*) Surveys

3.2.1 Introduction

As outlined in the ecological assessment supporting the EA, areas of suitable habitat within the Proposed Disturbance Area were considered to have the potential to contain (or support a large portion of) a viable population of pine donkey orchid (*Diuris tricolor*). Accordingly, the removal of this habitat could potentially have a significant impact on a local population of pine donkey orchid (*Diuris tricolor*) where it may occur within the Proposed Disturbance Area. On

this basis, NPM committed to a targeted survey of the Proposed Disturbance Area to confirm, or otherwise, the presence of pine donkey orchid (*Diuris tricolor*). These surveys were proposed to be undertaken across one suitable season, being September/October 2013. In addition, targeted surveys for pine donkey orchid (*Diuris tricolor*) were completed across the proposed Kokoda Offset Site, to identify likely presence.

The pine donkey orchid (*Diuris tricolor*) is listed as a vulnerable species under the TSC Act. Occurring in New South Wales and Queensland, its suitable habitat includes grassy sclerophyll forests. Species that pine donkey orchid (*Diuris tricolor*) is commonly associated with and that have been recorded in the Wider Study Area include white cypress pine (*Callitris glaucophylla*) and bumble box (*Eucalyptus populnea* subsp. *bimbi*) (OEH 2012b). The pine donkey orchid (*Diuris tricolor*) occurs in sandy soils on flats or small rises and typically flowers during September and October (OEH 2012b).

In the initial survey for the EA, the pine donkey orchid (*Diuris tricolor*) was not been recorded within the Proposed Disturbance Area. A population of 234 plants was recorded in a patch of White Cypress Pine Woodland within the Wider Study Area, approximately 2 kilometres north of the Proposed Disturbance Area. Approximately one quarter of this population occurs just inside the northern boundary of the Project Area. The species is also known to occur in Blow Clear West State Forest and Strahorn State Forest within the surrounding region.

No patches of White Cypress Pine Woodland occur within the Proposed Disturbance Area however, up to 37 hectares of suitable habitat for the species occurs, particularly in open areas of the Grey Box Woodland and Bumble Box – White Cypress Woodland where white cypress pine (*Callitris glaucophylla*) is locally dominant. Such habitat occurs, albeit in small areas, within the Adavale Lane and McClintocks Lane road reserves. Additional areas include the woodland north of the existing subsidence zone associated with E48. The total area of potential habitat likely occurs as areas dominated by white cypress pine occurring in areas of Grey Box Woodland and Bumble Box – White Cypress Woodland and is likely to be considerably less than 37 hectares.

3.2.2 Methods

As a species that flowers seasonally over a less than two month period, and that may not flower every year, a local reference site was required to determine if and when the species was flowering in the local area. The population of 234 plants to the north of the Project Area along Adavale Lane, was used as a reference site. The pine donkey orchid was confirmed as flowering on 19 September by NPM Farm Manager, Geoff McCallum, who provided photographs of the flowering individuals at the Adavale Lane reference site.

The pine donkey orchid (*Diuris tricolor*) searches were variable in length and location, and were tailored to suit the environment in which they occurred to gain maximum coverage of likely habitat for the species. A meandering technique was selected over a plot-based method in order to maximise coverage of areas of suitable habitat for the species within the Proposed Disturbance Area during the survey period. The meandering transect technique is useful for detecting threatened flora species across large areas, as it enables the surveyor to cover large proportions of the area under investigation, unlike plot-based surveys.

Meandering transects were conducted in the Proposed Disturbance Area and at the proposed Kokoda Offset Site by two suitably experienced Umwelt ecologists who were both familiar with the target species. Transects were conducted together, walking in parallel. The distance between the ecologists would vary depending on the suitability of the habitat. In less suitable environments, ecologists were separated by up to 20 metres, whereas in ideal habitat for the species this distance was reduced to less than five metres. If individual pine donkey orchids were recorded, the level of survey intensity in the surrounding area (approximate 20 metre radius) was increased to ensure that all nearby individuals were identified where possible.

Surveys for the pine donkey orchid were conducted across the Proposed Disturbance Area on 25 and 26 September 2013, and across the proposed Kokoda Offset Site on 26 and 27 September 2013.

3.2.3 Results

3.2.3.1 Proposed Disturbance Area

A total of 27.7 kilometres of walking meander searches were completed across the Proposed Disturbance Area (refer to **Figure 3.2**). The survey did not identify any species within areas of potential habitat within the Proposed Disturbance Area in the vicinity of Northparkes Lane.

The September 2013 survey identified a new potential population of the pine donkey orchid (*Diuris tricolor*) within areas of suitable habitat located centrally within and adjacent to the Project Area and approved E48 subsidence zone (refer to **Figure 3.3**). The population was of moderate size, covering approximately 1.9 hectares of land and 947 individual plants.

As shown on **Figure 3.3**, a proposed haul road is located within this identified population of the pine donkey orchid (*Diuris tricolor*). Based on this proposed haul road alignment, approximately 156 individual plants occurred in the Proposed Disturbance Area (refer to **Figure 3.3**).

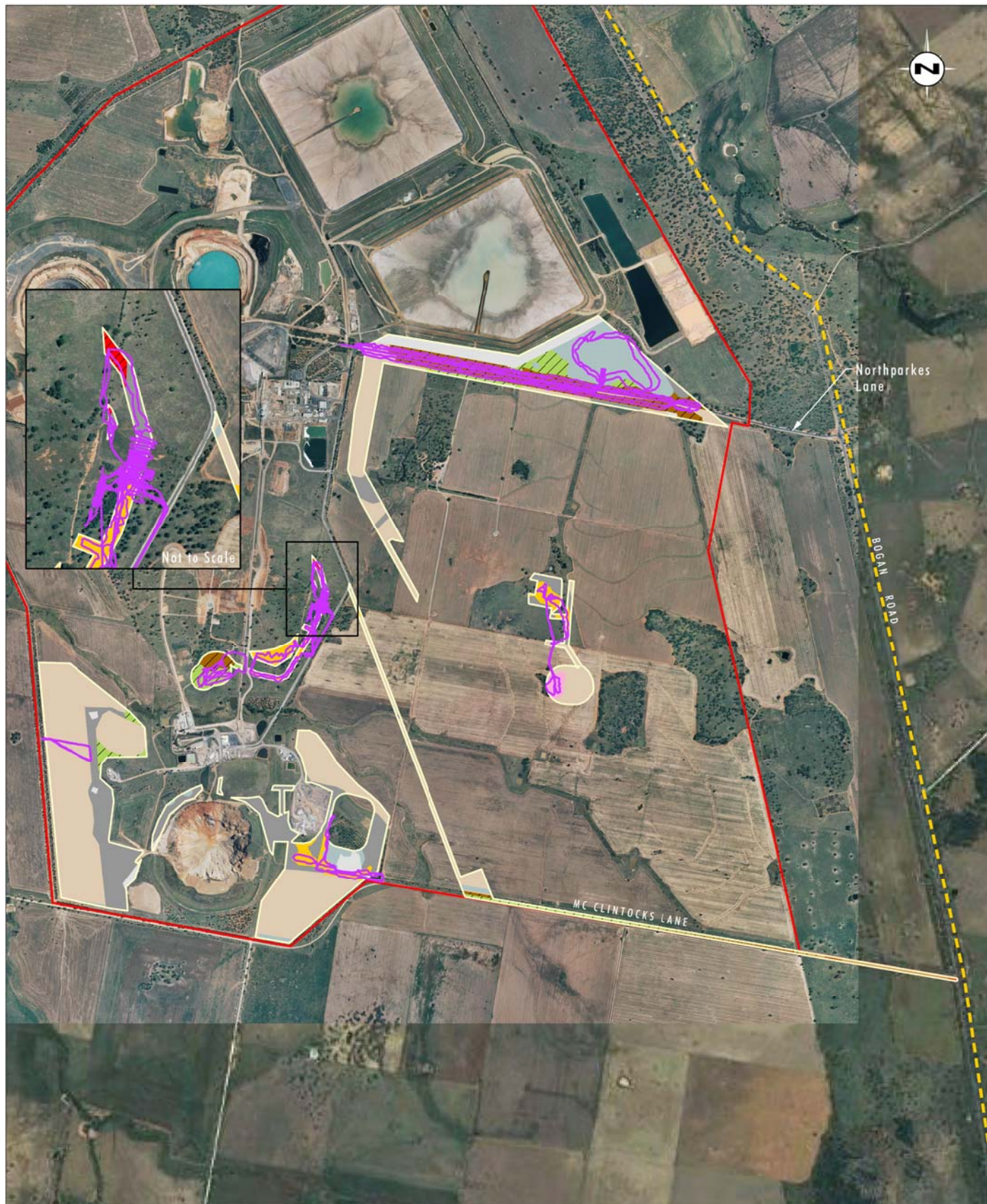
Following the identification of the pine donkey orchid (*Diuris tricolor*) population in the Proposed Disturbance Area, NPM has revised the project design to realign the location of the proposed haul road to avoid impacting as many pine donkey orchid plants as practicable. This design refinement also considered the minimisation of other potential design issues, including interactions with the proposed mine access road (refer to **Figure 3.4**).

The revised haul road alignment includes a 20 metre buffer area that may be subject to disturbance during construction as well as reducing potential for edge effect impacts during operations. Based on a conservative approach, the realigned haul road, inclusive of the 20 metre buffer area, will result in an impact on approximately 0.05ha of the mapped extent of the pine donkey orchid (*Diuris tricolor*) population and includes 14 individual plants. It is noted that all of the impacted individuals are located within the 20 metre buffer area adjacent to the revised haul road alignment. This revision to the project design results in the avoidance of direct impacts on 142 individual plants (refer to **Figure 3.4**). A revised Project layout figure, incorporating the proposed realigned haul road is shown on **Figure 3.5** (Figure 1.2 from the EA).

A revised seven-part test was undertaken to assess the level of impact on the species (refer to **Appendix 2**) and concluded that the Project (including the revised haul road location) is unlikely to have a significant impact on the pine donkey orchid as the 14 individuals represent a negligible impact on this population.

On the basis of the avoidance of the majority of the mapped extent of the pine donkey orchid population and the resultant non significant impact on this species (on 14 individuals), NPM submits that offsetting of this species is not required for the Project. Notwithstanding this, NPM will commit to the active management of the remaining population located outside of approved and Proposed Disturbance Areas. Specific mitigation strategies will include:

- fencing of the population to remove potential impacts from human access (particularly vehicle access);
- annual seasonal monitoring during the flowering period to assess the ongoing status of the population; and
- weed monitoring, and where required weed control. All weed control actions will be undertaken outside the flowering period of the species.



Source: Boundaries: NPM (2013), Aerial: Google Earth (2010)

0 0.5 1 1.5 km
1:35 000

Legend

- Project Area
- Wider Study Area
- Project Disturbance Area
- Diuris tricolor* Meandering Survey (on Foot)
- Bimble Box-White Cypress Pine Woodland
- Bimble Box-White Cypress Pine Woodland-Exotic Understorey
- Disturbed Land
- Exotic Grassland
- Grey Box Grassy Woodland (EEC - TSC Act/EEC - EPBC Act)
- Grey Box Grassy Woodland-DNG (EEC - TSC Act/EEC - EPBC Act)
- Plantation
- White Box-Yellow Box-Blakely's Red Gum Woodland (EEC - TSC Act/CEEC - EPBC Act)
- Cultivated Agricultural Land

FIGURE 3.2

Diuris tricolor Survey Effort
September/October 2013



Source: Aerial, Project Boundaries - NPM (2013)

0 25 50 75 m
1:1500

Legend

- Project Area
- Approved Disturbance Area
- Proposed Disturbance Area
- Estimated Area of *Diuris tricolor* Population Outside of the Approved Disturbance Area
- Diuris tricolor* Meandering Survey (on foot)
- *Diuris tricolor* Location

FIGURE 3.3

Diuris tricolor Impact Area of Exhibited Project



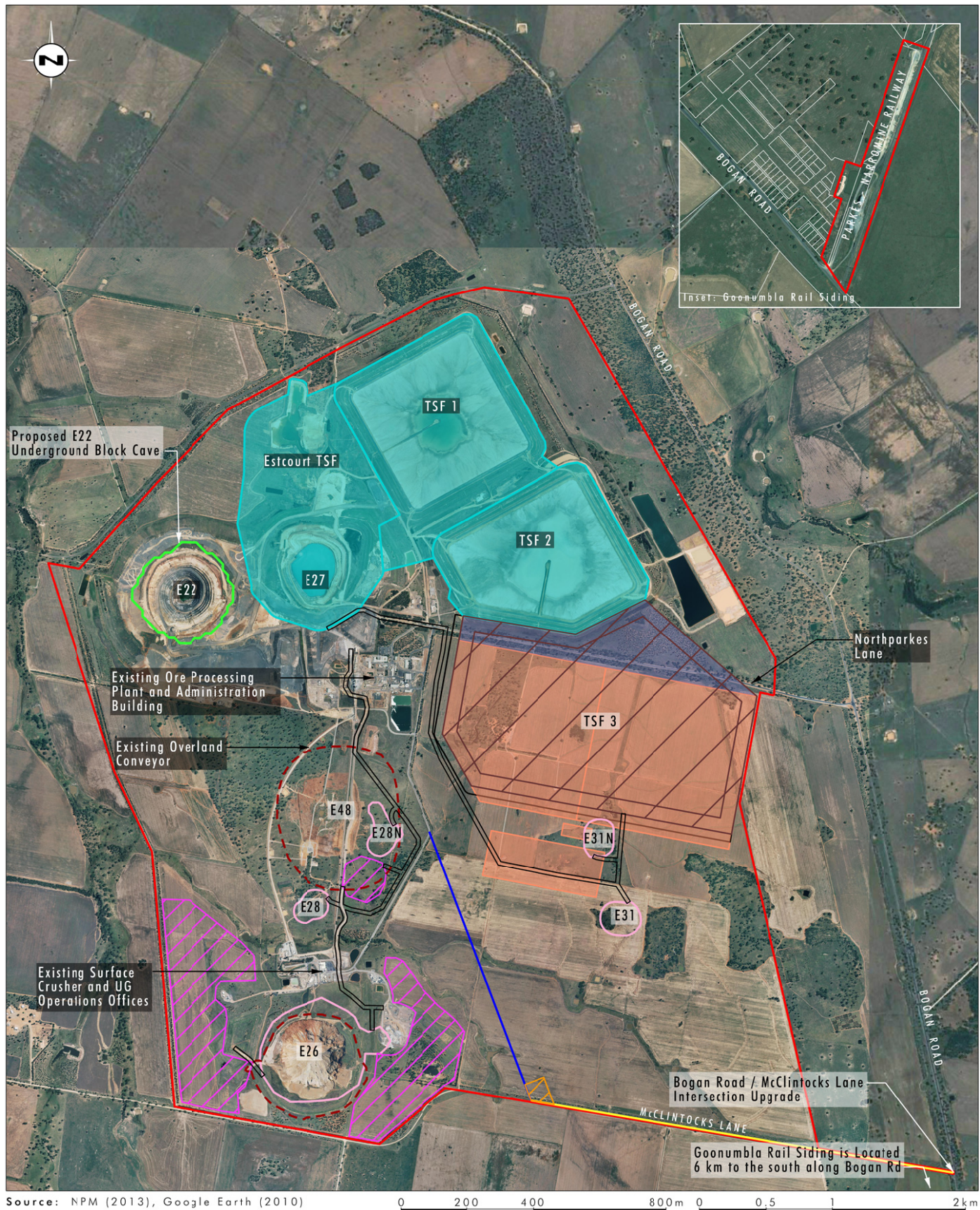
Source: Project Boundaries and Aerial - NPM (2013)

Legend

- Realigned Haul Road - October 2013
- Realigned Haul Road - October 2013 20m Buffer
- Approved Disturbance Area
- Proposed Disturbance Area
- Estimated Area of *Diuris tricolor* Population Outside of the Approved Disturbance Area
- Diuris tricolor*

FIGURE 3.4

Diuris tricolor and Realigned Haul Road Location



Source: NPM (2013), Google Earth (2010)

Legend

- Project Area
- Approved Tailings Storage Facility (Rosedale)
- Approved Subsidence Management Areas
- Existing Tailings Storage Facility
- Proposed Tailings Storage Facility Extension
- Proposed TSF3
- New Underground Block Cave Mining Area
- Proposed Open Cut Areas
- Proposed Upgrade to McClintocks Lane
- Proposed Access Control and Visitor Car Park
- Proposed Waste Dumps
- Proposed Site Access Road
- Proposed Haul Road

File Name (A4): R18/2949_389.dgn
20131030 12:58

FIGURE 3.5

Northparkes Mines Step Change Project

3.2.3.2 Proposed Kokoda Offset Site

Notwithstanding the assessment outcomes above, Umwelt completed targeted surveys of the proposed Kokoda Offset site, to confirm suitable habitat for this species. A total of 35 kilometres of walking meander searches were completed across the proposed Kokoda Offset Site (refer to **Figure 3.6**). No pine donkey orchids were identified on the proposed Kokoda Offset Site. While not recorded, it is noted that the species may occur, however the chance of occurrence is relatively low given the large area sampled during this survey. The following other (all non-threatened) orchid species were identified during the walking meandering orchid searches across the proposed Kokoda Offset Site:

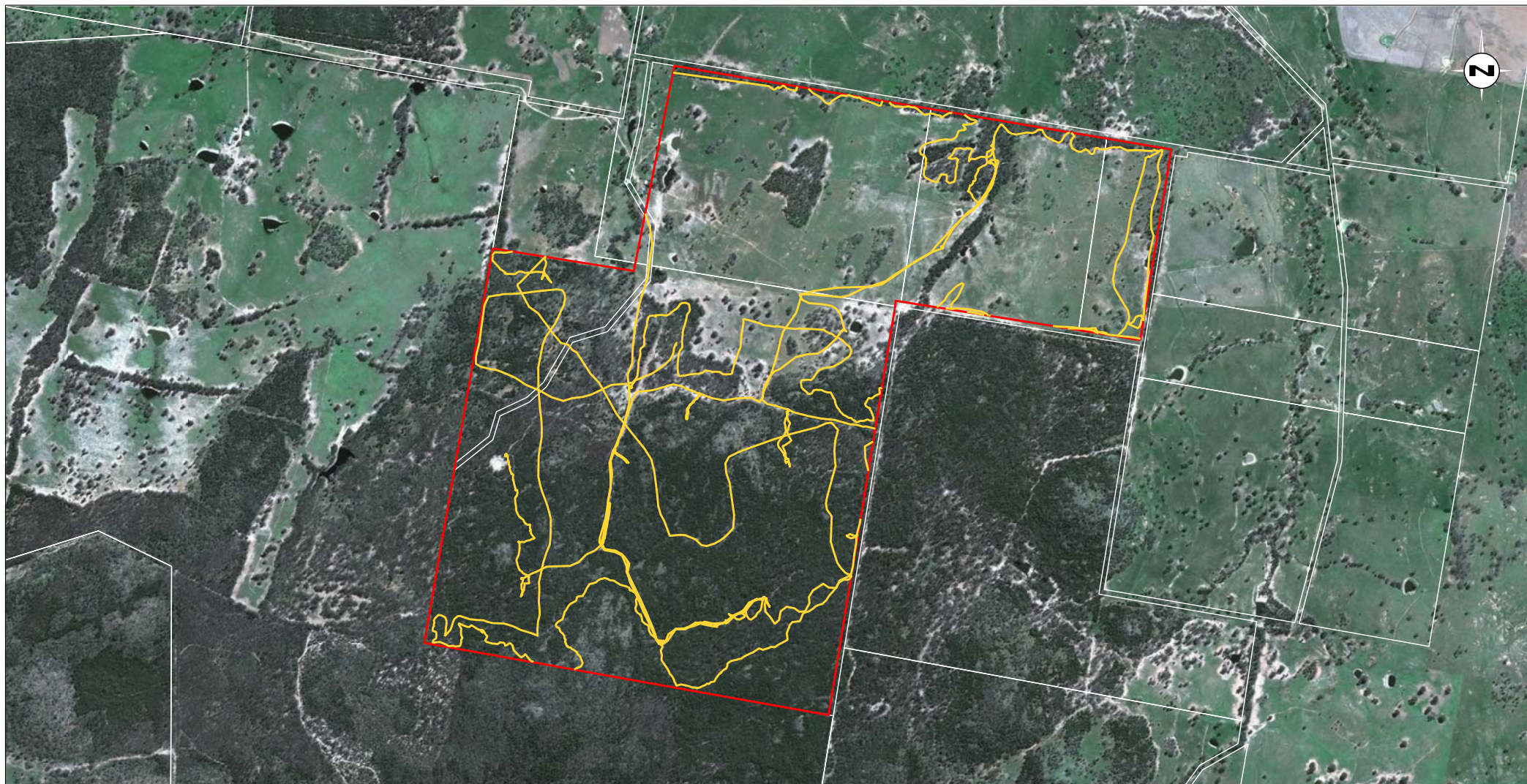
- *Acianthus collinus*;
- Pink fingers (*Caladenia carnea*);
- Musky caladenia (*Caladenia gracilis*);
- Fringed spider orchid (*Caladenia tentaculata*);
- Purplish beard orchid (*Calochilus robertsonii*);
- Blue caladenia (*Cyanicula caerulea*);
- *Diuris* sp.;
- Common onion orchid (*Microtis unifolia*);
- *Prasophyllum* sp.;
- Midget greenhood (*Pterostylis mutica*);
- Dwarf greenhood (*Pterostylis nana*); and
- *Pterostylis* sp.

3.3 Kokoda Offset Site Spring Survey

3.3.1 Introduction

As part of the proposed Kokoda Offset Site, NPM committed to completing further surveys during spring 2013. These surveys were completed to provide additional seasonal information on the ecological values of the proposed Kokoda Offset Site, refinement of previous surveys and further information on the proposed management actions. The following sections document the methodology undertaken and the results of the spring 2013 surveys of the proposed Kokoda Offset Site.

As described in the EA (Umwelt 2013) the proposed Kokoda Offset Site is a 350 hectare site located in the Mandagery locality of the Central West Slopes of NSW. The proposed Kokoda Offset Site is located approximately 12 kilometres north-west of Nangar National Park, approximately 8 kilometres south of Goobang National Park, approximately 12 kilometres west of Mandagery State Forest, approximately 17 kilometres east of Cookamidgera State Forest, and approximately 20 kilometres east of Back Yamma State Forest.



Source: Google Earth (2010), Department of Planning (2009) and Umwelt (2013)

Legend

- Proposed Kokoda Offset Site Boundary
- *Diuris tricolor* Walking Meander Survey

FIGURE 3.6

Diuris tricolor Survey Effort
Proposed Kokoda Offset Site

As described in the EA (Umwelt 2013), preliminary surveys of the proposed Kokoda Offset Site were undertaken during autumn 2013 focusing on the mapping of vegetation communities across the site and opportunistic surveys for fauna species.

3.3.2 Methodology

Additional field surveys were conducted across the proposed Kokoda Offset Site from 2 to 5 September and from 26 to 27 September 2013. The surveys were conducted in addition to those presented and described in the EA (Umwelt 2013).

Supplementary vegetation mapping and seasonal fauna survey were undertaken across the proposed Kokoda Offset Site, as detailed further below.

3.3.2.1 Supplementary Vegetation Mapping

Systematic Plot-based Survey

An additional 12 plots were undertaken across the proposed Kokoda Offset Site during the September 2013 survey, totalling 26 across all surveys as shown in **Figure 3.7**.

A detailed description of how a systematic plot is conducted including the information recorded is described in the EA (Umwelt 2013).

Meandering Transects

Meandering transects were walked through derived native grassland vegetation across the proposed Kokoda Offset Site (refer to **Figure 3.8**). Additional sampling of vegetation was undertaken along these transects, particularly searches for threatened and otherwise significant species, Endangered Populations (EPs) and Threatened Ecological Communities (TECs). Meandering transects enabled floristic sampling across a much larger area than systematic plots, especially where the number of plots was limited. Records along transects supplemented floristic sampling carried out in plots, however, the data was collected in the form of presence records, rather than semi-quantitative cover abundance scores.

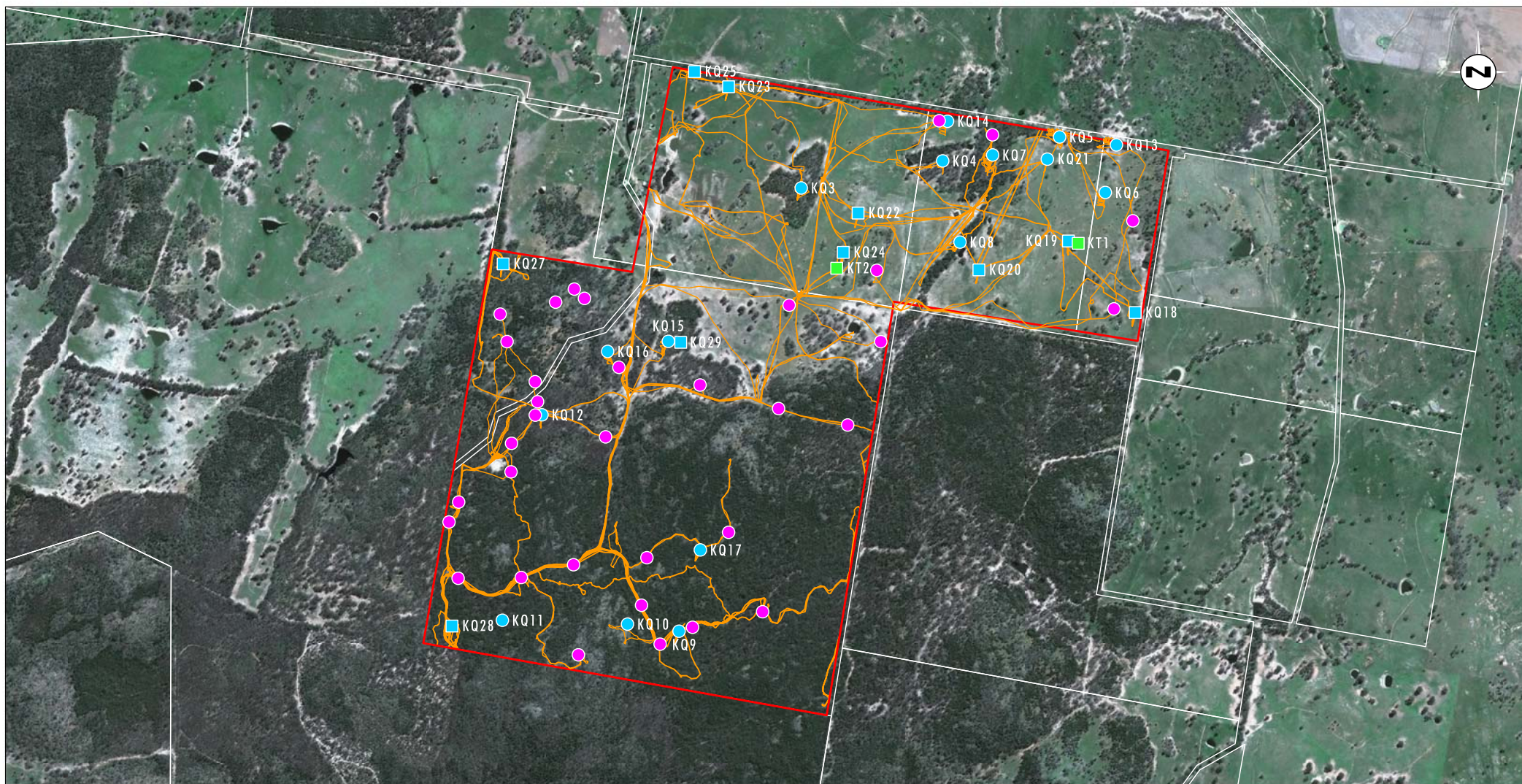
Meandering transects targeted specific vegetation units and provided information on spatial patterns of vegetation that fed into the refinement of vegetation community mapping for the Proposed Disturbance Area.

Ground-truthing of Vegetation Mapping

Ground-truthing of the vegetation map was carried out during all field surveys and while travelling throughout the proposed Kokoda Offset Site. This contributed to the understanding of vegetation community boundaries, refinement of community descriptions, and providing a more comprehensive understanding of the floristic features across the proposed Kokoda Offset Site.

Plant Identification and Nomenclature Standards

All vascular plants recorded or collected within quadrats and along transects were identified using keys and nomenclature in Harden (1992, 1993, 2000 and 2002) and Wheeler *et al.* (2002). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from *PlantNET* (Botanic Gardens Trust 2013), the online plant name database maintained by the National Herbarium of New South Wales.



Source: Aerial - Google Earth (2010), Cadastre - Department of Planning (2009)

0 0.25 0.5 1.0 km
1:20 000

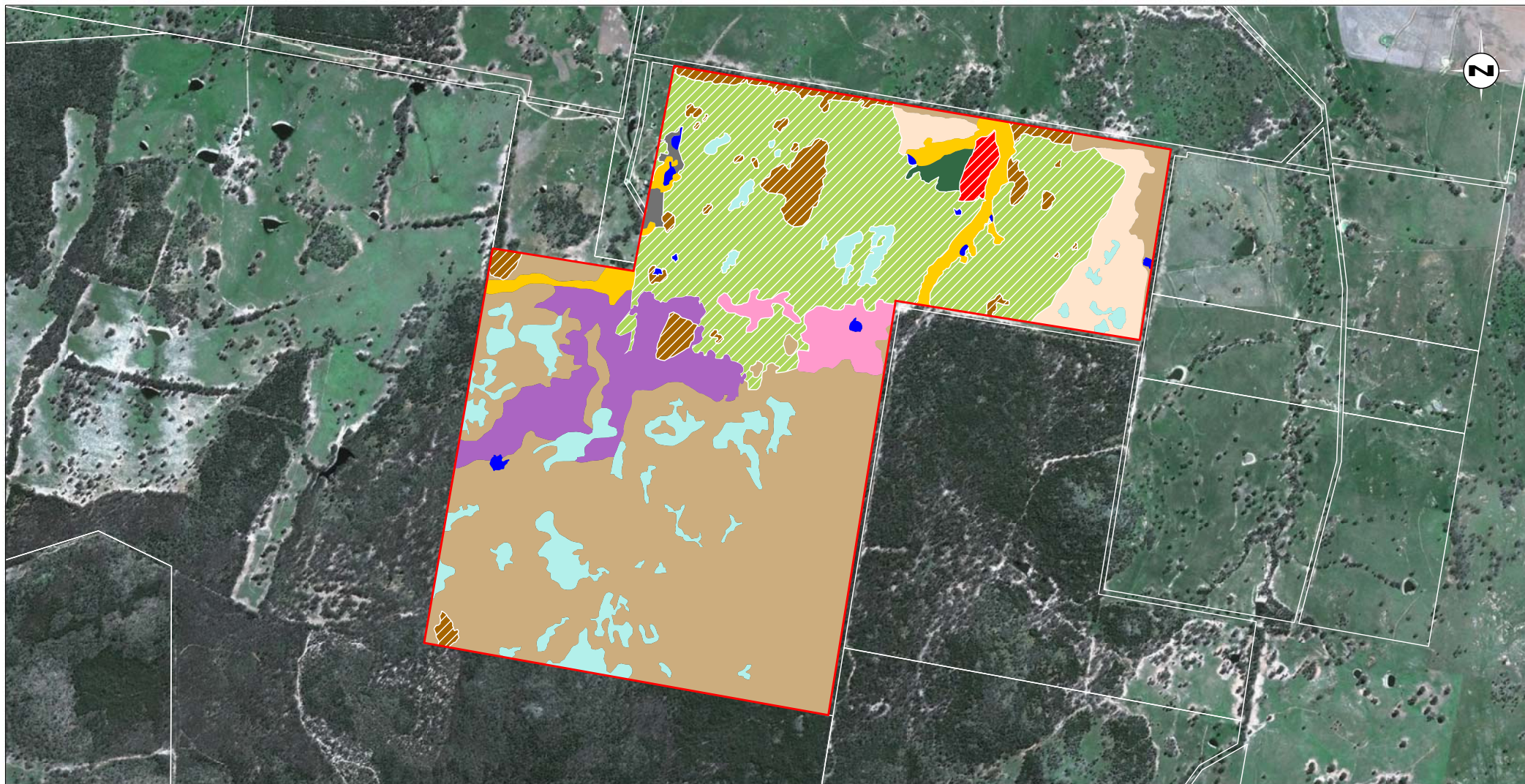
Legend

- Proposed Kokoda Offset Site Boundary
- Systematic Flora Quadrats (Autumn 2013)
- Systematic Flora Quadrats (Spring 2013)
- Rapid Flora Quadrats (Autumn 2013)
- Meandering Transects (Spring 2013)
- General Floristic Transects (Autumn & Spring 2013)

File Name (A4): R18/2949_381.dgn
20131029 16.04

FIGURE 3.7

Flora Survey Effort
Proposed Kokoda Offset Site



Source: Aerial - Google Earth (2010), Cadastre - Department of Planning (2009)

0 0.25 0.5 1.0 km
1:20 000

Legend

- | | | |
|---|---|---|
| Proposed Kokoda Offset Site Boundary | Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Pine Forest | Grey Box - Ironbark Woodland |
| Grey Box Grassy Woodland (EEC - TSC Act/CEEC - EPBC Act) | Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Pine Forest DNG | Mugga Ironbark Woodland |
| Grey Box Grassy Woodland - DNG (EEC - TSC Act/CEEC - EPBC Act) | Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Woodland Low Quality | Rocky Rise Shrubby Woodland |
| White Box Grassy Woodland (EEC - TSC Act/CEEC - EPBC Act) | Farm Dam | |
| Dwyer's Red Gum Creekline Woodland | Farm Track - Disturbed Land | |

File Name (A4): R18/2949_384.dgn
20131018 16.08

FIGURE 3.8

**Vegetation Community Mapping
Proposed Kokoda Offset Site**

Common names used follow Harden (1992, 1993, 2000 and 2002) where available, and draw on other sources such as local names where these references do not provide a common name. Where the identity of a specimen was unknown or uncertain, it was lodged with the National Herbarium of New South Wales at the Royal Botanic Gardens Sydney.

Biases and Limitations

The field surveys conducted during autumn and spring on the proposed Kokoda Offset Site have reduced the potential influence of seasonal factors as a limitation to the detection of cryptic species. It is noted that cryptic species with summer peak flowering may have gone unrecorded in the proposed Kokoda Offset Site.

Local environmental conditions have also had a noticeable impact on the quality of vegetation across the proposed Kokoda Offset Site. Extended periods of warm dry weather combined with low rainfall records prior to the autumn survey had resulted in very dry soils and the condition of vascular plants in the understorey and midstorey was poor. However reasonable records of late winter and early spring rainfall had resulted in return of many grass and understorey species detected through the spring survey period. Grazing pressure, primarily by macropods and domestic stock, continued to be high during the spring surveys.

For herbaceous and graminoid species, such as those belonging to the families Asteraceae, Orchidaceae, Cyperaceae and Poaceae, the allocation of specimens to sub-specific levels was affected by the availability of adequate flowering or fruiting material. Where specimens were considered to be of potential significance or importance they were forwarded to the National Herbarium of New South Wales for identification.

Vegetation Mapping

The vegetation mapping methodology described in the EA (Umwelt 2013) was undertaken across the proposed Kokoda Offset Site (refer to Section 3.3.6 of the EA).

Determination of Threatened Ecological Communities

The methodology described in the EA (Umwelt 2013) for the determination of threatened ecological communities was undertaken across the proposed Kokoda Offset Site (refer to Section 3.3.8 of the EA).

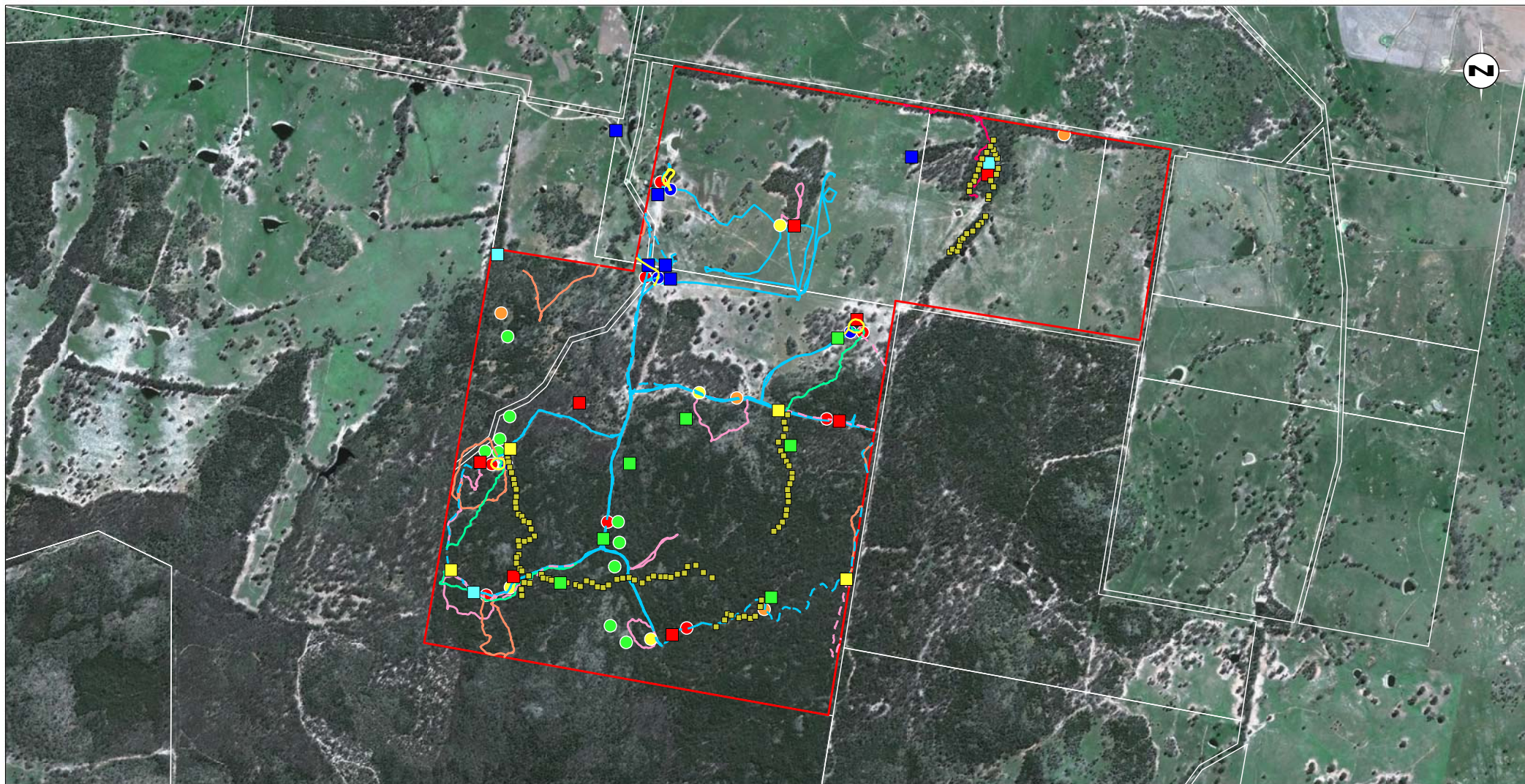
3.3.2.2 Spring Fauna Survey

Terrestrial and Arboreal Hair Funnels

Sections 3.4.2.4 and 3.4.2.5 of the EA (Umwelt 2013) describe the hair funnel methodology that was also undertaken across the proposed Kokoda Offset Site. A total of 80 terrestrial hair funnels and 40 arboreal hair funnels were set across the proposed Kokoda Offset Site (refer to **Figure 3.9**). Both terrestrial and arboreal hair funnels were set in the field for 22 nights, totalling 1760 terrestrial and 880 arboreal hair funnel nights.

Bird Searches

Section 3.4.3.3 of the EIA (Umwelt 2013) describes the bird search methodology that was also undertaken across the proposed Kokoda Offset Site. Four bird searches of at least one person hour duration were undertaken across the proposed Kokoda Offset Site (refer to **Figure 3.9**). Additionally, opportunistic records of bird species were made during all other survey activities.



Source: Aerial - Google Earth (2010), Cadastre - Department of Planning (2009)

0 0.25 0.5 1.0 km
1:20 000

Legend

Proposed Kokoda Offset Site Boundary

Autumn 2013 Surveys:

- Anabat Detector
- Bird and Mammal Call Playback
- Remote Camera
- Frog Call Playback
- Targeted 2013 Bird Surveys

Driving Spotlight

Walking Spotlight

Frog Search

Spring 2013 Surveys:

- Anabat Detector
- Bird and Mammal Call Playback
- Remote Camera
- Frog Call Playback
- Habitat Assessment

■ Hair Funnels (Arboreal and Terrestrial)

Driving Spotlight

Walking Spotlight

Nocturnal Reptile and Amphibian Survey

Diurnal Reptile and Amphibian Survey

Bird Survey

FIGURE 3.9

Fauna Survey Effort
Proposed Kokoda Offset Site

Diurnal Reptile and Amphibian Searches

Section 3.4.3.2 of the EA (Umwelt 2013) describes the diurnal reptile and amphibian search methodology that was also undertaken across the proposed Kokoda Offset Site. One person hour of diurnal reptile and amphibian searching was undertaken across the proposed Kokoda Offset Site (refer to **Figure 3.9**).

Spotlighting Searches

Section 3.4.3.1 of the EA (Umwelt 2013) describes the spotlight search methodology that was also undertaken across the proposed Kokoda Offset Site. A total of four person hours of walking spotlight searches and approximately 9.6 kilometres of driving spotlighting were undertaken across the proposed Kokoda Offset Site (refer to **Figure 3.9**).

Micro-bat Echolocation Recording

Section 3.4.3.6 of the EA (Umwelt 2013) describes the micro-bat echolocation recording methodology that was also undertaken across the proposed Kokoda Offset Site. Four Anabat records were used to sample eight sites for a period of two nights at each site (refer to **Figure 3.9**). A total of 16 Anabat detector nights were completed across the proposed Kokoda Offset Site during spring 2013.

Nocturnal Call Playback

Section 3.4.3.7 of the EA (Umwelt 2013) describes the nocturnal call playback methodology that was also undertaken across the proposed Kokoda Offset Site. Four call playback sessions were completed across two nights during spring 2013.

3.3.3 Results

The following sections present the updated flora and fauna results based on the outcomes of the spring 2013 field surveys. They comprise updates to the existing results section in Appendix I of the Flora and Fauna Assessment (Umwelt 2013), and the results of the spring 2013 surveys.

3.3.3.1 Flora Results

A total of 149 plant species were identified across the proposed Kokoda Offset Site during May and September 2013. Plants were recorded from three major vascular plant classes, comprising conifers, ferns and flowering plants (refer to **Table 3.2**) and included trees, shrubs, forbs, grasses, sedges, rushes, ferns, mistletoes, and twiners. The full list of flora species recorded within the proposed Kokoda Offset Site is provided in **Appendix 3**.

Table 3.2 – Composition of Plant Classes and Families Recorded

Plant class	Sub-class	Number of Families	Number of Species
Filicopsida (ferns)	-	1	2
Coniferopsida (conifers)	-	1	2
Magnoliopsida (flowering plants)	Magnoliidae (dicots)	38	92
Magnoliopsida (flowering plants)	Liliidae (monocots)	7	53
Totals (all plants)		47	149

A total of 47 plant families were recorded (refer to **Table 3.2**). Poaceae (grasses) was the most speciose family with 29 species recorded, followed by Asteraceae (daisies) with 20 species recorded, Orchidaceae (orchids) with 12 species recorded, and Myrtaceae (eucalypts and paperbarks) with nine species recorded.

Of the 149 species recorded, 25 (17 per cent) were introduced species. Introduced species recorded include Capeweed (*Arctotheca calendula*) and Patersons curse (*Echium plantagineum*). Blackberry (*Rubus fruticosus* sp. agg.) was the only species recorded that is declared noxious in the control area (Cabonne LGA).

Two introduced flora species were recorded in the proposed Kokoda Offset Site that are considered environmental weeds, namely black-berry nightshade (*Solanum nigrum*) and blackberry (*Rubus fruticosus* sp. agg.). An environmental weed is a plant species which invades native vegetation and has the potential to impact on the regeneration and success of indigenous flora and fauna (Carr *et al.* 1992; Richardson *et al.* 2006).

3.3.3.2 Vegetation Communities

Twelve vegetation communities were delineated on the proposed Kokoda Offset Site including three communities that conform to two TECs as shown in **Table 3.3**. **Figure 3.8** shows the location of the vegetation communities recorded on the proposed Kokoda Offset Site.

On the basis of the survey information collected during the spring 2013 survey some refinements of the vegetation community mapping were made. This resulted in the identification of an additional 3 hectares of Grey Box Grassy Woodland (EEC) and the removal of 2 hectares of Grey Box – Ironbark Woodland and 1 hectare of Dwyer’s Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest. Additional areas of Grey Box Grassy Woodland were identified following plot-based sampling in areas of potential grey box woodland (localised occurrences of grey box as a dominant canopy species) following further survey coverage of the proposed Kokoda Offset Site. The previous autumn survey focused on derived native grassland areas. During the spring surveys when increased sampling of woodland areas occurred, potential areas of Grey Box Grassy Woodland (EEC) were identified and sampled.

Table 3.3 – Vegetation Communities of the Proposed Kokoda Offset Site

Vegetation Community	TSC Act Status	EPBC Act Status	Vegetation within Kokoda Offset Site (ha)
Grey Box Grassy Woodland	EEC	EEC	13
Grey Box Grassy DNG	EEC	EEC	96
White Box Grassy Woodland	EEC	CEEC	2.2
Dwyer’s Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest			150
Rocky Rise Shrubby Woodland			26
Grey Box – Ironbark Woodland			25
Dwyer’s Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG			15
Dwyer’s Red Gum Creekline Woodland			9.4
Dwyer’s Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Woodland Low Quality			8.6
Mugga Ironbark Woodland			1.9

Table 3.3 – Vegetation Communities of the Proposed Kokoda Offset Site (cont.)

Vegetation Community	TSC Act Status	EPBC Act Status	Vegetation within Kokoda Offset Site (ha)
Farm Track – Disturbed Land			1.3
Farm Dam			1.2
Total			350¹

1 = Rounding of totals applied (numbers less than 1 – 2 decimal places, numbers between 1 and 10 – 1 decimal place, and greater than 10 - no decimal places)

CEEC = Critically Endangered Ecological Community

EEC = Endangered Ecological Community

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

TSC Act = *Threatened Species Conservation Act 1995*

DNG = Derived Native Grassland

ha = Hectares

Updated descriptions are provided below for each of the vegetation communities identified across the proposed Kokoda Offset Site that have been updated since previous surveys. Refer to the EA (Umwelt 2013) for the descriptions of all other vegetation communities.

Grey Box Grassy Woodland

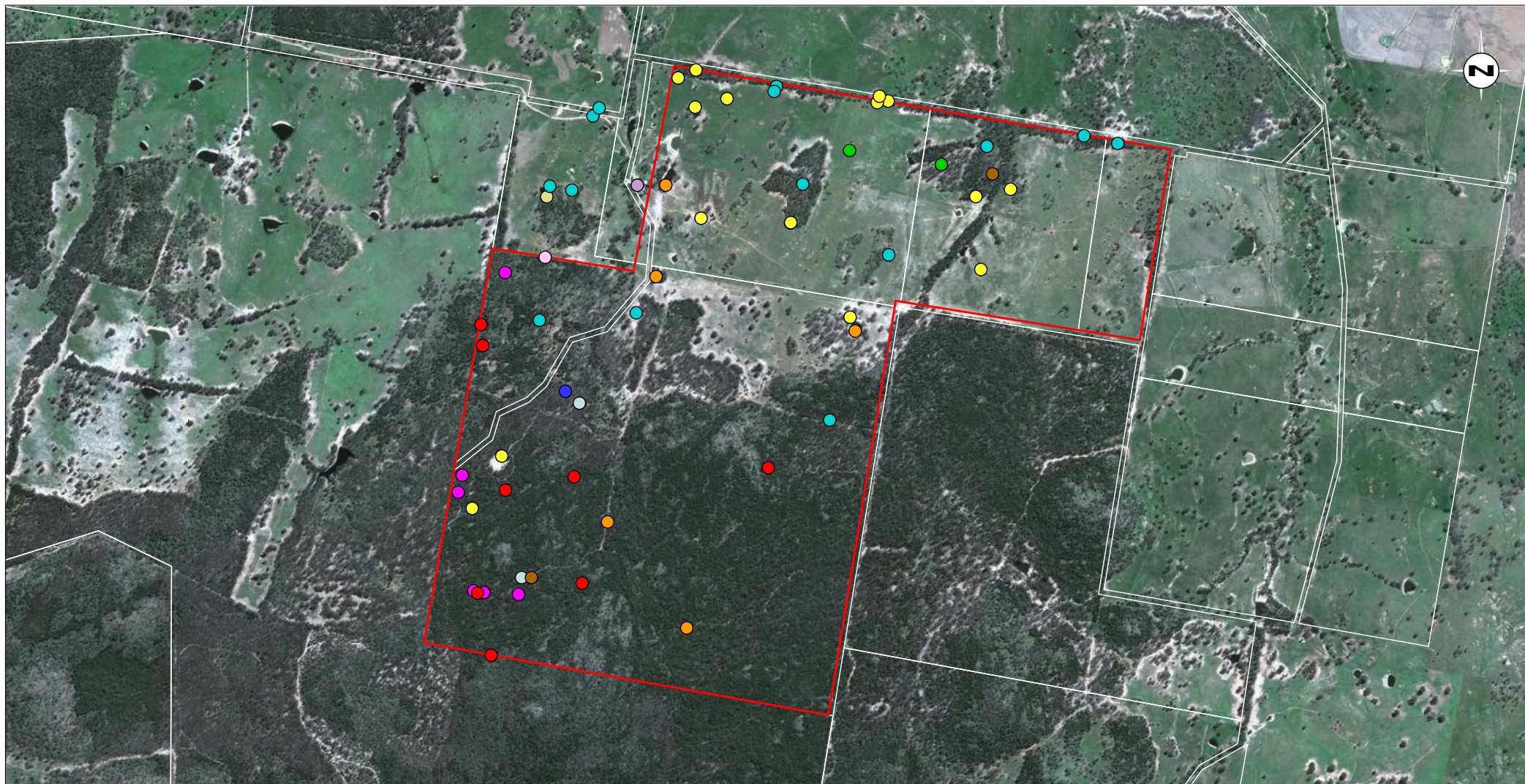
Grey Box Grassy Woodland occurred on the deeper more fertile soils in the north of the proposed Kokoda Offset Site, and totalled an area of 13 hectares (refer to **Figure 3.8**). The community was likely more prevalent across the northern extent of the site but it has been historically cleared for farming practices due to its more fertile position in the landscape. The Grey Box Grassy Woodland was predominantly restricted to thin corridors along the western and northern boundaries as well as a moderately sized patch on a hilltop in the northern area of the proposed Kokoda Offset Site.

The community comprised a tall eucalypt canopy ranging in height from 17 to 20 metres in height with 30 per cent canopy cover. Inland grey box (*E. microcarpa*) was the dominant canopy species, while Dwyers red gum (*Eucalyptus dwyeri*) also occurred in lower numbers.

An open sub-canopy (up to 20 per cent cover) up to 14 metres in height occurred and was dominated by regenerating canopy species and black cypress-pine (*Callitris endlicheri*). The community supported a sparse to moderately sparse (15 to 35 per cent cover) ground layer dominated by native grasses and forbs. Commonly recorded species included windmill grass (*Chloris truncate*), speargrass (*Austrostipa scabra* subsp. *falcata*), smallflower wallaby grass (*Rytidosperma setaceum*), open summer-grass (*Digitaria diffusa*), clustered lovegrass (*Eragrostis elongata*), *Aristida* sp., rough raspwort (*Haloragis heterophylla*) and bears-ear (*Cymbonotus lawsonianus*). Introduced flora species were relatively common, namely shivery grass (*Briza minor*), flatweed (*Hypochaeris radicata*), Capeweed (*Arctotheca calendula*) and common chickweed (*Stellaria media*).

The diversity of native flora species and the level of ground cover within the ground layer was reduced due to heavy grazing pressure that occurred across the northern section of the proposed Kokoda Offset Site.

White Box Grassy Woodland conforms to the TSC Act listed *Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Penepplain, Nandewar and Brigalow Belt South Bioregions* (EEC) and the EPBC Act listed *Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia* EEC.



Source: Aerial - Google Earth (2010), Cadastre - Department of Planning (2009)

0 0.25 0.5 1.0 km
1:20 000

Legend

- | | | |
|---|--|---|
| — Proposed Kokoda Offset Site Boundary | ● Little Lorikeet | ● Yellow-bellied Sheathtail Bat |
| ● Brown Treecreeper (eastern subspecies) | ● Speckled Warbler | |
| ● Diamond Firetail | ● Superb Parrot | |
| ● Grey-crowned Babbler (eastern subspecies) | ● Varied Sittella | |
| ● Hooded Robin (south-eastern form) | ● Eastern Bentwing-bat | |
| ● Glossy Black-cockatoo | ● Little Pied Bat | |

File Name (A4): R18/2949_385.dgn
20131029 10.09

FIGURE 3.10

Threatened Fauna Locations
Proposed Kokoda Offset Site

The corresponding biometric vegetation type for this community is Inland Grey Box – Black Cypress Pine Shrubby Woodland on Stony Slopes of NSW South Western Slopes and Riverina Bioregions (Benson 110) (LA151).

Grey Box Grassy DNG

Grey Box Grassy DNG occurred on deeper and more fertile soils in the north of the proposed Kokoda Offset Site, totalling an area of 96 hectares (refer to **Figure 3.8**). Grey Box Grassy DNG occurred on slightly east facing slopes in areas likely to have once been dominated by the Grey Box Grassy Woodland community. The grasslands to the east occur on shallower soils and are likely to be derived from Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest.

This community was mostly composed of native grasses and forbs and was largely devoid of mature and regenerating trees. Saplings recorded within the community were likely to be recruiting western grey box (*Eucalyptus microcarpa*), but occurred in very small numbers due to the presence of heavy grazing pressure. Native flora species comprised approximately 45 per cent cover within the Grey Box Grassy DNG areas. Commonly recorded native species included purple wiregrass (*Aristida ramosa*), red grass (*Bothriochloa macra*), redleg grass (*B. decipiens*), *Juncus homalocaulis*, *Elymus scaber*, speargrass (*Austrostipa scabra* subsp. *falcata*), smallflower wallaby grass (*Rytidosperma setaceum*), bogan flea (*Calotis hispidula*), bears-ear (*Cymbonotus lawsonianus*), *Fimbristylis dichotoma*, tufted bluebell (*Wahlenbergia communis*) and winged New Holland daisy (*Vittadinia pterochaeta*). Common introduced species included *Orobanche minor*, Capeweed (*Arctotheca calendula*), flatweed (*Hypochaeris radicata*) and scarlet pimpernel (*Anagallis arvensis*).

Grey Box Grassy DNG is likely to have originated from the Grey Box Grassy Woodland community that occurs on deeper, more fertile soils of the proposed Kokoda Offset Site. These areas occurred in the north of the site which had largely been cleared to support farming activities. Grey Box Grassy DNG may also have influences from Dwyers Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest which is a prominent vegetation community across the proposed Kokoda Offset Site but occurs on shallower less fertile soils.

Grey Box Grassy DNG conforms to the TSC Act listed *Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Penepplain, Nandewar and Brigalow Belt South Bioregions* EEC and the EPBC Act listed *Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia* EEC.

The corresponding biometric vegetation type for this community is Inland Grey Box – Black Cypress Pine Shrubby Woodland on Stony Slopes NSW South Western Slopes and Riverina Bioregions (Benson 110) (LA151).

3.3.3.3 Threatened Ecological Communities

Four TECs were recorded across the proposed Kokoda Offset Site (refer to **Figure 3.8**) and are listed below:

- White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland (EPBC Act – CEEC).
- White Box – Yellow Box – Blakely's Red Gum Woodland (TSC Act – EEC).
- Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia (EPBC Act – EEC).

- Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions (TSC Act – EEC).

For a full description of vegetation communities identified as conforming with the abovementioned TECs refer to Appendix I of the Flora and Fauna Assessment of the EA (Umwelt 2013).

3.3.3.4 Vegetation Management Zones

The proposed vegetation management zones (natural regeneration, potential regeneration and active revegetation zones) across the DNG areas of the proposed Kokoda Offset Site were further assessed during the spring surveys. Observations of regeneration potential across the DNG areas confirmed that the management zones proposed in the Response to Submissions report reflected the regeneration potential of the DNG areas across the proposed Kokoda Offset Site. No changes to the boundaries of the management zones (as shown on Figure 2.5 of the Response to Submissions report) or refinements to the proposed ecological management measures were made following the spring surveys of the proposed Kokoda Offset Site.

3.3.3.5 Terrestrial Fauna Habitats of the Proposed Kokoda Offset Site

Three general fauna habitat types occurred across the proposed Kokoda Offset Site. Each of these broad habitat types has a range of characteristics which influence the habitat value, and the range of fauna species which are likely to be identified within each type. The broad habitat types recorded across the proposed Kokoda Offset Site comprised woodland, grassland, and farm dams.

Each of the three general fauna habitat types identified above are described in detail within Appendix I of the Flora and Fauna Assessment of the EA (Umwelt 2013).

3.3.3.6 Terrestrial Fauna Species Recorded in the Proposed Kokoda Offset Site

A total of 130 vertebrate fauna species were recorded across the proposed Kokoda Offset Site and comprised eight frogs, five reptile, 93 birds and 24 mammals. The 130 species included 11 threatened bird species and nine introduced fauna species. Following are updated summaries (from the EA) of the species recorded across the proposed Kokoda Offset Site and the full list of species recorded is shown in **Appendix 4**.

Frogs

Eight frog species were recorded across the proposed Kokoda Offset Site, comprising two tree frogs and six ground frogs. Commonly recorded species included the eastern sign-bearing froglet (*Crinia parinsignifera*), the spotted marsh frog (*Limnodynastes tasmaniensis*) and Perons tree frog (*Litoria peronii*).

No threatened or introduced amphibian species were recorded.

Reptiles

Five frog species were recorded across the proposed Kokoda Offset Site, comprising the bearded dragon (*Pogona barbata*), *Cryptobelpharus carnabyi*, shingleback lizard (*Trachydosaurus rugosus*), snake-necked turtle (*Chelodina longicollis*) and lace monitor (*Varanus varius*).

No threatened or introduced reptile species were recorded.

Birds

A total of 93 bird species were recorded throughout the proposed Kokoda Offset Site. Commonly observed species included the eastern rosella (*Platycercus eximius*), spotted pardalote (*Pardalotus punctatus*), buff-rumped thornbill (*Acanthiza reguloides*), noisy miner (*Manorina melanocephala*) and silvereye (*Zosterops lateralis*).

Ten threatened bird species (refer to **Figure 3.10** and **Section 3.3.6**) and one introduced bird species were recorded.

Mammals

A total of 24 mammal species were recorded across the proposed Kokoda Offset Site. The most common mammal family was the Vespertilionidae (micro-bats), with eight species recorded. Two species of micro-bat from the Molossidae family, the white-striped mastiff bat (*Tadarida australis*) and southern freetail-bat (*Mormopterus planiceps*) and a single member of the Emballonuridae family, the yellow-bellied sheath-tail-bat (*Saccolaimus flaviventris*) were also recorded.

Other native mammals recorded included the eastern grey kangaroo (*Macropus giganteus*), common ringtail possum (*Pseudocheirus peregrinus*) and common brush-tailed possum (*Trichosurus vulpecula*).

Three threatened mammal species, all micro-bats, were recorded (refer to **Figure 3.10** and **Section 3.3.6**).

A total of eight introduced mammal species were identified across the proposed Kokoda Offset Site, comprising the fox (*Vulpes vulpes*), rabbit (*Oryctolagus cuniculus*), sheep (*Ovis aries*), goat (*Capra hircus*), cat (*Felis catus*), pig (*Sus scrofa*), rats (*Rattus* sp.) and brown hare (*Lepus capensis*).

3.3.3.7 Threatened Fauna Species

A total of 13 threatened species have been recorded across the proposed Kokoda Offset Site. Further details on each of these threatened species are provided in the following sections.

Grey Crowned Babbler (*Pomatostomus temporalis temporalis*)

The grey-crowned babbler, listed as vulnerable under the TSC Act, was recorded at 14 locations across the proposed Kokoda Offset Site (refer to **Figure 3.10**). Between two and six individuals were sighted at each location. This species was recorded in open woodland vegetation and is likely to be a resident species across parts of the proposed Kokoda Offset Site.

Black Falcon (*Falco subniger*)

The black falcon (*Falco subniger*), listed as vulnerable under the TSC Act, was recorded at a single location approximately 2 kilometres from the proposed Kokoda Offset Site, along a public road that leads to the proposed Kokoda Offset Site. A single bird was recorded sitting on power lines. While not recorded directly on the proposed Kokoda Offset Site, the site provides suitable habitat for the black falcon and the species is considered to occur across the proposed Kokoda Offset Site.

Glossy Black Cockatoo (*Calyptorhynchus lathami*)

The glossy black cockatoo (*Calyptorhynchus lathami*), listed as vulnerable under the TSC Act, was recorded at a single location adjacent to the proposed Kokoda Offset Site (refer to **Figure 3.10**). Two birds were recorded. This species was recorded in an isolated patch of Rocky Rise Shrubby Woodland and was seen feeding on drooping sheoak (*Allocasuarina verticillata*). It is likely that this species is an occasional visitor to parts of the proposed Kokoda Offset Site.

Superb Parrot (*Polytelis swainsonii*)

The superb parrot, listed as vulnerable under the TSC Act and EPBC Act, was recorded at 17 locations across the proposed Kokoda Offset Site (refer to **Figure 3.10**). The number of birds recorded at each location ranged between a single bird and 25 individuals. In a majority of the records, the species was recorded flying in an easterly direction, above canopy height, generally in open country in the northern section of the proposed Kokoda Offset Site. The species was only seen perched and feeding on site at three locations. The species is likely a seasonal visitor of the proposed Kokoda Offset Site.

Little Lorikeet (*Glossopsitta pusilla*)

The little lorikeet, listed as vulnerable under the TSC Act, was recorded at two locations (in groups of 20 and five birds) across the proposed Kokoda Offset Site (refer to **Figure 3.10**). It is likely that the little lorikeet is an occasional visitor to the proposed Kokoda Offset Site during periods of eucalypt flowering.

Brown Treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*)

The brown treecreeper (eastern subspecies), listed as vulnerable under the TSC Act, was recorded at six locations across the proposed Kokoda Offset Site (refer to **Figure 3.10**). Single birds were recorded at each of these locations. This species was recorded in open woodland vegetation and is likely to be a resident species across parts of the proposed Kokoda Offset Site.

Hooded Robin (south-eastern form) (*Melanodryas cucullata cucullata*)

The hooded robin (south-eastern form), listed as vulnerable under the TSC Act, was recorded at a single location on the proposed Kokoda Offset Site (refer to **Figure 3.10**), with a single female bird recorded. This species was recorded in an isolated patch of Rocky Rise Shrubby Woodland and may be a resident species or regular visitor to parts of the proposed Kokoda Offset Site.

Diamond Firetail (*Stagonopleura guttata*)

The diamond firetail, listed as vulnerable under the TSC Act, was recorded at a single location on the proposed Kokoda Offset Site on three occasions (refer to **Figure 3.10**). Between two and five individuals were recorded during each sighting. This species was recorded in open woodland vegetation and may be a resident species across parts of the proposed Kokoda Offset Site.

Speckled Warbler (*Chthonicola sagittata*)

The speckled warbler, listed as vulnerable under the TSC Act, was recorded at eight locations across the proposed Kokoda Offset Site (refer to **Figure 3.10**). Between one and three individuals were sighted at each location. This species was recorded in dense areas of

woodland with a shrubby understorey in the southern half of the proposed Kokoda Offset Site. It is likely to be a resident species across parts of the proposed Kokoda Offset Site.

Varied sittella (*Daphoenositta chrysoptera*)

The Varied sittella, listed as Vulnerable under the TSC Act, was recorded at one location at the proposed Kokoda Offset Site (refer to **Figure 3.10**). A single bird was sighted within dense areas of woodland with a shrubby understorey in the southern half of the proposed Kokoda Offset Site. The varied sittella is likely to be a resident species across parts of the proposed Kokoda Offset Site.

Eastern bentwing-bat (*Miniopterus schreibersii oceanensis*)

The eastern bentwing-bat, listed as vulnerable under the TSC Act, was recorded at five locations across the proposed Kokoda Offset Site during micro-bat echolocation recording (refer to **Figure 3.10**). The eastern bentwing-bat was identified as 'confident' at two sites, 'probable' as two sites and as 'possible' at the remaining site. This species may be a resident foraging species that forages across the proposed Kokoda Offset Site. Cave habitats which provide roosting sites are absent from the proposed Kokoda Offset Site.

Yellow-bellied Sheath-tail-bat (*Saccolaimus flaviventris*)

The yellow-bellied sheath-tail-bat, listed as vulnerable under the TSC Act, was recorded at two locations across the proposed Kokoda Offset Site during micro-bat echolocation recording (refer to **Figure 3.10**). The yellow-bellied sheath-tail-bat was identified as 'possible' at both sites. The yellow-bellied sheath-tail-bat may be a resident species of the proposed Kokoda Offset Site.

Little Pied Bat (*Chalinolobus picatus*)

The little pied bat, listed as vulnerable under the TSC Act, was recorded at a single location at the proposed Kokoda Offset Site during micro-bat echolocation recording (refer to **Figure 3.10**). The little pied bat was identified with a 'possible' level of confidence. The little pied bat may be a resident species of the proposed Kokoda Offset Site.

3.3.3.8 Migratory Species

A single migratory species, as listed under the EPBC Act, the rainbow bee-eater (*Merops ornatus*) was recorded on the proposed Kokoda Offset Site. A single individual was heard calling above woodland during the spring survey.

3.3.4 Offsetting Value of the Proposed Kokoda Offset Site

The completion of the spring surveys across the proposed Kokoda Offset Site has resulted in an increase in the assessed biodiversity value (and therefore offsetting value) through an increase in the identified area of Grey Box Grassy Woodland (EEC) and the identification of additional threatened fauna species.

3.3.4.1 Increased Area of Grey Box Grassy Woodland

Additional areas of Grey Box Grassy Woodland were identified following plot-based sampling in areas of potential grey box woodland (localised occurrences of grey box as a dominant canopy species) following further survey coverage of the proposed Kokoda Offset Site (refer to **Section 3.3.3**). Three additional hectares of Grey Box Grassy Woodland (EEC) were identified during spring 2013.

A total of 13 hectares of Grey Box Grassy Woodland (EEC) have been identified across the proposed Kokoda Offset Site. Combined with the 96 hectares of Grey Box Grassy Woodland (EEC) in derived native grassland form, a total of 109 hectares of the Grey Box Grassy Woodland (EEC) has been identified across the proposed Kokoda Offset Site.

The 109 hectares represents an offset to clearing ratio of 2.9:1 for Grey Box Grassy Woodland (EEC), well above the minimum Tier 3 requirement (the OEH interim policy requires a minimum land offset to clearing ratio of 2:1).

3.3.4.2 Additional Threatened Fauna Species Identified

During autumn, three threatened fauna species were identified during surveys. The three species comprised the:

- little lorikeet (*Glossopsitta pusilla*);
- grey-crowned babbler (*Pomatostomus temporalis temporalis*); and
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*).

Surveys during spring 2013 identified an additional 10 threatened species across the proposed Kokoda Offset Site. The 10 species comprised the:

- glossy black cockatoo (*Calyptorhynchus lathamii*);
- superb parrot (*Polytelis swainsonii*);
- black falcon (*Falco subniger*);
- brown treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*);
- speckled warbler (*Chthonicola sagittata*);
- hooded robin (south-eastern form) (*Melanodryas cucullata cucullata*);
- diamond firetail (*Stagonopleura guttata*);
- varied sittella (*Daphoenositta chrysoptera*);
- yellow-bellied sheath-tail-bat (*Saccolaimus flaviventris*); and
- little pied bat (*Chalinolobus picatus*).

The completion of fauna surveys across the proposed Kokoda Offset Site, combined with increases in detectability due to season for some species, resulted in the identification of the additional species.

The proposed Kokoda Offset Site provides a direct offsetting opportunity for the grey-crowned babbler, black falcon, superb parrot, brown treecreeper, eastern bentwing-bat and little pied bat, all species recorded in the Project Area or Proposed Disturbance Area. The proposed Kokoda Offset Site also provides conservation value for threatened fauna species which were not recorded in the Project Area or Proposed Disturbance Area. Such species comprise the glossy black cockatoo, little lorikeet, hooded robin, diamond firetail, varied sittella and yellow-bellied sheath-tail-bat.

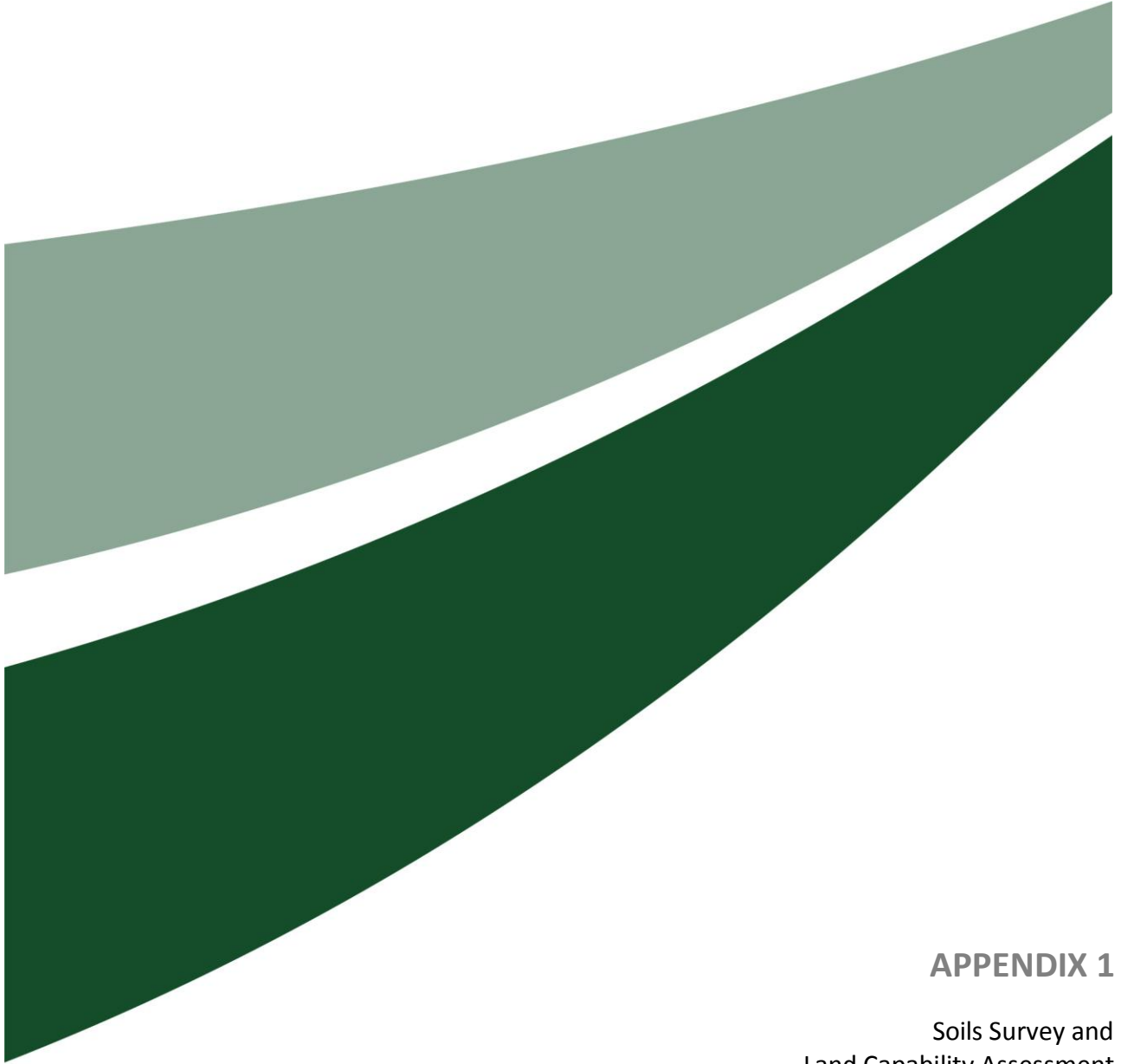
The findings of the spring 2013 survey reinforce the suitability of the proposed Kokoda Offset Site in providing an appropriate ecological offset for the Project. Other key features of the proposed Kokoda Offset Site include:

- The woodland habitats of the Kokoda Offset Site occurs along a north-south potential corridor of remnant woodland and forest vegetation that runs along ridges and hills from north of Eugowra in the south to east of Narromine in the north, including Goobang National Park, the largest conserved remnant of woodland and forest vegetation in the Central West region of NSW.
- The high recovery potential of the Grey Box Grassy Woodland EEC DNG areas across the proposed Kokoda Offset Site with the removal of existing grazing pressure.
- NPM commitment to implement specific management measures, including active regeneration, across the proposed Kokoda Offset Site in order to increase the recovery potential of Grey Box Grassy Woodland EEC DNG. The measures will be built from the expertise in native vegetation regeneration implemented over the past 15 years at the NPM site.

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APPENDIX 1

Soils Survey and
Land Capability Assessment

North Mining Limited

ABN: 78 000 081 434

Northparkes Mines - E48 Project

Soils Survey and Land Capability Assessment

Prepared by

Geoff Cunningham Natural Resource Consultants Pty Ltd

August, 2006

**Specialist Consultant Studies Compendium
Part 2**

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Soils Survey and Land Capability Assessment

of the

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EXECUTIVE SUMMARY

Soils in the Northparkes Mines E48 Project Study Area have been described and two Soil Mapping Units have been identified.

The physical and chemical attributes of the soils of the Study Area have been quantified through a combination of field assessment and laboratory testing and indicate the following.

- The soils are currently relatively stable but have a generally low to moderate erodibility rating as determined using the laboratory data obtained from samples from the Study Area in the SOLOSS computer model.
- In reality, however, the soils may have a higher degree of erodibility given the dispersibility values obtained from the laboratory analyses.
- The fact that much of the cultivated land within the Study Area is protected by soil conservation works, conservation tillage practices, stubble retention and an absence of livestock grazing contributes to a large degree to the absence of visible signs of erosion.
- The soils have a generally high structure grade and so can be stripped and respread using scrapers.
- For both SMU 1 and SMU 2, the topsoil material [to 12cm depth] and the subsoil [to about 70cm total depth below the original soil surface] is favourable for use in rehabilitating the disturbed landscape.
- This topsoil material can be striped as a single entity and material from the two SMUs does not need to be stockpiled separately.
- It is likely from the test pits that the soil depth within SMU 1 is probably not much greater than the 70cm recommended total stripping depth.
- The remaining soil material from SMU 2 [below 70cm depth] should remain in situ because of the likelihood of encountering saline material below this depth from the surface.
- If, for some reason material from >70cm depth has to be removed, it should be mixed with overburden to dilute the salinity impacts that would make storage difficult and cause problems when it is used in rehabilitation.
- All soils would be subject to structural degradation if worked when too moist.

Depth of stripping recommendations have been provided along with advice on stabilising the soil stockpiles in the period between stripping and resspreading.

The pre-mining land capability and agricultural land suitability of the Study Area has been determined, as has that of the post-mining landform.

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1 INTRODUCTION and DESCRIPTION OF PROJECT

1.1 Introduction

This study was carried out to provide soils and land capability information relating to areas proposed to be disturbed by works that would be necessary for North Mining Limited [the Proponent] to implement the proposed underground mining E48 Project at their existing Northparkes Mines Site, 27km north of Parkes (**Figure 1**).

The Study Area for this soils and land capability study comprises a total area of approximately 630ha and is shown in **Figure 1**. It is somewhat less in area than the whole Project Site and more extensive than the surface area that is proposed to be disturbed – ie. approximately 386ha.

The soils study covers the surface area that would be disturbed by the proposed E48 Project mining development, including the subsidence area and associated areas to be used for borrow pits, service corridors, tailings storage facilities and related infrastructure.

The land capability and agricultural land suitability assessments apply to the entire Project Site.

Field sampling of the area was carried out on the 18th, 19th, 26th and 27th April, 2005.

The brief for the study required the preparation of a report on:

the soils on that part of the Project Site likely to be disturbed as a result of the proposed development of the E48 Project, and

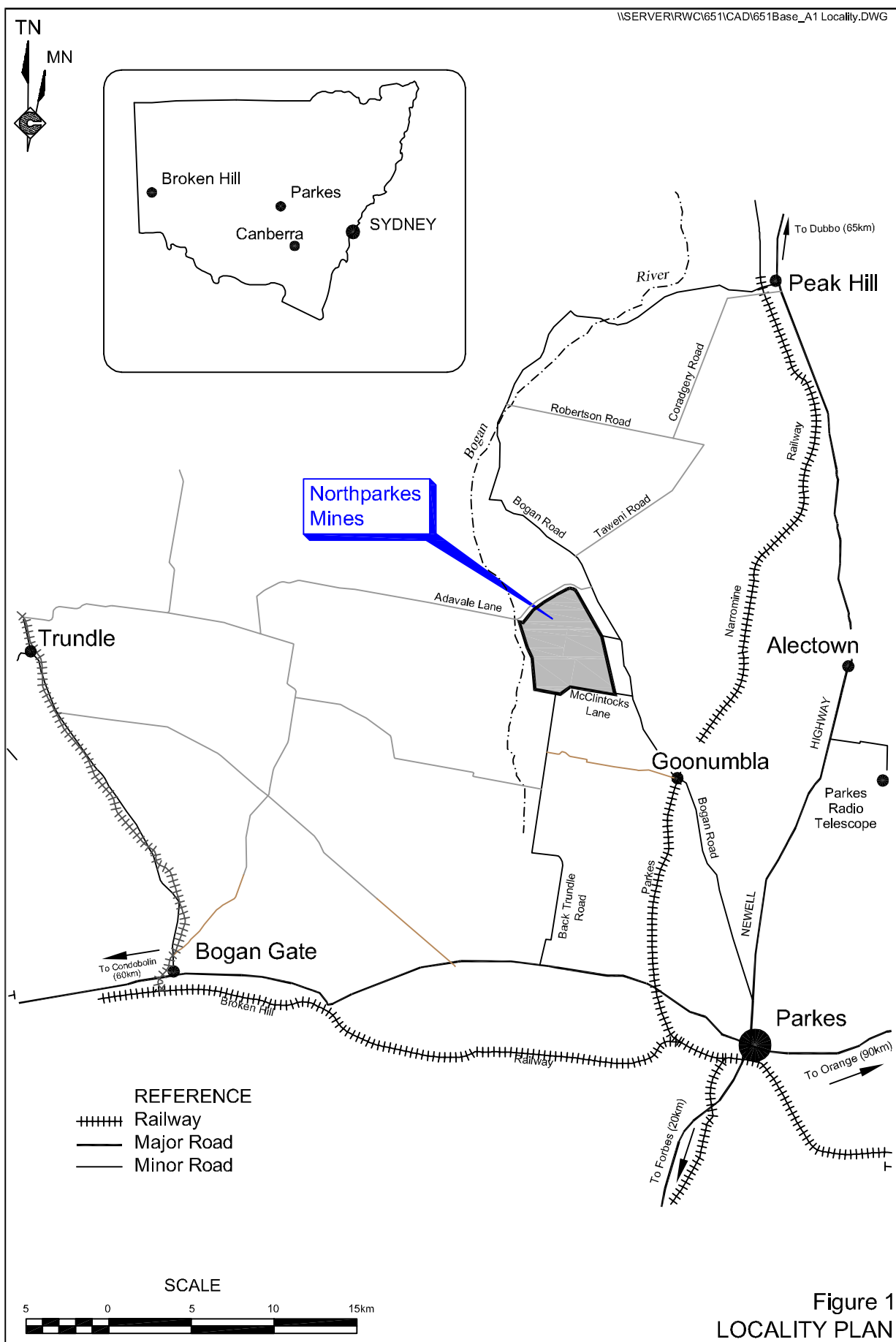
the land capability and agricultural land suitability of the Project Site.

The report was required to include a sufficient level of detail to satisfy the Department of Primary Industries (Mineral Resources) in relation to Mine Operations Plan guidelines and to satisfy the requirements of the Department of Natural Resources' [DNR] specifications for soil surveys associated with proposed mining operations.

This report describes the soils of the Study Area based upon sixty three representative soil profiles and laboratory analyses of a selection of representative profiles. In addition, the land capability and agricultural land suitability of the Project Site are determined.

In particular, this report provides:

- the results of the field survey and laboratory testing of samples;
- a discussion of the results of field survey and laboratory physical and chemical analysis in technical as well as "Plain English" terms;
- a discussion of the stripping suitability of the soil materials found at the Study Area;
- details of soil handling strategies and recommendations about soil stripping and stockpiling; and
- details of the land capability and agricultural suitability of the Project Site.



1.2 Description of Proposal

The E48 Project incorporates the following components (see **Figure 2**).

- Development and operation of an underground block cave mining operation.
- Development of a surface subsidence zone associated with the underground block cave mine.
- Construction and use of a paddock style tailings storage facility.
- Development and use of a temporary waste rock stockpile area, as required.
- Development of the Rosedale Borrow Pit to provide the required clay construction materials.
- Relocation of the overland ore conveyor from the proposed E48 surface subsidence zone to the processing plant.

2 DESCRIPTION OF THE STUDY AREA

The Study Area surrounds the existing facilities and areas of disturbance associated with the Northparkes Mines. The mines are located near the Bogan Road some 27km north-northwest of Parkes.

The Study Area comprises a mixture of open cleared and cultivated paddocks, areas of remnant native vegetation and the Limestone National Forest, which is an area of very open woodland.

The landforms of the Study Area comprise mainly gently undulating rises and depressions / drainage lines with generally low relief.

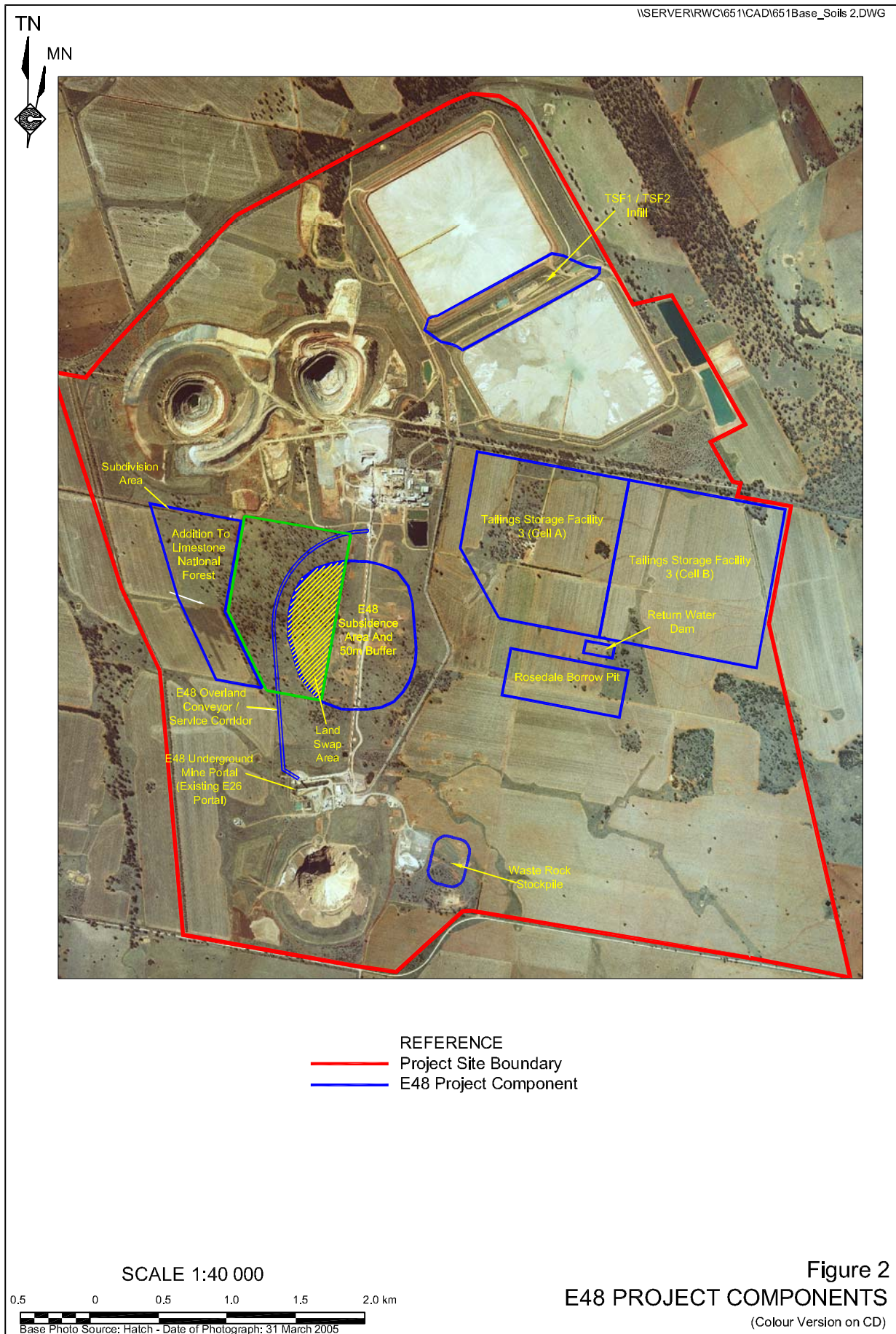
3 LITERATURE REVIEW

3.1 Soil Landscape Mapping

Soil Landscape mapping for Narromine 1:250 000 map sheet area, in which the Study Area is located, is not yet published.

3.2 Soil Conservation Service Technical Manuals

There are no Technical Manuals published by the former Soil Conservation Service of New South Wales that cover the Study Area.



3.3 Northparkes Project EIS

The Northparkes Project EIS [[NSR [1990]] notes that a soils mapping and analysis program had been carried out to establish characteristics relevant to the proper planning management of soils during mining and for purposes of rehabilitation of completed areas. The document [as available] contains limited soils information that can be summarised as follows.

- Surface soils show generally good structure, high cation exchange capacity, good organic matter content and adequate nutrient levels.
- In general, the A and B horizons can be mixed, and would form good topsoiling material [provided excessive dilution of the A horizon material is avoided].
- A highly saline and dispersive clay frequently occurs at the base of the B horizon, extending down into the C horizon.
- Local surface exposures of this saline material occur and local farming experience has shown it to be a very poor plant growth medium. The need to avoid this material would define the depth of soil stripping.
- Calcareous subsoils occur.
- The Study Area soils are, in general, of good quality for plant regrowth provided soil structure is maintained.

3.4 Statement of Environmental Effects: "Caloola" Borrow Pit

3.4.1 Soil Descriptions

In 2000, the Statement of Environmental Effects: "Caloola" Borrow Pit [R.W. Corkery & Co., 2000] discussed the soils of the Borrow Pit area in terms of 'safeguards and constraints'.

This document noted that the soils of the Borrow Pit Project Site comprised:

grey cracking clays along drainage lines;

red brown earths on slightly elevated areas and midslopes; and

brown cracking clays on lower slopes.

In areas generally undisturbed by agriculture, [R.W. Corkery & Co., 2000] noted that

"these soil types are generally characterised by:

'A' Horizon – clay loam, weakly structured, 15cm - 30cm deep; over

'B' Horizon – well developed strongly pedal medium to heavy clay."

R.W. Corkery & Co. [2000] further noted that the soils of the Borrow Pit Project Site:

- are hardsetting and cracking on drying with cracks often extending to the B horizon;
- are neutral in pH at the surface and alkaline at depth; and
- show low salinity in the topsoils but moderately high salinity in subsoils.

It was further noted that all topsoil material would be valuable for use in rehabilitation and that the erodibility of the 'A' horizons of all soil types found within the Project Site was assessed to be medium. The erodibility of the subsoils was assessed to be low.

3.4.2 Land Capability and Agricultural Land Suitability Assessments

R.W. Corkery & Co. [2000] notes that the land capability class within the 'Caloola" Borrow Pit Project Site is predominantly Class III and that the Agricultural Land Suitability Class is Class 3.

In addition, R.W. Corkery & Co. [2000] noted that, overall, the soils within the Project Site do not pose a constraint provided they are carefully stripped, stored, replaced and stabilised.

4 METHODOLOGY

4.1 Preparations

Prior to field investigations, the Study Area was subjected to stereoscopic airphoto interpretation to ascertain the nature of the landforms present at the site and to develop a broad appreciation of the landform units that would require sampling.

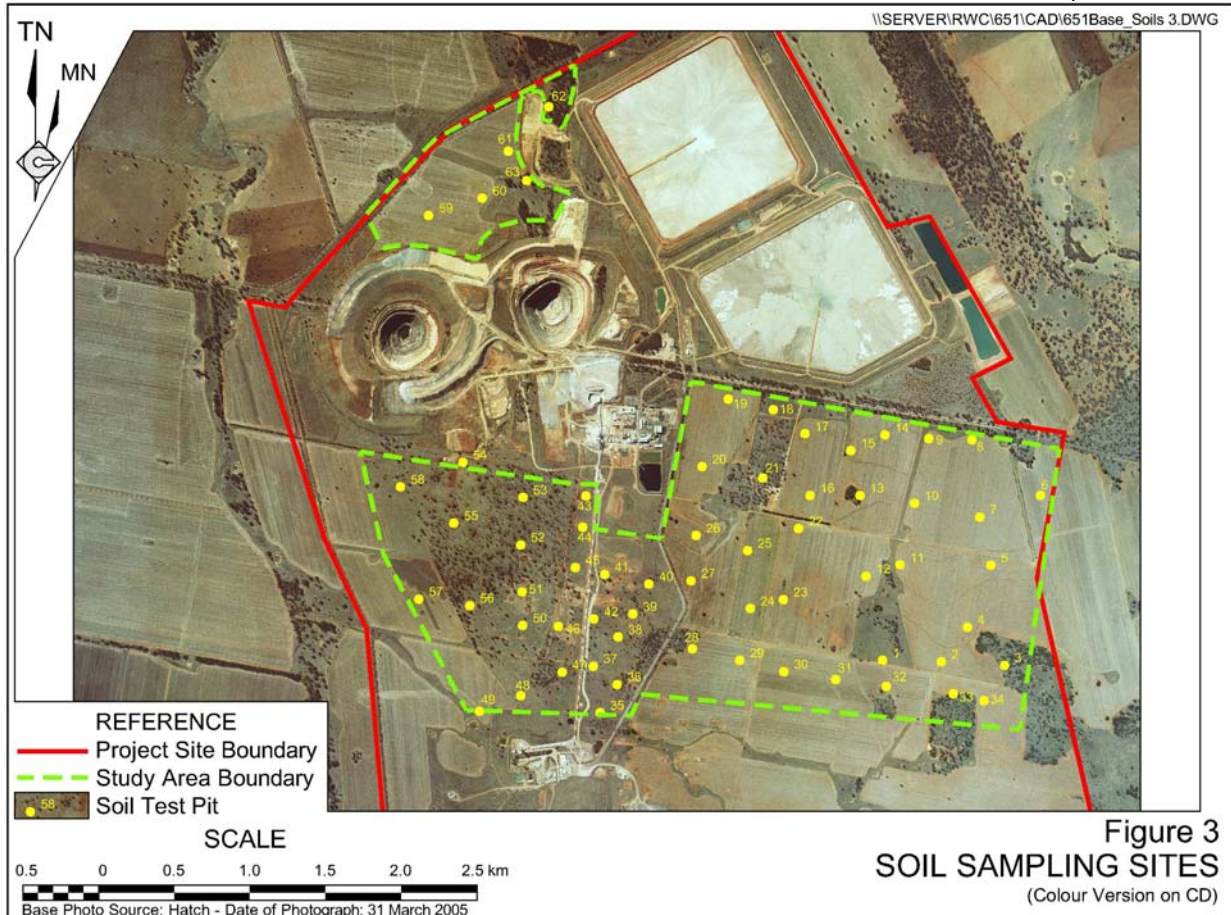
The 1: 50 000 scale colour airphotos used were those produced by the Department of Lands.

The prints used in the stereoscopic interpretation were Peak Hill Run 6, Print Nos. 80, 81 82, flown on 11th May, 2004.

4.2 Field Procedures

For the soil study, sampling involved the complete description of sixty three profiles to a depth of approximately 2.5m or the depth of backhoe refusal. The locations of the soil sampling sites within the Study Area are shown in **Figure 3**.

The soil profiles at each pit location were fully described in the field after a detailed examination of the different layers.



For each test profile [site] described, details of the following soil properties were noted.

- Texture
- Fabric
- Structure
- Consistency
- Boundary sharpness
- Colour [moist and dry]
- Gravel/stone occurrence
- Presence of roots
- Presence of lime
- Presence of manganese
- pH

Soil pH was measured using the Raupach method [Raupach indicator and barium sulphate]. Soil colour [moist and dry] was determined using Munsell soil colour charts [Macbeth, 1992]. The classification of the soils that were described was based on Isbell [1996].

In determining the soil classifications the CD-ROM titled "The Australian Soil Classification - An Interactive Key" [Jacquier *et al*, 2001] was used.

The information obtained was recorded in a form that is compatible with that required for entry on soil data cards used in DNR's SPADE Soil Database.

Samples from all layers in nine of these profiles [Nos. 1,11,21,25,26,53,57,59 and 61] were forwarded to the Department of Lands' NATA - registered Soil and Water Testing Laboratory at Scone for more detailed analysis to determine the following properties.

- Range of particle size [particle size analysis].
- Dispersion percentage.
- Coherence [Emerson aggregate test].
- Electrical conductivity.

4.3 Soil Stripping Suitability

The stripping suitability of the soils at the sites sampled using the backhoe pits was determined on the basis of the procedure outlined by Elliott and Veness [1981].

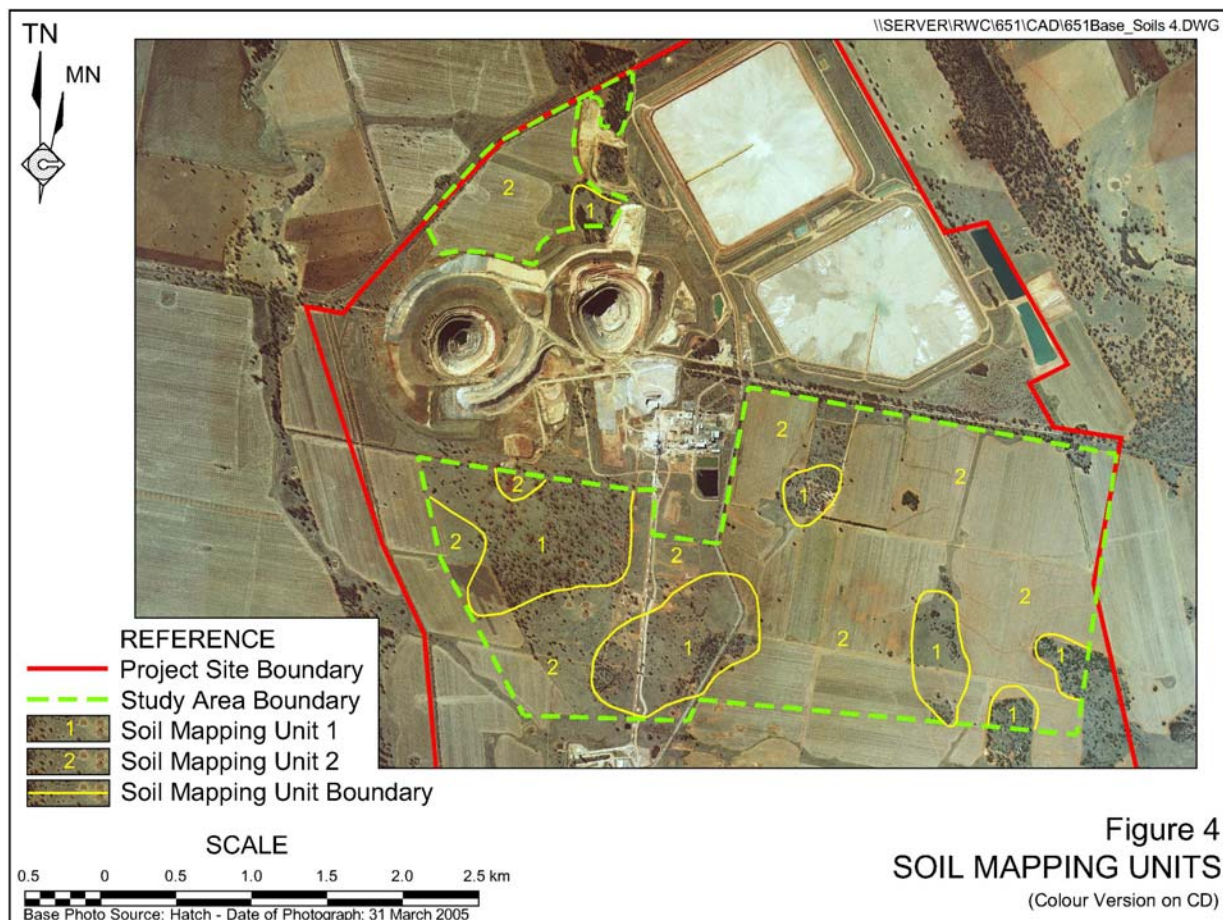
From the data gained in this process, recommendations on the depths of topsoil and subsoil stripping were developed.

5 RESULTS

From the information gained from both the detailed soil profile descriptions, and the additional check pits, two Soil Mapping Units [SMUs] were identified.

- **Soil Mapping Unit 1** – the crests and outcrop areas; and
- **Soil Mapping Unit 2** – the remainder of the Study Area including the slopes and level plains and areas associated with drainage lines.

The soil mapping unit boundaries are shown in **Figure 4**.



It is important to note that not all soil layers described for each of the Soil Mapping Units are present in every profile. Soils are inherently variable in nature and while they may have similar overall characteristics they may vary in layer detail and properties.

Appendix 1 contains detailed information on the layers present in the sixty three pits that were described in detail.

5.1 Soil Mapping Unit Descriptions

Descriptions of the layers found in the profiles of the two SMUs identified within the Study Area are set out below.

In each case, the soil within each unit is described in two ways – a “Plain English” version followed by a technical description.

Definitions of the technical terms used in the descriptions can be found in **Appendix 4** or by consulting McDonald et al [1990] or Houghton and Charman [1986].

5.1.1 Soil Mapping Unit 1 - Soils of the Crests and Rocky Outcrops

Soil Mapping Unit 1 is restricted to the areas where rock outcrops or occurs at relatively shallow depths.

5.1.1.1 “Plain English” Description:

Soil to 88cm deep; usually crest location, sometimes midslopes; surface condition usually firm to hardsetting, sometimes loose; some to much angular [sometimes rounded] surface gravel 1-5cm present; at times angular stones to 20cm recorded.

Topsoil – loam, sandy clay loam, clay loam, occasionally silty clay loam or loam; many roots present; no lime present; no gypsum present; no manganese present; pH 5.0-7.0; some to much angular, flat or rounded gravel, 1-4cm, occasionally some stones to 10cm, rarely gravel and stones absent; not mottled; not bleached; highly pedal, weak to firm [occasionally very firm] consistency dry; usually hydrophobic.

Subsoil – two subsoil horizons identified in sample pits; texture generally becomes more clayey with depth; sandy light clay, light clay, light to medium clay, medium to heavy clay; usually many roots present; no lime present; no gypsum present; usually some manganese present at depth; pH 5.5 – 7.5; some to much angular gravel to 4cm, occasionally flat stone to 15-30cm; sometimes mottled at depth; not bleached; highly pedal or massive; very firm to strong consistency dry; usually not hydrophobic.

5.1.1.2 Technical Description [based on test pits]

[a] Australian Soil Classification Names – Red Dermosol, Red Chromosol

[b] Field Description:

Layer 1 – A horizon – Layer always present [12-36cm thick]

Sandy clay loam, clay loam, occasionally silty clay loam or loam; many roots present; no lime present; no gypsum present; no manganese present; pH 5.0-7.0; some to much angular, flat or rounded gravel, 1-4cm, occasionally some stones to 10cm, rarely gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4], reddish brown [2.5YR4/4, 5YR4/4, 5YR5/4], strong brown [7.5YR4/6] dry, dark brown [7.5YR3/2], dark reddish brown [5YR3/3, 2.5YR3/3, 5YR2.5/2, 5YR3/2, 5YR3/3] moist; peds usually rough-faced, occasionally rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; weak to firm [occasionally very firm] consistency dry; usually hydrophobic; *abrupt, occasionally gradual or diffuse to:-*

Layer 2 – B1 Horizon – Layer usually present [10-61cm thick]

Sandy light clay, light clay, light to medium clay, medium to heavy clay; usually many roots present; no lime present; no gypsum present; usually no manganese present; pH 5.5 – 7.5; some to much angular gravel to 4cm, occasionally flat stone to 15-30cm; not mottled; not bleached; red [2.5YR4/4, 2.5YR4/6], reddish brown [5YR4/4, 5YR5/4], strong brown [7.5YR4/6], weak red [10R4/4], yellowish red [5YR5/6] dry, dark reddish brown [2.5YR3/3, 5YR3/3], red [2.5YR4/6], reddish brown [5YR4/4], weak red [10R4/4] moist; peds rough-faced or rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm to very strong consistency dry; usually not hydrophobic; *abrupt, gradual or diffuse to:-*

Layer 3 – B2 Horizon - Layer usually present [25-51cm thick]

Light to medium clay; medium clay [sometimes gritty], heavy clay; usually few roots present, sometimes roots common to many; no lime present; no gypsum present, manganese stains and / or concretions present or manganese absent; pH 6.0 - 7.5; some to much angular and rounded gravel to 2cm, sometimes weathered rock present; not bleached; **usually whole coloured**; reddish brown [5YR4/4], yellowish red [5YR4/6], strong brown [7.5YR4/6], reddish brown [5YR5/4] dry, dark reddish brown [2.5YR3/3], dusky red [10R3/4], reddish brown [5YR4/4], strong brown [7.5YR4/6] moist; **sometimes mottled in colours of**; light brown [10YR6/3], red [2.5YR5/6], yellowish brown [10YR5/4], yellowish red [5YR5/6] dry, brown [10YR4/3], dark yellowish brown [10YR4/4], red [2.5YR4/6], yellowish red [5YR4/6] moist; **sometimes highly pedal** [100%], peds rough- / smooth-faced, polyhedral, <5-20mm in size; very firm to strong consistency dry; **sometimes massive**, fabric rough or rough / smooth; not hydrophobic; *abrupt, gradual or -diffuse to:-* weathered rock / bedrock.

5.1.2 Soil Mapping Unit 2

Soil Mapping Unit 2 occurs in midslope, lower slope, level plains and shallow drainage depression locations.

5.1.2.1 “Plain English” Description:

Soil to 280 cm deep as recorded; surface condition firm or self-mulching and cracked, sometimes loose, soft or hardsetting; surface stone and gravel often absent or some rounded and / or angular surface gravel to 1- 4cm present, occasionally stones to 20cm evident;

Topsoil usually silty clay, light clay, light to medium clay, medium clay, medium to heavy clay, rarely loam; usually roots common to many; no lime present; no gypsum present; no manganese present; pH usually 5.0 – 6.5, occasionally 4.5, 7.0, 7.5, 8.0 and 9.5; no gravel or stones observed, occasional rounded and angular gravel <1-5-cm evident; not mottled; not bleached; highly pedal [100%], usually firm to strong consistency dry; sometimes hydrophobic. **Subsoil** comprised of up to five horizons; clay texture throughout with horizons sometimes becoming gritty near bedrock; usually highly pedal but some massive horizons were recorded; mottles increase with depth.

5.1.2.2 Technical Description [based on test pits]

[a] Australian Soil Classification Names – Red, Brown or Black Vertosol

[b] Field Description:

Layer 1 – A Horizon - Layer always present [10-37cm thick]

Usually silty clay, light clay, light to medium clay, medium clay, medium to heavy clay, rarely loam; usually roots common to many; no lime present; no gypsum present; no manganese present; pH usually 5.0 – 6.5, occasionally 4.5, 7.0, 7.5, 8.0 and 9.5; no gravel or stones observed, occasional rounded and angular gravel <1-5-cm evident; not mottled; not bleached; brown [10YR5/3, 7.5YR4/2, 7.5YR4/4, 7.5YR5/3, 7.5YR5/4], reddish brown [2.5YR4/4, 5YR4/3, 5YR4/4, 5YR5/4], strong brown [7.5YR4/6], yellowish red [5YR5/6] dry, dark brown [10YR3/3, 7.5YR3/2, 7.5YR3/3], dark reddish brown [2.5YR3/3, 2.5YR3/4, 5YR2.5/2, 5YR3/2, 5YR3/3], occasionally dusky red [2.5YR3/2], reddish brown [5YR4/3, 5YR4/4], very dark greyish brown [10YR3/2] moist; peds rough-faced or rough- / smooth-faced, highly pedal [100%], usually polyhedral, sometimes polyhedral/platy, <5-20mm in size; firm to strong consistency dry, occasionally weak; sometimes hydrophobic; *usually abrupt [occasionally gradual] to:-*

Layer 2 – B1 Horizon - Layer always present [14-94cm thick]

Light clay, light to medium clay, medium clay, medium to heavy clay, heavy clay, rarely silty clay loam; few to many roots present; usually no lime present, occasionally some to many stains or concretions; no gypsum present; no manganese present, or, rarely, some manganese stains and concretions; usually pH 6.0 – 7.5, sometimes 8.0 to 9.5-10, rarely 5.0; usually no gravel or stones present, sometimes occasional rounded and angular gravel <1-4-8cm observed; usually no gravel or stones present, occasionally some rounded and angular gravel <1-8cm; not mottled; not bleached; brown [10YR5/3, 7.5YR4/2, 7.5YR4/4], dark reddish brown [2.5YR3/4, 5YR3/2, 5YR3/3], dusky red [10R3/4], red [2.5YR4/6], reddish brown [2.5YR4/3, 2.5YR4/4, 5YR4/3, 5YR4/4], yellowish red [5YR4/6, 5YR5/6] dry, dark brown [7.5YR3/2], dark greyish brown [10YR4/2], dark red [2.5YR3/6], dark reddish brown [2.5YR3/3, 2.5YR3/4, 5YR3/2, 5YR3/3], dusky red [10R3/3, 10R3/4], red [2.5YR4/6], reddish brown [2.5YR4/3, 2.5YR4/4, 5YR4/3, 5YR4/4], very dark greyish brown [10YR3/2], weak red

[10R4/4], yellowish red [5YR4/6] moist; usually highly pedal [100%], peds rough- / smooth-faced, occasionally rough-faced or smooth-faced, polyhedral, usually <5-20mm in size; strong consistency, occasionally firm, very strong dry; rarely massive, fabric rough; usually not hydrophobic; *diffuse or gradual [rarely abrupt] to:-*

Layer 3 – B2.1 Horizon – Layer always present [20-176cm thick]

Medium clay, medium to heavy clay, heavy clay, occasionally light clay or light to medium clay; usually few roots present, sometimes absent or common to many; usually no lime present, sometimes lime stains and concretions present to abundant; gypsum occasionally present; manganese concretions and stains sometimes present; pH usually 9.5-10, sometimes 7.0 to 8.5; no gravel or stones present, occasionally grit, gravel to 4cm present or weathered rock present; not bleached; **usually whole coloured**; brown [7.5YR4/4, 7.5YR5/4], light olive brown [2.5Y5/3], red [2.5YR4/6, 2.5YR5/6], reddish brown [2.5YR4/4, 2.5YR5/4, 5YR5/4], weak red [10R4/4], yellowish red [5YR4/6, 5YR5/6] dry, brown [7.5YR4/4, 7.5YR5/4], dusky red [10R3/4], olive brown [2.5Y4/3], red [2.5YR4/6, 2.5YR5/6], reddish brown [2.5YR4/3, 2.5YR4/4, 2.5YR5/4, 5YR4/4, 5YR5/4], weak red [10R4/4], yellowish red [5YR4/6, 5YR5/6] moist; **very rarely mottled** in colours of; pink [7.5YR7/4], red [2.5YR4/8], reddish brown [2.5YR4/4, 5YR4/3], yellowish brown [10YR5/4] dry, dark reddish brown [5YR3/2], red [2.5YR4/6], reddish brown [2.5YR4/4, 5YR5/4], yellowish brown [10YR5/4] moist; highly pedal [100%]; peds rough- / smooth-faced, occasionally rough-faced or smooth-faced, usually polyhedral, sometimes polyhedral / platy, <5-20mm in size; firm to very strong consistency dry; rarely massive, fabric rough, not hydrophobic; *diffuse or gradual to:-*

Layer 4 – B2.2 Horizon – Layer usually present [20-171cm thick]

Light to medium clay, medium clay, medium to heavy clay; heavy clay, sometimes gritty; few roots present or roots absent; lime mostly absent, some profiles with scattered concretions or stains; some to much gypsum sometimes present; some manganese stains and concretions present or manganese absent; pH often 9.5-10, sometimes 5.0-8.5; gravel and stones mostly absent, sometimes much angular gravel to 5cm or weathered rock or stones to 15cm present; not bleached; **mostly whole coloured**; brown [7.5YR5/4], light brown [7.5YR6/4], light yellowish brown [10YR6/4], red [2.5YR4/6, 2.5YR4/8, 2.5YR5/6], reddish brown [2.5YR4/4, 2.5YR5/4, 5YR5/4], reddish yellow [5YR6/6], very pale brown [10YR7/4], yellowish brown [10YR5/4], yellowish red [5YR4/6, 5YR5/6] dry, brown [7.5YR5/4], dark yellowish brown [10YR4/4], light yellowish brown [10YR6/4], red [2.5YR4/6, 2.5YR4/8, 2.5YR5/6], reddish brown [2.5YR4/4, 2.5YR5/4, 5YR4/4, 5YR5/4], reddish yellow [5YR6/4, 5YR5/6], strong brown [10YR4/4], yellowish red [5YR4/6, 5YR5/6] moist; **sometimes mottled in colours of**; brown [7.5YR5/3, 7.5YR5/4], light brownish grey [10YR6/2, 10YR6/3, 2.5Y6/2], light grey [10YR7/1], light reddish brown [5YR6/4], pale yellow [2.5Y8/3], pinkish grey [7.5YR6/2, 7.5YR7/2], red [2.5YR4/6, 2.5YR5/6], reddish brown [5YR5/3, 5YR5/4, 5YR6/6], very pale brown [10YR7/3, 10YR8/3] dry, brown [7.5YR5/3, 7.5YR5/4], grey [10YR6/1], greyish brown [10YR5/2], light brownish grey [10YR6/2, 10YR6/3, 2.5Y6/2], light reddish brown [5YR6/4], pale yellow [2.5Y7/4], pinkish grey [7.5YR7/2], red [2.5YR4/6, 2.5YR5/6], reddish brown [5YR4/4, 5YR5/4, 5YR5/3], strong brown [7.5YR4/6], very pale brown [10YR7/4, 10YR8/4], yellowish brown [10YR5/4], yellowish red [5YR5/6] moist; highly pedal [100%]; peds rough- / smooth-faced or smooth-faced, sometimes rough-faced, mostly polyhedral, sometimes polyhedral / platy, <5-20mm in size; firm to very strong consistency dry; sometimes massive, fabric rough, rough- / smooth or smooth; not hydrophobic; *gradual or diffuse to lower horizon or overlying bedrock:-*

Layer 5 – B2.3 Horizon – Layer often present [30-90cm thick]

Sandy clay, gritty light to medium clay, medium clay, medium to heavy clay [sometimes gritty], heavy clay; usually no roots present; no lime present; gypsum usually absent; manganese generally absent, occasionally manganese stains and concretions present; pH 5.0 to 9.5-10; gravel and stones absent or some gravel and weathered rock present; **usually mottled in colours of** ; brown [7.5YR5/3], greyish brown [10YR5/2], light brown [7.5YR6/4], light brownish grey [10YR6/2], light grey [10YR7/1], light reddish brown [5YR6/3], pale yellow [2.5Y8/3], pink [7.5YR8/3], red [2.5YR4/6, 2.5YR5/6], reddish brown [2.5YR4/4, 5YR5/3, 5YR5/4], reddish yellow [7.5YR7/6], very pale brown [10YR8/3], yellowish red [5YR5/6] dry, brown [7.5YR5/3, 7.5YR5/4], brownish grey [10YR6/2], grey [10YR6/1], greyish brown [10YR5/2], light brown [7.5YR6/4], light yellowish brown [10YR6/4], pinkish grey [7.5YR6/2], red [2.5YR4/6, 2.5YR5/6], reddish brown [2.5YR4/4, 5YR4/4, 5YR5/3, 5YR5/4], reddish yellow [7.5YR6/6], strong brown [7.5YR4/6, 7.5YR5/6], yellowish red [5YR4/6, 5YR5/6] moist; **sometimes whole coloured**; brown [7.5YR5/4], light yellowish brown [10YR6/4], red [2.5YR4/6], reddish brown [5YR5/4], very pale brown [10YR8/4, 10YR5/4], yellowish red [5YR4/6] dry, light yellowish brown [10YR6/4], red [2.5YR4/6], reddish brown [5YR5/4], strong brown [10YR4/4, 7.5YR4/6], yellowish red [5YR4/6] moist; usually highly pedal [100%], peds usually rough- / smooth-faced, sometimes rough-faced or smooth-faced, polyhedral, rarely polyhedral / platy, <5-20mm in size; firm to very strong consistency dry; sometimes massive, fabric rough; not hydrophobic; *gradual or diffuse to lower horizon or overlying bedrock:-*

Layer 6 – B3 Horizon – Layer occasionally present [20-100cm thick]

Gritty sandy clay, gritty medium clay, medium clay, medium to heavy clay, heavy clay; no lime present; no gypsum present; no manganese present; pH 5.0 to 9.5-10; gravel or stones absent or some present, to 8cm, some weathered rock; not bleached; **sometimes whole coloured**; light brown [7.5YR6/4], reddish brown [5YR5/4], yellowish red [5YR5/6] dry, brown [7.5YR5/4], reddish brown [5YR5/4], yellowish red [5YR4/6] moist; **sometimes mottled in colours of**: pale yellow [2.5Y8/3], red [10R4/6, 2.5YR5/6], very pale brown [10YR7/4], white [10YR8/1], yellowish red [7.5YR5/6] dry, light yellowish brown [10YR6/4, 2.5Y6/4], red [10R4/6], reddish brown [2.5YR4/4], reddish yellow [7.5YR6/6], yellowish red [5YR4/6] moist; usually highly pedal [100%], peds rough- / smooth-faced or smooth-faced, polyhedral [usually] or polyhedral / platy, <5-15mm in size; strong to very strong consistency dry; occasionally massive, fabric rough / smooth; usually not hydrophobic

5.2 Soil Laboratory Analyses

Thirty four samples from nine representative soil profiles were selected for laboratory analysis at the Department of Lands' Soil and Water Testing Laboratory at Scone.

The tests performed aimed at assessing the potential erodibility of the soils [Particle Size Analysis [PSA], Dispersion % [D%] and Emerson Aggregate Test [EAT] and Electrical Conductivity [EC]].

5.2.1 Physical and Chemical Analyses

Tables 1 and 4 show the results obtained from laboratory analysis of the samples from the nine pits.

Samples from three profiles from within SMU 1 and six from within SMU 2 were analysed in the laboratory.

Table 1
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
SMU 1 PIT 1	1	Sandy loam	0-14	16.5	10.3	36.1	37.1	73.2	3
	2	Sandy loam	14-41	17.2	9.7	24.7	48.4	72.1	7
	3	Clay	41-82	52.7	8.8	14.2	24.2	38.5	9
SMU 1 PIT 21	1	Loam	0-12	13.6	18.2	44.3	23.9	68.2	12
	2	Clay	12-30	35.8	19.8	34.6	22.2	56.8	9
	3	Clay	30-81	50.0	16.7	18.8	14.6	33.3	4
SMU 1 PIT 53	1	Loam	0-27	17.0	14.0	37.0	32.0	69.0	<1
	2	Sandy clay loam	27-45	23.2	6.3	29.5	41.1	70.5	5
	3	Sandy clay loam	45-70	22.9	8.4	24.1	44.6	68.7	17
SMU 2 PIT 11	1	Clay loam	0-14	28.0	20.0	48.0	4.0	52.0	0
	2	Clay	14-70	60.0	13.0	25.0	2.0	27.0	<1
	3	Clay	70-130	67.0	6.0	24.0	3.0	27.0	<1
	4	Clay	130-165	63.0	9.0	26.0	2.0	28.0	<1
SMU 2 PIT 25	1	Clay loam	0-18	24.0	18.0	50.0	8.0	58.0	<1
	2	Clay	18-60	54.0	13.0	30.0	3.0	33.0	<1
	3	Clay	60-96	62.0	9.0	26.0	3.0	29.0	<1
	4	Clay	96-148	53.0	16.0	28.0	3.0	31.0	<1
	5	Clay	148-178	35.6	15.1	23.3	26.0	49.3	27.0
	6	Clay loam	178-250	27.5	13.7	19.6	139.2	58.8	49.0
SMU 2 PIT 48	1	Clay loam	0-17	26.0	20.0	46.0	8.0	54.0	<1
	2	Clay	17-69	51.5	13.1	27.3	8.1	33.3	1
	3	Clay	69-174	51.0	13.0	29.0	7.0	36.0	<1
	4	Clay	174-250	4.0	10.0	35.0	11.0	46.0	<1
SMU 2 PIT 57	1	Loam	0-27	17.0	14.0	37.0	32.0	69.0	<1
	2	Sandy clay loam	27-45	23.2	6.3	29.5	41.1	70.5	5
	3	Sandy clay loam	45-70	22.9	8.4	24.1	44.6	68.7	17
SMU 2 PIT 59	1	Clay	0-33	52.0	14.0	31.0	3.0	34.0	<1
	2	Clay	33-115	54.0	14.0	29.0	3.0	32.0	<1
	3	Clay	115-220	54.0	12.0	31.0	3.0	34.0	<1
	4	Clay	220-260	53.0	9.0	36.0	2.0	38.0	<1
SMU 2 PIT 61	1	Loam	0-25	21.0	20.0	50.0	9.0	59.0	<1
	2	Clay	25-54	54.0	12.0	29.0	5.0	34.0	<1
	3	Clay	54-150	53.0	11.0	30.0	6.0	36.0	<1
	4	Loam	150-250	22.0	21.0	28.0	29.0	57.0	<1
Note: PSA = Particle Size Analysis # texture based on laboratory measurements									

Table 1 [cont]
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	D %	D% level of dispersion	EAT	EAT level of dispersion
SMU 1 PIT 1	1	Sandy loam	0-14	19	Slight	8/3[1]	Negligible - slight
	2	Sandy loam	14-41	19	Slight	3[1]	Slight
	3	Clay	41-82	7	Slight	5	Slight
SMU 1 PIT 21	1	Loam	0-12	12	Slight	8/3[1]	Negligible – slight
	2	Clay	12-30	9	Slight	3[3]	Moderate
	3	Clay	30-81	4	Slight	5	Slight
SMU 1 PIT 53	1	Loam	0-27	10	Slight	8/3[1]	Negligible – slight
	2	Sandy clay loam	27-45	5	Negligible	5	Slight
	3	Sandy clay loam	45-70	7	Slight	5	Slight
SMU 2 PIT 11	1	Clay loam	0-14	11	Slight	3[2]	Slight
	2	Clay	14-70	37	Moderate	3[3]	Moderate
	3	Clay	70-130	0	Negligible	4	Negligible
	4	Clay	130-165	0	Negligible	4	Negligible
SMU 2 PIT 25	1	Clay loam	0-18	13	Slight	3[3]	Moderate
	2	Clay	18-60	55	High	2[3]	Very high
	3	Clay	60-96	0	Negligible	2[2]	High
	4	Clay	96-148	51	High	2[3]	Very high
	5	Clay	148-178	72	Very high	2[3]	Very high
	6	Clay loam	178-250	61	High	1	Very high
SMU 2 PIT 48	1	Clay loam	0-17	12	Slight	3[3]	Moderate
	2	Clay	17-69	23	Slight	4	Negligible
	3	Clay	69-174	42	Moderate	3[1]	Slight
	4	Clay	174-250	33	Moderate	2[3]	Very high
SMU 2 PIT 57	1	Loam	0-27	12	Slight	3[1]	Slight
	2	Sandy clay loam	27-45	7	Slight	5	Slight
	3	Sandy clay loam	45-70	5	Negligible	5	Slight
SMU 2 PIT 59	1	Clay	0-33	19	Slight	5	Slight
	2	Clay	33-115	19	Slight	4	Slight
	3	Clay	115-220	0	Negligible	4	Slight
	4	Clay	220-260	12	Slight	6	Slight
SMU 2 PIT 61	1	Loam	0-25	13	Slight	3[3]	Moderate
	2	Clay	25-54	33	Moderate	3[1]	Slight
	3	Clay	54-150	0	Negligible	4	Negligible
	4	Loam	150-250	71	Very high	2[3]	Very high
Notes: D = Dispersion EAT = Emerson Aggregate Test # texture based on laboratory							

6.0 DISCUSSION OF SOIL ANALYSES

6.1 Physical Attributes

The laboratory analysis results contained in **Table 1** are important in assessing the erodibility of the soil units found within the Study Area.

The three tests [Particle Size Analysis, Dispersion %, Emerson Aggregate Test] carried out on samples from each of the horizons within the nine selected soil profiles, when considered together, provide a good indication of the soil's likely behaviour in relation to the erosive forces encountered in the field.

6.1.1 Particle Size Analysis

The Particle Size Analysis [PSA] test shows the amounts of gravel, clay, silt, fine sand and coarse sand contained within each sample.

The results shown in **Table 1** are those contained in the laboratory test report.

From this data, it is evident that most soils analysed contain relatively low to negligible levels of gravel.

The texture class of each soil layer is determined by analysis of the material [fine earth fraction] that is less than 2mm in size – i.e. the sample from each tested horizon with the gravel removed. The calculated texture of the fine earth fraction of each of the layers tested in the laboratory is shown in **Table 1**.

It should be noted that the field textures of almost all layers of the sixty three profiles that were examined indicated that the soils were generally more clayey than was shown in the laboratory analyses.

6.1.2 Dispersion Percentage

The Dispersion Percentage [D%] test indicates the proportion of the soil material less than 0.005 mm in size that would disperse on wetting [i.e. the clay and some of the silt fractions].

Hazelton and Murphy [in press] provide the following guides to the interpretation of D% values [**Table 2**]

Table 2
Interpretation of Dispersion Percentage Values
[after Hazelton and Murphy, in press]

D% Value	Dispersion Rating
< 6	Negligible
6 – 30	Slight
30 – 50	Moderate
50 – 65	High
> 65	Very high

In interpreting the results of the values of dispersion percentage obtained in laboratory testing it is important to consider other related soil attributes such as the Particle Size Analysis [PSA] and Emerson Aggregate Test [EAT] data.

Soil horizons with high clay contents and high D% values would be more dispersive in practice than those with a high D% value and a low clay content in the soil.

The D% values shown in **Table 1** indicate that:

- the topsoils of SMU 1 showed slight dispersibility;
- the topsoils of SMU 2 showed slight to moderate dispersibility;
- the subsoils of SMU 1 showed negligible to slight dispersibility; and
- the subsoils of SMU 2 showed variable dispersibility ranging from slight or moderate to high to very high.

Many of the subsoils contain moderate to high levels of clay and this fact undoubtedly makes them more dispersive than the analyses indicate – although, for some, this is difficult since they already exhibit moderate to high values.

Given these indications of dispersibility, the erosion potential is undoubtedly high for any areas of exposed subsoil either in situ or in stockpiles.

Consequently, appropriate measures need to be taken to protect the stockpiles of stripped subsoil. The same material, when respread, should be afforded rapid protection from soil erosion in the form of vegetative cover.

6.1.3 Emerson Aggregate Test

This test provides a measure of the coherence of soil aggregates when they are immersed in water. Natural peds are used [Houghton and Charman, 1986] and the method originally used by the (former) Department of Land and Water Conservation to determine the Emerson Class Number is fully described in Craze et al [1993].

Basically, the degree of soil aggregate stability increases from Class 1 through to Class 8. Classes 2 and 3 have a number of subclasses based on the degree of dispersion.

Aggregates in Emerson Classes 1 and 2 are generally regarded as being unstable while those in classes 4 to 8 are considered to be stable.

Hazelton and Murphy [in press] present a summary of the Emerson Aggregate Classes. This is contained in **Table 3**.

Table 3
Comparison of Aggregate Dispersibility and Emerson
Aggregate Classes [after Hazelton and Murphy, in press]

Aggregate Dispersibility	Emerson Aggregate Classes*
Very High	1 and 2[3]
High	2[2]
High to Moderate	2[1]
Moderate	3[4] and 3[3]
Slight	3[2], 3[1] and 5
Negligible / Aggregated	4,6,7,and 8

* **NOTE** – the subclasses of the Emerson Aggregate Test [EAT] Classes are as follows:

- [1] slight milkiness immediately adjacent to the aggregate;
- [2] obvious milkiness, less than 50% of the aggregate affected;
- [3] obvious milkiness, more than 50% of the aggregate affected; and
- [4] total dispersion, leaving only sand grains [NB – Class 2[4] is equivalent to Class 1].

The EAT data in **Table 1** show that:

- the surface layers of the soils of SMU 1 have a negligible to slight dispersibility rating;
- the surface layers of the soils of SMU 2 generally have a slight [sometimes moderate] dispersibility rating;
- the subsoils of SMU 1 have a negligible to slight or slight [occasionally moderate] dispersibility rating; and
- the subsoils of SMU 2 vary in dispersibility rating ranging between negligible to slight, slight moderate, high and very high dispersibility rating.

The dispersibility of the subsoils of SMU 2 in particular makes it essential that any exposed subsoil and subsoil stockpiles are adequately protected from soil erosion at all times.

6.2 Soil Chemical Attributes

Laboratory testing of the samples extended only to an examination of the electrical conductivity. Soil pH was measured in the field using the Raupach method. The results of the laboratory analyses and the field pH measurements are contained in **Table 4**.

Table 4
Chemical Analyses Laboratory Analysis Data for Selected Soil Profiles

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	pH *	EC [dS/m]#
SMU 1 PIT 1	1	Sandy loam	0-14	5.5	0.12
	2	Sandy loam	14-41	6.0	0.02
	3	Clay	41-82	6.0	0.03
SMU 1 PIT 21	1	Loam	0-12	6.0	0.18
	2	Clay	12-30	6.0	0.06
	3	Clay	30-81	7.0	0.04
SMU 1 PIT 53	1	Loam	0-27	6.5	0.17
	2	Sandy clay	27-45	6.5	0.02
	3	Sandy clay	45-70	6.5	0.01
SMU 2 PIT 11	1	Clay loam	0-14	5.5	0.20
	2	Clay	14-70	9.0	0.12
	3	Clay	70-130	9.5- 10	2.73
	4	Clay	130-165	9.5- 10	2.33
SMU 2 PIT 25	1	Clay loam	0-18	6.0	0.08
	2	Clay	18-60	9.0	0.16
	3	Clay	60-96	9.5- 10	2.05
	4	Clay	96-148	8.0	1.27
	5	Clay	148-178	5.5	1.02
	6	Clay loam	178-250	5.0	0.65
SMU 2 PIT 48	1	Clay loam	0-17	6.5	0.07
	2	Clay	17-69	9.5- 10	0.18
	3	Clay	69-174	9.5- 10	0.33
	4	Clay	174-250	9.5- 10	0.76
SMU 2 PIT 57	1	Loam	0-27	6.0	0.06
	2	Sandy clay	27-45	7.0	0.02
	3	Sandy clay	45-70	7.0	0.01
SMU 2PIT 59	1	Clay	0-33	7.5	0.20
	2	Clay	33-115	9.0	0.22
	3	Clay	115-220	9.0	1.30
	4	Clay	220-260	5.0	1.39
SMU 2 PIT 61	1	Loam	0-25	6.0	0.19
	2	Clay	25-54	9.5- 10	0.33
	3	Clay	54-150	8.5- 9.0	1.67
	4	Loam	150-250	5.5	0.79

texture based on laboratory measurements

6.2.1 Soil pH

In general, the pH [water] range in most soils is between 4.0 and 8.5 although pH values above and below this range are measured at times [Glendinning, 1990].

This range of soil pH levels is generally accepted as being one that is suitable for plant growth.

The pH 6.0 to 6.5 range is usually regarded as the optimum for growth of most plants and there are some more serious impacts on the growth of many species at the lower, or acid, end of the range.

As the pH scale [between 0 and 14] is a logarithmic one, a soil with a pH of 5.0 is ten times as acid as a soil of pH 6.0 and 100 times as acid as one with a pH of 7.0.

Perusal of the data in the pH column in **Table 4** indicates that about two-thirds of the thirty four samples tested showed pH levels within the 4.0 to 8.5 range.

The uppermost soil layers in both SMUs had a pH within the acceptable range. This indicates that the pH values of the topsoil layers that would be stripped from both SMUs for use in rehabilitation are very much within acceptable limits for plant growth.

Some of the lower layers in SMU 2 were often very alkaline and outside the range acceptable for plant growth.

This should not present a problem as the process of stripping and respreading would mix the soil materials from higher and lower pH areas and result in material with an acceptable pH level.

6.2.2 Electrical Conductivity

Soil salinity is a measure of the presence of water-soluble salts, mainly of sodium, calcium and magnesium, in the soil solution. These salts may be chlorides, sulphates or carbonates and can have a major impact on plant growth if they occur in sufficiently large quantities.

The level of salinity in a soil sample is determined by measuring the electrical conductivity [EC] of a 1:5 soil / water suspension.

As the published salinity tolerance data for crops and pastures is based on the electrical conductivity of a saturated extract of the soil solution, a series of conversion factors, based on the estimated water holding capacity of soil sample, are used to convert the measured EC value to one for the conductivity of the saturated extract [EC_e].

The electrical conductivity of the 1:5 soil / water suspension and that of the saturated extract are measured in units called deciSiemens / metre [dS/m].

The measured level of electrical conductivity of the 1:5 soil / water suspension is multiplied by the appropriate factor in **Table 5** [extracted from Hazelton and Murphy, in press] based on the measured soil texture.

Table 5
Texture Class Multipliers for Calculating EC_e Values

Soil Texture Class	Multiplier Factor
Loamy sand, clayey sand, sand	23
sandy loam, fine sandy loam, light sandy clay loam	14
loam, loam fine sandy, silt loam, sandy clay loam	9.5
clay loam, silty clay loam, fine sandy clay loam, sandy clay, silty clay, light clay	8.6
light medium clay	7.5
medium clay	5.8
Heavy clay	5.8

Table 6 shows the calculated EC_e values for the samples analysed in the laboratory and shows the salinity status of the various horizons based on these EC_e values.

Hazelton and Murphy [in press] note that EC_e values below 2.0 indicate non-saline horizons while values between 2 and 4 indicate slight salinity. Values between 4 and 8 indicate moderate salinity while those between 8 and 16 indicate high salinity.

The data in **Table 6** indicate that:

- both topsoil and subsoil materials from SMU 1 are non-saline;
- the topsoils of SMU 2 profiles are non-saline; but
- the subsoils of SMU 2 profiles contain many horizons that vary in salinity from moderately to extremely saline.

This poses limitations on the depth to which these SMU2 subsoils can be stripped to avoid having to store, and otherwise deal with, soil material that has a salinity problem.

Table 6
Calculated EC_e Values and Salinity Status for Selected Soil Profiles

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	EC [dS/m] #	MULTI-PLIER	CALCULATED EC _e	SOIL SALINITY STATUS
SMU 1 PIT 1	1	Sandy loam	0-14	0.12	14	1.68	Non-saline
	2	Sandy loam	14-41	0.02	14	0.28	Non-saline
	3	Clay	41-82	0.03	7.5	0.23	Non-saline
SMU 1 PIT 21	1	Loam	0-12	0.18	9.5	1.71	Non-saline
	2	Clay	12-30	0.06	7.5	0.45	Non-saline
	3	Clay	30-81	0.04	7.5	0.30	Non-saline
SMU 1 PIT 53	1	Loam	0-27	0.17	9.5	1.62	Non-saline
	2	Sandy clay	27-45	0.02	9.5	0.19	Non-saline
	3	Sandy clay	45-70	0.01	9.5	0.01	Non-saline
SMU 2 PIT 11	1	Clay loam	0-14	0.20	8.6	1.72	Non-saline
	2	Clay	14-70	0.12	7.5	0.90	Non-saline
	3	Clay	70-130	2.73	7.5	20.48	Extremely saline
	4	Clay	130-165	2.33	7.5	17.48	Extremely saline
SMU 2 PIT 25	1	Clay loam	0-18	0.08	8.6	0.69	Non-saline
	2	Clay	18-60	0.16	7.5	1.20	Non-saline
	3	Clay	60-96	2.05	7.5	15.38	Highly saline
	4	Clay	96-148	1.27	7.5	9.25	Highly saline
	5	Clay	148-178	1.02	7.5	7.63	Moderately saline
	6	Clay loam	178-250	0.65	8.6	5.59	Moderately saline
SMU 2 PIT 48	1	Clay loam	0-17	0.07	8.6	0.60	Non saline
	2	Clay	17-69	0.18	7.5	1.35	Non-saline
	3	Clay	69-174	0.33	7.5	2.48	Slightly saline
	4	Clay	174-250	0.76	7.5	5.70	Moderately saline
SMU 2 PIT 57	1	Loam	0-27	0.06	8.6	0.52	Non-saline
	2	Sandy clay	27-45	0.02	7.5	0.15	Non-saline
	3	Sandy clay	45-70	0.01	7.5	0.08	Non-saline
SMU 2PIT 59	1	Clay	0-33	0.20	7.5	1.50	Non-saline
	2	Clay	33-115	0.22	7.5	1.65	Non-saline
	3	Clay	115-220	1.30	7.5	9.75	Highly saline
	4	Clay	220-260	1.39	7.5	10.42	Highly saline
SMU 2 PIT 61	1	Loam	0-25	0.19	9.5	1.81	Non-saline
	2	Clay	25-54	0.33	7.5	2.48	Slightly saline
	3	Clay	54-150	1.67	7.5	12.53	Highly saline
	4	Loam	150-250	0.79	9.5	7.51	Moderately saline

texture based on laboratory measurements

7. EROSION POTENTIAL

The soils within the Study Area are currently generally stable although there are a number of areas where soil conservation structures have been constructed indicating that erosion may have been a problem in the past under regular cropping.

Many parts of the Study Area have been cleared for cultivation while other areas still support remnant native tree cover. These latter areas are generally those where soils are shallow and coarser in texture. The Limestone National Forest supports an open woodland of remnant native vegetation and the soils within this area are generally shallow and coarse textured.

Care should be taken to ensure that the rehabilitated post-mining landscape is protected by appropriate soil conservation measures and that these adequately interface with any parts of existing soil conservation bank and waterway systems that are not disturbed during development.

To this end, the assistance of the local staff of the Department of Lands [Soil Services] should be sought to design and construct alternative water disposal systems where they are required and to integrate these with remnants of any existing systems.

Groundcover varies over the site but the cultivated lands exhibited a good cover of stubble at the time of inspection and the remnant vegetation areas, including Limestone National Forest, generally support a reasonable cover of native and naturalised groundcover species.

It would be essential, if erosion is to be prevented, to maintain an adequate groundcover on the existing landscape, on any stockpiles during the mine's operation and on the reformed landscapes after rehabilitation work is carried out.

7.1 SOILOSS Program

An appropriate method of assessing the erosion hazard associated with the soils of the study area is to use the SOILOSS computer program devised by Rosewell and Edwards [1988] and updated by Rosewell [1993].

This program computes soil loss values for a given site under various land uses and climatic [rainfall] conditions and so provides an indication of erosion hazard.

SOILOSS is based on the Universal Soil Loss Equation or USLE described by Wischmeier and Smith [1978] and subsequently updated as the Revised Universal Soil Loss Equation or RSLE [Renard et al, 1993].

The USLE is

$$A = R * K * L * S * P * C \quad \text{where}$$

- A is the average annual soil loss [tonnes / hectare]
R is the rainfall erosivity factor, a measure of the erosive power of the rain
K is the soil erodibility factor, a measure of the resistance of the soil to erosion
L is the slope length factor
S is the slope steepness factor
P is the support practice factor, a measure of the effect on erosion of soil conservation measures such as contour cultivation and bank systems
C is the crop and cover management factor

In using SOILOSS, the rainfall erosivity factor is obtained from maps provided with the program manual [Rosewell, 1993].

Soil erodibility is either estimated from details of the soil type and soil surface texture by comparison with a table of soils presented by the program or is derived from a knowledge of soil particle size analysis, organic matter content, surface soil structure and profile permeability.

Slope length and steepness factors are derived from field measurements and / or examination of topographic maps or airphotos.

The support practice factor is estimated by the program from a description of the land management practices in use, details of cultivation direction and information on bank systems if these are present.

To determine the value of the 'K' factor for use in the program, a generic or standard method can be utilised from within the program to indicate the likely soil losses from a range of crop rotations and management practices.

In addition, a more detailed approach can be used to determine likely soil loss given the availability of precise detail relating to sowing dates, cultivation practices etc.

Provision is made within the program for estimating soil loss from areas with a range of non-arable uses.

Table 7 provides details of the calculated erodibility values [K] and erodibility ratings for topsoils and subsoils from a selection of soil profiles in the Study Area.

The erodibility estimates contained in **Table 7** for the three basic soil types recorded from the Study Area have been calculated using part of the overall SOILOSS program capability and the Particle Size Analysis and other data for three typical soil profiles at the Study Area.

The only value for which estimates were used in the calculations were those for organic matter %. After a perusal of the data for this variable for soils from the Cooks Myalls Soil Landscape as mapped and described by King [1998a, 1998b] values of 2.7% [topsoils] and 0.40% [subsoils] were chosen.

The Erodibility classes used were < 0.020 = LOW; 0.020 – 0.040 = MODERATE; > 0.040 = HIGH.

Table 7
Soil Erodibility Values and Ratings for a Selection of Soils

SMU	PIT NUMBER	TOPSOIL LAYER [cm]	TOPSOIL 'K' RATING	SUBSOIL LAYER [cm]	SUBSOIL 'K' RATING	AVERAGE 'K' RATING [WHOLE SOIL]	SOIL MAPPING UNIT ERODIBILITY
SMU 1	1	0-14	0.026 moderate	41-82	0.011 low	0.018	LOW
SMU 1	53	0-27	0.030 moderate	45-70	0.021 moderate	0.026	MODERATE
SMU 2	25	0-18	0.036 moderate	18-60	0.017 low	0.027	MODERATE
SMU 2	59	0-33	0.016 low	33-115	0.017 low	0.017	LOW

The data in **Table 7** show that the SOILOSS program predicts that the erodibility of the selected soils from the Study Area varies between low and moderate with the topsoils of SMU 1 having a moderate rating and their subsoils showing low to moderate values. For SMU 2, the topsoil values varied from low to moderate while the subsoils showed low values.

Because of the general MODERATE erodibility of the topsoils as assessed by the SOILOSS analysis, they should be managed carefully during the stripping and rehabilitation stages to ensure that soil structure damage is minimal and that they are suitably protected by vegetation or some other medium at all times.

The erodibility of the subsoils was generally low as assessed by SOILOSS but the same comments apply.

This erodibility constraint, when considered with the measured high pH, relatively high dispersibility and the occurrence of salinity in some SMU 2 subsoil layers, indicates that the subsoil materials within SMU 2 would have to be very carefully stripped and managed during the life of the mine.

8 STRIPPING SUITABILITY OF SOIL MATERIALS

An approach has been developed by Elliott and Veness [1981] to determine the stripping suitability of soil materials found at a site where stripping of upper soil layers is required. The key used in this method of stripping suitability assessment is contained in **Appendix 2**.

This method has been used in the present study.

The basis for the Elliott and Veness approach is that not all soil material that might be available for topdressing of disturbed sites is suitable for agricultural or pastoral use. Rather, some may be poorly structured, too sandy or gravelly or too poorly drained to allow a stabilising vegetative cover to develop.

In their work, Elliott and Veness established that there are a number of critical soil physical attributes that can be used to distinguish between suitable and unsuitable topdressing materials. These are:

- [a] soil structure;
- [b] soil macrostructure;
- [c] soil coherence;
- [d] soil texture; and
- [e] the force necessary to disrupt peds

NOTE: The following descriptions of soil materials are based on the detail gained from all 63 profiles sampled in the field.

8.1 Stripping Recommendations for Soil Mapping Units 1 and 2 - General

The topsoil material from SMU 1 is generally coarser in texture than the topsoils from SMU 2. However, there is little point in segregating the two topsoils based purely on these textural differences.

As a consequence, the stripping recommendations are for the topsoil material to be stripped and stockpiled as a single entity. The stripping and resspreading process would result in a mixing of the finer and coarser materials and overall would result in the availability of a good plant growth medium for use in rehabilitation

The subsoil material can be mixed as well during the stripping operation with two provisos. These are:

- **within SMU 1, stripping should cease if weathered rock or bedrock is encountered before the recommended stripping depth from the current land surface is reached; and**
- **within SMU 2, stripping should NOT progress beyond the recommended stripping depth because of the likelihood of stripping highly saline soil material that would cause problems during storage and later during rehabilitation**

8.2 Stripping Recommendations for Soil Mapping Units 1 and 2 - Topsoil

Strip topsoil to 12cm depth.

The topsoil material has the following characteristics that are used in assessment in the Elliott and Veness [1981] key.

Loam, sandy clay loam, clay loam, silty clay loam, silty clay, light clay, light to medium clay, medium clay, medium to heavy clay; pH 5.0-7.0; gravel and stones usually absent or some to much angular, flat or rounded gravel, 1-4cm recorded, occasionally some stones to 10cm present; not mottled; highly pedal [100%]; firm to strong consistency dry, rarely weak;

Suitability Assessment: mainly structure grade 3, coherent dry, mottles absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; gravel and stone content well within limits; pH levels suitable; salt content suitable.

This material is generally suitable for topsoiling on the basis of the Elliott and Veness key. The material contains valuable seed, organic matter, nutrient reserves and has other favourable attributes.

This allows it to be stripped and stockpiled as **topsoil** provided suitable stripping and storage methods are used [discussed later in this report].

Recommendation – Strip all of the Layer 1 topsoil to a depth of 12cm. Although there is some variation in soil texture within this SMU, the soil material from all parts of the SMU 1 and SMU 2 areas can be mixed and stored in the same topsoil stockpiles.

[NOTE: Topsoil stripping should be carried out on all areas that would be disturbed by mining and associated infrastructure development within the boundaries of SMU 1. It should not be necessary to further strip areas that are only to be used for roads, buildings, hardstand areas etc.]

However, on areas where the disturbance is deeper - ie. areas to be mined, waste rock emplacements etc - the subsoil should be stripped as indicated for layers 2 and 3 below.]

8.3 Stripping Recommendations for Soil Mapping Units 1 and 2 - Subsoil

Strip subsoil to 70cm depth from, the present land surface [ie. a 58cm thick layer] unless weathered rock is encountered - when stripping should cease.

The subsoil material has the following characteristics that are used in assessment in the Elliott and Veness [1981] key.

Usually silty light clay; silty clay; light to medium clay; medium clay; medium to heavy clay; heavy clay; occasionally loam, loam fine sandy, sandy clay loam, silty clay loam, clay loam, sandy light clay; pH commonly 5.0 to 7.5, rarely 4.5, often 9.0 to 9.5-10; gravel and stones commonly absent, sometimes gritty, some profiles with some to much angular gravel to 5cm, stones to 15cm and floaters occasionally present; rarely mottled; usually highly pedal [100%], rarely massive; firm to very strong consistency dry, occasionally weak;

Suitability Assessment: mainly structure grade 3; coherent dry, mottles usually absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer contains considerable though not excessive amounts of gravel; pH levels generally suitable although some areas have pH levels of up to 9.5-10. The extensive mixing of material during stripping and respreading should result in generally lower composite pH levels on the rehabilitated land; salt content suitable but stripping should not proceed below 70cm as saline material is likely to be encountered below this depth.

This material is suitable for use as subsoil on the basis of the Elliott and Veness key. This allows it to be stripped and stockpiled as **subsoil** provided suitable stripping and storage methods are used [discussed later in this report].

Recommendation – Strip all of the Layer 2 subsoil to a depth of 58cm below the base of Layer 1 - ie. a total depth from the surface of 70cm. Although there is some variation in soil texture within the two SMUs, the subsoil material from all parts of the SMU 1 and SMU 2 areas can be mixed and stored in the same subsoil stockpiles.

8.4 Stripping Recommendations for Soil Mapping Units 1 and 2 - Layer 3 [Remainder of the Profile]

It is likely that on most areas covered by SMU 1 that at 70cm depth weathered rock or bedrock would be encountered. Similarly within SMU 2, it is likely that material from depths of >70cm from the present land surface would have saline characteristics that would pose problems for storage and use in rehabilitation.

Recommendation – *This material should preferably be left in situ.*

However, on areas that have, for some reason, to be stripped below 70cm depth, the stripped material should be treated as overburden and mixed with other overburden material to dilute the salinity levels.

9 HANDLING STRIPPED SOILS

9.1 General Issues

Stripping of topsoil materials is proposed for those sections of the Study Area to be used for the development of the proposed open cut mine and construction of the haul road, coal handling and administrative facilities.

In addition, subsoil material would need to be stripped from the area to be disturbed by the proposed subsidence area, waste rock stockpile, borrow pit and tailings storage facilities for later use in rehabilitation.

It is appropriate to consider, in this report, the techniques for handling the soil materials that are to be stripped, stockpiled and then respread during the rehabilitation phase.

The recommendations made are based on an interpretation of the results of soil survey at the site and the associated laboratory analysis data.

As a general rule in soil stripping, stockpiling etc, the weaker [more sandy] the *in situ* structure of the soil being removed, the more care that is required in all phases of handling. The soil needs to be handled [disturbed] as little as possible to minimise mechanical damage to soil structure that would be detrimental to rapid establishment of ground cover once rehabilitation works commence.

There have been a number of studies in the past relating to the impact of the stripping and stockpiling of soils associated with mining and similar activities. These studies indicate that working of soils in situations where the soil moisture content is unfavourable can have detrimental impacts on soil structure [Elliott and Veness, 1985; Hunter and Currie, 1956]. There are also unfavourable effects related to mixing of soil materials with different fertility levels, textures and other critical soil properties.

Stockpiling also has its effects although there is evidence that the impacts are, at least to some degree, reversible. Jenkin et al [1987] have noted that these effects seem similar to those of normal agricultural uses on soils.

Dougall [1950] has noted that stockpiling of soil results in some structure breakdown and changes associated with some other physical and chemical properties.

However, despite these negative impacts, Elliott and Veness [1985] conclude that the quality of stockpiled soil can, in fact, improve with time – especially in the outer layers of material.

9.2 Stripping and Stockpiling Recommendations

9.2.1 Earthmoving Procedures.

As mentioned previously, the topsoils and subsoils to be moved within the Northparkes Mines Study Area generally have good structure. However, the topsoil structure is generally somewhat weaker than that of the subsoils - particularly in the moist state.

As a consequence, improper or excessive handling of the material during the stripping and stockpiling operation has the potential to destroy the soil structure by mechanically breaking down the soil aggregates that are present.

Notwithstanding the comments above, the generally good structure grades of both topsoils and subsoils would allow the stripping operation to be carried out using machines such as open-bowl scrapers. However, the scrapers should dump their loads neatly to form a uniform dump that requires little further forming prior to establishment of a vegetation cover.

Even so, care should be taken also to ensure that topsoils are not stripped when they are too moist as greater damage would occur at this time.

Similar precautions should be taken with the subsoils.

Driving of machinery on the topsoil and subsoil stockpiles, other than the scrapers during unloading, should be kept to an absolute minimum to maximise soil aggregation and prevent compaction.

Ideally, the topsoil stockpiles should be 60cm to 1m high but, if necessary, higher stockpiles can be used. These should not exceed about 2m in height.

The subsoil stockpiles should not exceed 3m in height.

9.2.2 Soil Conservation Measures

Stockpiles should preferably be positioned where runoff water from upslope does not pose a problem, with the best stockpile sites being on a level ridgetop.

However, if a suitably-sized ridgetop site is not available, an upper slope position or some other relatively level area would be an acceptable alternative, provided an appropriate soil conservation bank design is used immediately above the site to prevent erosion of the stockpile by run-on water.

In addition, measures should be taken to minimise loss of soil material from the stockpiles, especially in the period before they are stabilised, eg using geotextile “fences” or lines of hay bales etc.

The stockpile surfaces should be left with a “rough” but even surface to assist in runoff control and seed retention and germination and be sown with stabilising species as soon as possible after placement. Where stockpile construction is conducted in stages, the stockpiles should be progressively stabilised.

10 LAND CAPABILITY

10.1 Methodology

Houghton and Charman [1986] in their “Glossary of Terms Used in Soil Conservation” define land capability as follows.

“The ability of land to accept a type and intensity of use permanently, or for specified periods under specific management, without permanent damage.”

They further note that land capability is “...an expression of the effect of biophysical land resources, including climate, on the ability of land to sustain use without damage under various uses such as crop production requiring regular tillage, grazing, woodland or wildlife. Land capability involves consideration of:

- the various land resources;
- the production to be obtained from the land;
- the activities or inputs required to achieve that production;
- the risks of damage to the land, on-site or off-site, resulting from those activities; and
- the inter-relations of the above.”

Houghton and Charman note that land capability is taken into account in determining land suitability – another form of land classification relating to use for various purposes.

Land that is used beyond its capability ultimately loses its productive capacity as a consequence of exhaustion of soil nutrient supplies or the development of various forms of land degradation.

The land capability classification system used in New South Wales has been described by Emery [undated] and is a modification of the system devised and used by the former USDA Soil Conservation Service in the United States of America.

Emery's paper [in its Table 1] contains details of the Land Capability legend used on land capability maps prepared by the former Soil Conservation Service of New South Wales [now part of DNR].

This shows the hierarchical classification used in the eight class system based on the management and protection needs of different types of land ranging from land needing no special soil conservation works or practices [Class I] through to land that is unsuitable for agricultural or pastoral production [Class VIII].

Emery's table also shows two other land capability classes – Mining and Urban land use – and also deals with class subscripts used to further subdivide some capability classes. The information presented by Emery is contained in **Appendix 3**.

10.2 Land Capability and Agricultural Land Suitability Classification of the Study Area

It should be noted that both the former NSW Soil Conservation Service [DNR] Land Capability mapping and the Agricultural Land Suitability mapping of NSW Department of Primary Industries [Agriculture] were carried out at a very different scale to that of the present study and in most cases the assessments were subjected to only limited field checking.

As a consequence, there are often differing assessments that result from more detailed examination of relatively small study areas.

An explanation of the Agricultural Land Suitability Classification can be found in Cunningham et al [undated] and Hulme et al [2002].

10.2.1 Land Capability as Mapped by DNR

The 1: 100 000 scale Land Capability map of the Peak Hill map sheet area prepared by the former Soil Conservation Service of NSW shows the Study Area to comprise mainly **Class III** with some **Class IV** land.

Class III lands are those *suited to regular cultivation provided it is suitably protected by soil conservation measures and practices* [It should be noted that soil conservation bank and waterway systems have been installed on much of this land].

Class IV lands are those not capable of being regularly cultivated but suitable for grazing with occasional cultivation; and requiring soil conservation practices such as pasture improvement, application of fertilizer and minimal cultivation for the establishment or re-establishment of permanent pasture.

10.2.2 Current Assessment

After a stereoscopic interpretation of airphotos of the site and field assessments during the vegetation and soil survey, it is evident that:

- the DNR mapped **Class III** lands are a mix of **Class III** and **Class VI** lands - the **Class VI** lands are those with shallow soils and rock outcrop; and
- the DNR mapped **Class IV** lands are more realistically **Class III** lands and their current land use reflects this assessment.

Class VI land is 'land not capable of being cultivated but suitable for grazing with use of soil conservation practices including limitation of grazing, broadcasting of seed and fertiliser, prevention of fire, destruction of vermin and structural soil conservation works'

In all cases the **Class III** lands appear to have a potential salinity problem although with proper agricultural land management this may never cause problems.

The land capability classes for the Study Area, as mapped in the present study, are shown in **Figure 5**.

10.3 Agricultural Land Suitability Classification

10.3.1 NSW Department of Primary Industries [Agriculture] Assessment

Information supplied by NSW Department of Primary Industries [Agriculture] at Dubbo [Mary Kovac, pers.comm.] indicates that the Department has classified the lands of the Study Area using its agricultural land suitability system.

The maps showing the Study Area indicate that the lands are mainly **Class 3** and **Class 4** land.

The **Class 4** land is located on the more elevated areas associated with the current Project Site and the Limestone National Forest while the **Class 3** land covers the remainder of the Study Area.



The NSW Department of Primary Industries [Agriculture] Land Suitability classification defines these land classes as follows:

- **Class 3** lands are grazing lands or those well suited to pasture improvement. These lands have a moderate productivity and may be cultivated or cropped in rotation with pasture although soil and environmental constraints [eg. erosion hazard and soil structure breakdown] limit productivity; and
- **Class 4** lands are suited suitable for grazing [using native pastures or possibly for pasture improvement with minimum tillage] but not for cultivation. These lands have a low overall productivity although production may be high in some seasons.

10.3.2 Current Assessment

A more detailed study of the Study Area indicates that the **Class 3** lands shown in the NSW Department of Primary Industries [Agriculture] mapping is probably correct in a general sense although the actual boundary between the **Class 3** and **Class 4** lands is difficult to accurately pinpoint because of the map scale.

The **Class 4** lands generally equate to the area occupied by SMU 1 [this study] and the **Class 3** lands are generally those associated with SMU 2. The high levels of soil salinity associated with SMU 2 add some limitations to the potential of the identified **Class 3** lands but overall this classification is most appropriate.

The agricultural land suitability classes for the Study Area as mapped in the present study are shown in **Figure 6**.

10.4 Land Capability and Agricultural Land Suitability of the Final Landform

The conceptual final landform and land use for the Project Site is shown in Figure C10 of the Environmental Assessment.

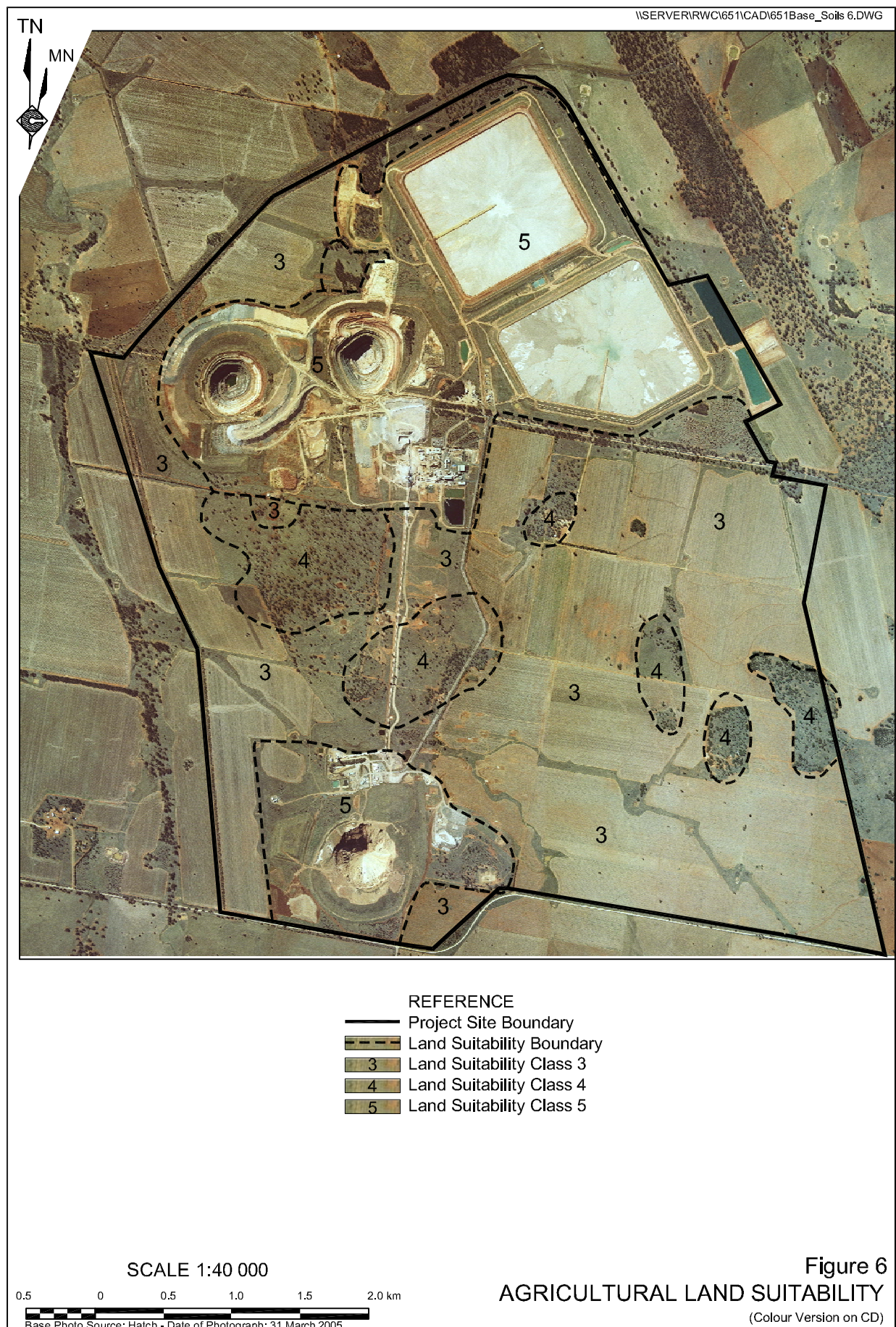
10.4.1 Land Capability

The areas designated 'Restricted Use' and Dam / Water Storage' would be designated Class VIII –land incapable of sustaining any agricultural use.

The areas designated 'Pasture with Scattered Native Vegetation' would be designated Class VI land with severe restrictions placed on grazing rates and times.

The areas designated 'Native Vegetation' would be designated Class VII land – land best protected by green timber.

The areas designated 'Farming' would remain a mixture of Class III and Class VI land.



10.4.2 Agricultural Land Suitability

The areas designated 'Restricted Use', 'Native Vegetation' and Dam / Water Storage' would be designated Class 5 –land unsuitable for agriculture or at best suited to light grazing – grazing should not occur on these lands.

The areas designated 'Pasture with Scattered Native Vegetation' would be designated Class 5 land with severe restrictions placed on grazing rates and times.

The areas designated 'Farming' would remain a mixture of Class 3 and Class 4 land.

11 CONTAMINATED LAND

The Study Area did not include any areas of known contaminated land.

12 COVERAGE OF DIRECTOR-GENERAL'S REQUIREMENTS

A number of issues listed in the Director-General's Requirements and in the list of issues raised at the Planning Focus Meeting relate to the soils of the Project Site.

The sections of this soils and land capability assessment where each issue is addressed are listed in **Table 8**.

Table 8
Coverage of Environmental Assessment Requirements and Environmental Issues in the
Soils Survey and Land Capability Report

Page 1 of 2

ENVIRONMENTAL REQUIREMENTS RAISED BY THE DIRECTOR-GENERAL RELATING TO SOILS (10.02.06)		
		Relevant Section(s)
References <ul style="list-style-type: none"> <i>Managing Urban Stormwater: Soils & Construction</i> (Landcom) 		
ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING TO SOILS		
Government Agency	Paraphrased Requirement	Relevant Section(s)
DEC(EPA) (10.02.05)	Outline soil contamination treatment and prevention systems.	
	Provide details of spoil disposal with particular attention to: <ul style="list-style-type: none"> (a) the quantity of spoil material likely to be generated; (b) proposed strategies for the handling, stockpiling, reuse/recycling and disposal of spoil; (c) the need to maximise reuse of spoil material in the construction industry; (d) identification of the history of spoil material and whether there is any likelihood of contaminated material, and if so, measures for the management of any contaminated material; and (e) designation of transportation routes for transport of spoil. 	EA (C5) [b] Sections 7 & 8 EA (C5)

Table 8 (Cont'd)
Coverage of Environmental Assessment Requirements and Environmental Issues in the
Soils Survey and Land Capability Report

Page 2 of 2

ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING TO SOILS		
Government Agency	Paraphrased Requirement	Relevant Section(s)
	Identify impacts associated with the disturbance of acid sulfate soils and potential acid sulfate soils.	Section 5.2.3
	Provide details of site history, for example if the site was previously a landfill site or if irrigation of effluent has occurred.	No previous landfill or effluent irrigation activities have been identified.
	Provide details describing the existing soil types and properties and soil contamination.	Whole report
	Identify likely impacts resulting from the construction or operation of the proposal, including: (a) disturbing any existing contaminated soil; (b) contamination of soil by operation of the activity; (c) subsidence or instability; (d) soil erosion; and (e) disturbing acid sulfate or potential acid sulfate soils.	[d] Section 8.2.2 [e] Section 5.2.3
	Refer to <i>Contaminated Sites – Guidelines for Consultants Reporting on Contaminated Sites</i> (EPA, 1997); <i>Contaminated Sites – Guidelines on Significant Risk of Harm and Duty to Report</i> (EPA, 1999).	Section 10
	Describe and assess the effectiveness or adequacy of any soil management and mitigation measures during construction and operation of the proposal.	Sections 7 & 8

13 CONCLUSION

Soils in the Study Area have been described and two Soil Mapping Units have been identified.

The physical and chemical attributes of the soils of the study area have been quantified through a combination of field assessment and laboratory testing and indicate the following.

- The soils are currently relatively stable but have a generally low to moderate erodibility rating as determined using the laboratory data obtained from samples from the study area in the SOILOSS computer model.
- In reality, however, the soils may have a higher degree of erodibility given the dispersibility values obtained from the laboratory analyses.
- The fact that much of the cultivated land within the Study Area is protected by soil conservation works, conservation tillage practices, stubble retention and an absence of livestock grazing contributes to a large degree to the absence of visible signs of erosion.
- The soils have a generally high structure grade and so can be stripped and respread using scrapers.
- For both SMU 1 and SMU 2, the topsoil material [to 12cm depth] and the subsoil [to about 70cm total depth below the original soil surface] is favourable for use in rehabilitating the disturbed landscape.
- This material can be striped as a single entity and material from the two SMUs does not need to be stockpiled separately.
- It is likely from the test pits that the soil depth within SMU 1 is probably not much greater than the 70cm recommended total stripping depth.
- The remaining soil material from SMU 2 [below 70cm depth] should remain in situ because of the likelihood of encountering saline material below this depth from the surface.
- If, for some reason material from >70cm depth has to be removed, it should be mixed with overburden to dilute the salinity impacts that would make storage difficult and cause problems when it is used in rehabilitation.
- All soils would be subject to structural degradation if worked when too moist.

Depth of stripping recommendations have been provided along with advice on stabilising the soil stockpiles in the period between stripping and respreading.

The pre-mining land capability and agricultural land suitability of the Study Area has been determined as has that of the post-mining landform.

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APPENDIX 1

Soil Profile Descriptions From Required Backhoe Test Pits – Field Descriptions

(No. of pages excluding this page = 33)

(Available on CD only)

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Profile 1 [SMU 1] - Crest location; surface condition firm; surface stone absent

0-14cm; sandy clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5; some angular gravel, <1cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; firm consistency dry; hydrophobic; *abrupt to:-*

14-41cm; sandy light clay; many roots present; no lime present; no gypsum present; some manganese stains present; pH 6.0; much rounded gravel, to 4cm; not mottled; reddish brown [5YR4/4] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistency dry; not hydrophobic; *gradual to:-*

41-82cm; light to medium clay; few roots present; no lime present; no gypsum present; manganese concretions present; pH 6.0; pockets of gravel and weathering rock; not mottled; not bleached; strong brown [7.5YR4/6] dry, strong brown [7.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic; *diffuse to:-*

82-102cm; not sampled; few roots present; weathering rock

Profile 2 [SMU 2] - Depression location; surface condition self-mulching/cracked some rounded surface stone, 3-4cm present

0-18cm; medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/3] dry, dark brown [7.5YR3/2] moist; peds rough- smooth faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

18-48cm; medium to heavy clay; few roots; no lime present; no gypsum present; no manganese present; pH 8.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong to very strong consistency dry; not hydrophobic; *gradual to:-*

48-150cm; medium clay; few roots; lime nodules present from 94cm depth; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

150-170cm; heavy clay; few roots; no lime present; much gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

170-230cm; medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR4/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

230-250cm; medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR4/6] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic

Profile 3 [SMU 1] - Crest location; surface condition hard setting; angular surface stone to 20cm present

0-15cm; sandy clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; some angular and flat gravel to 10cm; not mottled; not bleached; strong brown [7.5YR4/6] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistency dry; hydrophobic; *gradual to:-*

15-76cm; medium clay; many roots to 40cm few from there on; no lime present; no gypsum present; some manganese concretions present; pH 6.0; mainly angular and flat stone to 30cm; not mottled; not bleached; red [2.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; very strong consistency dry; not hydrophobic

Profile 4 [SMU 2] – Drainage flat location; surface condition self-mulching/cracked; some rounded surface gravel to 2cm present

0-18cm; light to medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.5; small rounded gravel to <1cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

18-44cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough-smooth faced, highly pedal [100%], polyhedral 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

44-93cm; medium clay; few roots present; lime nodules abundant; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

93-180cm; medium to heavy clay; no roots observed; no lime present; gypsum present at 120-150cm; manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

180-245cm; medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 8.0; no gravel or stones observed; mottled; not bleached; 80% brown [7.5YR5/3] 20% yellowish red [5YR5/6] dry, 80% brown [7.5YR5/4] 20% red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic

Profile 5 [SMU 2] - Mid slope location; surface condition self-mulching/cracked; surface stone absent

0-14cm; light to medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

14-61cm; medium clay; few roots; lime nodules present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

61-185cm; medium clay; no roots observed; lime nodules present; gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral/platy, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

185-245cm; medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; red [2.5YR5/6] dry, red [2.5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic

Profile 6 [SMU 2] - Drainage flat location; surface condition self-mulching/cracked; surface stone absent

0-17cm; medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/2] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

17-60cm; medium clay; few roots; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/2] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

60-110cm; medium clay; few roots; lime stains present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, brown [7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

110-190cm; medium to heavy clay; no roots observed; no lime present; 30cm wide band of gypsum from 112cm; no manganese present; pH 8.0; no gravel or stones observed; mottled; not bleached; 50% light brownish grey [10YR6/3] 50% reddish brown [5YR5/3] dry, 50% light brownish grey [10YR6/3] 50% reddish brown [5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral/platy, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

190-260cm; heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; mottled; not bleached; 95% reddish brown [5YR5/4] 5% light brownish grey [10YR6/2] dry, 95% reddish brown [5YR5/4] 5% light brownish grey [10YR6/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic

Profile 7 [SMU 2] - Drainage flat location; surface condition self-mulching/cracked; occasional rounded gravel to 2cm on surface

0-13cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; some small rounded and angular gravel, to 1cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

13-44cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; dark reddish brown [5YR3/2] dry, dark reddish brown [5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

44-102cm; heavy clay; few roots present; lime nodules present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-50mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

102-165cm; heavy clay; no roots observed; no lime present; much gypsum present; manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

165-250cm; medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; mottled; not bleached; 60% reddish brown [5YR5/4] 40% brown [7.5YR5/3] dry, 60% reddish brown [5YR5/4] 40% brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic

Profile 8 [SMU 2] - Level plain location; surface condition self-mulching/cracked; some rounded and angular surface gravel to 1cm present

0-18cm; light clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

18-82cm; medium to heavy clay; few roots present; lime stains and concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

82-190cm; medium to heavy clay; no roots observed; no lime present; much gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/5] dry, reddish brown [5YR5/4] moist; peds smooth-faced, highly pedal [100%], polyhedral/platy, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

190-250cm; medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; mottled; not bleached; 60% light brownish grey[2.5Y6/2] 40% red [2.5YR5/6] dry, 60% light brownish grey[2.5Y6/2] 40% red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral., <5-10mm in size; very strong consistency dry; not hydrophobic

Profile 9 [SMU 2] - Level plain location; surface condition self-mulching/cracked; some angular surface gravel present, 1-2cm

0-14cm; medium clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/3] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral/platy, 5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

14-63cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; dark reddish brown [5YR3/3] dry, reddish brown [5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

63-118cm; heavy clay; no roots present; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

118-165cm; gritty medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; mottled; not bleached; 50% pale yellow [2.5Y8/3] 50% reddish yellow [5YR6/6] dry, 50% pale yellow [2.5Y7/4] 50% yellowish red [5YR5/6] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

165-220cm; gritty light to medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 5.5; no gravel or stones observed; mottled; not bleached; 90% pale yellow [2.5Y8/3] 10% reddish yellow [7.5YR7/6] dry, 90% strong brown [7.5YR5/6] 10% yellowish red [5YR5/6] moist; fabric rough, massive; not hydrophobic; *diffuse to:-*

220-250cm; gritty sandy clay; no roots present; no lime present; no gypsum present; no manganese present; pH 5.0; some cubic gravel to 8cm; mottled; not bleached; 70% pale yellow [2.5Y8/3] 30% yellowish red [7.5YR5/6] dry, 70% light yellowish brown [2.5Y6/4] 30% yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic

Profile 10 [SMU 2] - Mid to upper slope location; surface condition self-mulching/cracked; some rounded surface gravel 1-2cm present

0-20cm; light to medium clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached, brown [10YR5/3] dry, very dark greyish brown [10YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

20-69cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; brown [10YR5/3] dry, very dark greyish brown [10YR3/2] moist; peds rough- / smooth-faced; highly pedal [100%], polyhedral, 10-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

69-134cm; medium to heavy clay; few roots present; scattered lime stains present; some gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds smooth- faced, highly pedal [100%], polyhedral/platy, 5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

134-180cm; heavy clay; few roots present; no lime present; no gypsum present; some manganese nodules present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish yellow [5YR6/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

180-260cm; heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; mottled; not bleached; 80% reddish brown [5YR5/4] 20% greyish brown [10YR5/2] dry, 80% reddish brown [5YR5/4] 20% greyish brown [10YR5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; very strong consistency dry; not hydrophobic

Profile 11 [SMU 2] - Upper slope location; surface condition self-mulching/cracked; some rounded and angular surface gravel, 1-2cm

0-14cm; medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 5.5; no gravel or stones observed; not mottled; not bleached; brown [10YR5/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

14-70cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- smooth faced, highly pedal [100%], polyhedral, 5-20mm in size; firm consistency dry; not hydrophobic; *gradual to:-*

70-130cm; medium clay; few roots present; some lime stains and concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

130-250cm; medium clay; no roots observed; no lime present; scattered gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, yellowish red [5YR5/6] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic

Profile 12 [SMU 2] - Crest location; surface condition cracked; some surface gravel present 1-2cm some to 5cm rounded and angular

0-17cm; silty clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; weak consistency dry; hydrophobic; *abrupt to:-*

17-40cm; medium to heavy clay; roots common; no lime present; no gypsum present; no manganese present; pH 7.5; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; firm consistency dry; not hydrophobic; *gradual to:-*

40-77cm; heavy clay; few roots present; some lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistency dry; not hydrophobic; *diffuse to:-*

77-108cm; medium to heavy clay; few roots present; many lime concretions present; some gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

108-150cm; heavy clay; few roots present; no lime present; some gypsum present; manganese stains present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

150-250cm; heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic

Profile 13 [SMU 2] - Level plain location; surface condition loose to firm; surface stone absent

0-12cm; loam; roots common; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

12-60cm; medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very strong consistency dry; hydrophobic; *gradual to:-*

60-100cm; medium clay; few roots present; scattered lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached yellowish red [5YR4/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

100-160cm; medium to heavy clay; few roots present; no lime present; no gypsum present; manganese stains present; pH 9.0; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR4/6] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

160-230cm; gritty medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 5.0-5.5; no gravel or stones observed; mottled; not bleached; 90% red [2.5YR5/6] 10% light brown [7.5YR6/4] dry, 90% red [2.5YR5/6] 10% strong brown [7.5YR4/6] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic

Profile 14 [SMU 2] - Level plain location; surface condition self-mulching/cracked; surface stone absent

0-22cm; light to medium clay; few roots present; no lime present; no gypsum present; no manganese present; pH 5.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/3] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

22-36cm; medium clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, reddish brown [5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

36-100cm; medium to heavy clay; few roots present; scattered lime concretions present; no gypsum present; no manganese present; pH 8.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

100-150cm; medium to heavy clay; no roots observed; no lime present; some gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR5/6] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic

Profile 15 [SMU 2] - Level plain location; surface condition firm/cracked; surface gravel present 1-2cm rounded

0-14cm; light clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

14-102cm; heavy clay; few roots present; no lime present; no gypsum present; some manganese stains and concretions present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; dark reddish brown [2.5YR3/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

102-170cm; medium to heavy clay; few roots present; some lime staining present; no gypsum present; some very small manganese concretions present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

170-250; medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 5.5; no gravel or stones observed; mottled; not bleached; 90% red [2.5YR5/6] 10% brown [7.5YR5/3] dry, 90% red [2.5YR5/6] 10% brown [7.5YR5/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; very strong consistency dry; not hydrophobic

Profile 16 [SMU 2] - Crest location; surface condition loose / occasionally cracked; some angular surface gravel 1-3cm present

0-16cm; light to medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/3] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

16-39cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 8.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, reddish brown [5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm size; very strong consistency dry; not hydrophobic;
gradual to:-

39-99cm; light to medium clay; few roots present; some lime stains and concretions present; some gypsum present; small manganese concretions present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

99-270cm; heavy clay; no roots observed; no lime present; some gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; very firm consistency dry; not hydrophobic

Profile 17 [SMU 2] - Crest/level plain location; surface condition self-mulching/cracked rounded surface stone to 25cm present, occasional large stones

0-14cm; silty clay to light clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

14-44cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced; highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

44-94cm; heavy clay; few roots present; scattered lime concretions and stains present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced; highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

94-194cm; medium to heavy clay; no roots observed; no lime present; some gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

194-260cm; light to medium clay; no roots observed; no lime present; no gypsum present; some manganese stains and concretions present; pH 7.0; no gravel or stones observed; mottled; not bleached; 95% yellowish red [5YR5/6] 5% light reddish brown [5YR6/3] dry, 95% yellowish red [5YR5/6] 5% pinkish grey [7.5YR6/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic

Profile 18 [SMU 2] - Level plain location; surface condition firm; surface stone absent

0-31cm; silty clay to light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced; highly pedal [100%], polyhedral, <5-20mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

31-117cm; heavy clay; roots common; lime stains present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

117-220cm; heavy clay; few roots present; no lime present; occasional small gypsum accumulations present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistency dry; not hydrophobic; *diffuse to:-*

220-250cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; mottled; not bleached; 50% reddish brown [5YR5/4] 50% pinkish grey [7.5YR7/2] dry, 50% reddish brown [5YR5/4] 50% pinkish grey [7.5YR7/2] moist; peds smooth-faced, highly pedal [100%], polyhedral/platy, <5-15mm in size; strong consistency dry; not hydrophobic

Profile 19 [SMU 2] - Level plain location; surface condition firm to self-mulching and cracked; surface gravel and stone present 4-10cm angular and rounded

0-14cm; silty clay to light clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.5-7.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

14-72cm; heavy clay; few roots present; some lime concretions present; no gypsum present; no manganese present; pH 9.5-10; occasional gravel, rounded, to 1cm; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

72-140cm; medium to heavy clay; no roots observed; some lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR5/4] dry, reddish brown [2.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

140-190cm; medium clay; no roots observed; large concretions of lime to 10cm present; no gypsum present; no manganese present; pH 9.5-10; layer of angular stones to 30cm; not mottled; not bleached; reddish brown [2.5YR5/4] dry, reddish brown [2.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

190-250cm; gritty medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.5-10; some rounded gravel to 3cm; mottled; not bleached; 80% light brown [7.5YR6/4] 15% very pale brown [10YR8/3] 5% yellowish red [5YR5/6] dry, 80% yellowish red [5YR5/6] 15% light yellowish brown [10YR6/4] reddish brown [5YR4/4] moist; fabric rough, massive; not hydrophobic

Profile 20 [SMU 2] - Level plain location; surface condition self-mulching/cracked; surface stone absent

0-14cm; silty clay; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5-6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

14-54cm; medium to heavy clay; few roots present; some lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

54-97cm; medium clay; few roots present; many lime stains and concretions present; some gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR4/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

97-200cm; medium clay; no roots observed; no lime present; much gypsum present; no manganese present; pH 6.0; no gravel or stones observed; mottled; not bleached; 90% reddish brown [5YR5/4] 10% light grey [10YR7/1] dry, 90% reddish brown [5YR5/4] 10% grey [10YR6/1] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistency dry; not hydrophobic; *gradual to:-*

200-260cm; medium clay; no roots observed; no lime present; some gypsum present; no manganese present; pH 5.0; no gravel or stones observed; mottled; not bleached; 90% reddish brown [5YR5/4] 10% light grey [10YR7/1] dry, 90% yellowish red [5YR5/6] 10% grey [10YR6/1] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic;

Profile 21 [SMU 1] - Low ridge location; surface condition firm; some surface stone angular 10-15-20cm present

0-12cm; sandy clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; much angular and flattish gravel to 15cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; weak consistency dry; hydrophobic; *abrupt to:-*

12-30cm; light to medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; some angular gravel to 3cm; not mottled; not bleached; yellowish red [5YR5/6] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

30-81cm; medium clay; roots common; no lime present; no gypsum present; manganese stains present; pH 7.0; some angular gravel to 1.5cm; not mottled; not bleached; yellowish red [5YR4/6] dry, dusky red [10R3/4] moist; fabric rough /smooth, massive; not hydrophobic

Profile 22 [SMU 2] - Crest location; surface condition self-mulching/cracked; some rounded surface gravel 1-2cm present

0-10cm; silty clay; roots common; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/3] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

10-52cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown 5YR4/3 dry, reddish brown 5YR4/3 moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

52-116cm; heavy clay; few roots present; some lime stains and concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR5/4] dry, reddish brown [2.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral / platy, <5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

16-235cm; medium to heavy clay; few roots present; no lime present; some gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

235-260cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 8.5-9; no gravel or stones observed; mottled; not bleached; 95% red [2.5YR5/6] 5% reddish brown [5YR5/3] dry, 95% red [2.5YR5/6] 5% reddish brown [5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic

Profile 23 [SMU 2] - Mid slope location; surface condition hard setting; surface stone common 1-5-8cm angular

0-15cm; silty clay to light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 4.5; some angular gravel 2-5cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

15-30cm; light clay; few roots present; no lime present; no gypsum present; no manganese present; pH 5.0; some angular gravel to 3cm; not mottled; not bleached; reddish brown [2.5YR4/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm to strong consistency dry; not hydrophobic; *abrupt to:-*

30-50cm; light to medium clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.0; gritty layer; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

50-150cm; gritty heavy clay; few roots present; no lime present; no gypsum present; manganese stains present; pH 7.0; much angular gravel to 5cm; not mottled; not bleached; yellowish brown [10YR5/4] dry, strong brown [10YR4/4] moist; fabric rough, massive not hydrophobic; *diffuse to:-*

150-200cm; sandy clay; no roots observed; no lime present; no gypsum present; much manganese staining present; pH 7.0; grit layer with much gravel to 5cm; not mottled; not bleached; yellowish brown [10YR5/4] dry, strong brown [10YR4/4] moist; fabric rough, massive; not hydrophobic

Profile 24 [SMU 2] - Flat to mid slope location; surface condition firm/cracked; surface stone absent

0-13cm; silty clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral 5-15mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

13-40cm; light clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [2.5YR3/3] moist; peds rough- /smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

40-79cm; medium clay; few roots present; some lime stains and concretions present; no gypsum present; no manganese present; pH 8.5; no gravel or stones observed; not mottled; not bleached reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

79-250cm; light to medium clay; few roots present; no lime present; some gypsum present towards the bottom of the layer; no manganese present; pH 8.5; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- /smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic

Profile 25 [SMU 2] - Flat location; surface condition firm/cracked; surface stone absent

0-18cm; silty clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/3] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

18-60cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; dark reddish brown [5YR3/3] dry; dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

60-96cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry; reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

96-148cm; medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 8.0; no gravel or stones observed; mottled; not bleached; 50% reddish brown [5YR5/4], 50% pinkish grey [7.5YR6/2] dry, 50% reddish brown [5YR5/4] 50% greyish brown [10YR5/2] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

48-178cm; medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 5.5; much weathered rock with stones; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; fabric rough /smooth; massive; not hydrophobic; *gradual to:-*

178-250cm; gritty medium clay; no roots present; no lime present; no gypsum present; no manganese present; pH 5.0; mainly weathered rock; not mottled; not bleached; light brown [7.5YR6/4] dry, brown [7.5YR5/4] moist; fabric rough / smooth, massive; not hydrophobic

Profile 26 [SMU 2] - Level plain location; surface condition self-mulching/cracked; some rounded surface gravel to 4cm

0-24cm; silty clay to light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/4] dry, dark reddish brown [5YR3/2] moist; peds rough- /smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

24-118cm; heavy clay; roots common; many lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- /smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

118-250cm; heavy clay; no roots observed; some lime present; scattered gypsum present; some manganese concretions present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR4/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic; *diffuse to:-*

250-270cm; medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; mottled; not bleached; 20% very pale brown [10YR7/3] 80% light reddish brown [5YR6/4] dry, 20% yellowish brown [10YR5/4] 80% light reddish brown [5YR6/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistency dry; not hydrophobic

Profile 27 [SMU 2] - Mid slope location; surface condition loose; angular surface stone 1-20cm common

0-31cm; light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5; occasional angular gravel to 2cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

31-50cm; medium clay; few roots present; no lime present; no gypsum present; manganese stains present; pH 7.0; much angular gravel 2-4cm; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR4/6] moist; fabric rough, massive; not hydrophobic; *gradual to:-*

50-103cm; heavy clay; few roots present; no lime present; no gypsum present; manganese stains present; pH 7.0; gritty layer with angular stones to 4cm; not mottled; not bleached; light olive brown [2.5Y5/3] dry, olive brown [2.5Y4/3] moist; fabric rough, massive not hydrophobic; *diffuse to:-*

103-150cm; Weathered rock, not sampled; no roots observed

Profile 28 [SMU 2] - Mid slope location; surface condition loose; some surface stone to 4cm angular

0-17cm; light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5; occasional rounded gravel to 1cm; not mottled; not bleached; yellowish red [5YR5/6] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

17-57cm; medium clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; dusky red [10R3/4] dry, dusky red [10R3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

57-98cm; medium to heavy clay; few roots present; lime stains present; no gypsum present; no manganese present; pH 9.5-10; much rounded gravel <1cm; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

98-250cm; gritty medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.0; mainly stones - increasing in size through the layer, weathering rock; not mottled; not bleached; red [2.5YR4/8] dry, red [2.5YR4/8] moist; peds rough-/ smooth-faced, massive; not hydrophobic

Profile 29 [SMU 2] - Level plain location; surface condition firm/cracked; some rounded surface gravel, 1-2cm

0-23cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5-6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/3] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral/platy, <5-15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

23-64cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/2] dry, dark greyish brown [10YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

64-141cm; medium clay; few roots present; some lime stains present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

141-185cm; medium clay; no roots observed; no lime present; scattered gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

185-250cm; heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 8.5-8.5; no gravel or stones observed; not mottled; not bleached; light yellowish brown [10YR6/4] dry, light yellowish brown [10YR6/4] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic

Profile 30 [SMU 2] - Lower slope location; surface condition firm to hardsetting; some rounded surface gravel to 2cm

0-25cm; silty clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

25-53cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-10mm in size; very firm consistency dry; not hydrophobic; *gradual to:-*

53-95cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; mottled; not bleached; 95% reddish brown [2.5YR4/4]; 5% pink [7.5YR7/4] dry, 95% red [2.5YR4/6] 5% reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

95-150cm; medium to heavy clay; few roots present; some lime stains and concretions present; some gypsum present; some manganese stains and concretions present; pH 9.0; occasional flat and angular gravel to 3cm; not mottled; not bleached; yellowish red [5YR4/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic; *diffuse to:-*

150-220cm; heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; mottled; not bleached; 70% reddish brown [2.5YR4/4] 30% pink [7.5YR8/3] dry, 70% reddish brown [2.5YR4/4] 30% light brown [7.5YR6/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; <5-10mm in size; very firm consistency dry; not hydrophobic; *diffuse to:-*

220-260cm; heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.0; much angular gravel <5mm; mottled; not bleached; 50% red [10R4/6] 50% very pale brown [10YR7/4] dry, 50% red [10R4/6] 50% reddish yellow [7.5YR6/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral/platy, <5-10mm in size; strong consistency dry; not hydrophobic

Profile 31 [SMU 2] - Level plain location; surface condition loose; self-mulching/cracked; some angular surface gravel 1-2cm present

0-26cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral/platy, <5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

26-49cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; dark reddish brown [2.5YR3/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; <5-10mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

49-86cm; medium to heavy clay; few roots present; no lime present; no gypsum present no manganese present; pH 9.5; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

86-170cm; heavy clay; few roots present; scattered lime concretions present; some gypsum present; no manganese present; pH 9.5; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

170-250cm; medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR4/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic

Profile 32 [SMU 1] - Crest location; surface condition hard setting; surface gravel 2-10cm common

0-26cm; clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5; some angular gravel to 2cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; hydrophobic; *diffuse to:-*

26-62cm; weathered rock; not sampled; few roots present

Profile 33 [SMU 1] - Mid slope location; surface condition firm/handsetting; angular surface gravel 1-5cm, common

0-36cm; clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 5.0; some angular gravel to 4cm; not mottled; not bleached; reddish brown [2.5YR4/4] dry, dark reddish brown [2.5YR3/3] moist; peds rough- faced, highly pedal [100%], polyhedral, <5-20mm in size; firm consistency dry; hydrophobic; *abrupt to:-*

36-70cm; medium to heavy clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; some angular and rounded gravel <1cm-3cm; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

70-106cm; rock; not sampled; no roots observed

Profile 34 [SMU 2] - Low saddle location; surface condition cracked; some rounded and angular surface gravel 1-4cm present

0-18cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

18-52cm; medium to heavy clay; many roots present; lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

52-228cm; heavy clay; few roots present; some lime concretions present; some gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR4/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

228-260cm; heavy clay; no roots observed; no lime present; no gypsum present; manganese stains present; pH 7.5-8; no gravel or stones observed; not mottled; not bleached; red [2.5YR5/6] dry, red [2.5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic

Profile 35 [SMU 2] - Level plain location; surface condition firm; surface stone absent

0-29cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/3] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

29-81cm; medium to heavy clay; many roots present; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

81-235cm; heavy clay; roots common; no lime present; no gypsum present; manganese concretions present; pH 9.0; no gravel or stones observed; not mottled; not bleached; red [2.5YR5/6] dry, red [2.5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic

Profile 36 [SMU 2] - Lower slope location; surface condition firm; some surface stone rounded to 10cm present

0-14cm; silty clay; many roots present; no lime present; no gypsum present; no manganese present; pH 5.0; occasional angular gravel to 1.5cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; weak consistency dry; hydrophobic; *abrupt to:-*

14-55cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

55-142cm; heavy clay; few roots present; some lime concretions present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

142-166cm; heavy clay; few roots present; no lime present; no gypsum present; many manganese concretions present; pH 9.0; angular weathered rock to 4cm; not mottled; not bleached red [2.5YR5/6] dry, red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

166-250cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 8.0; mainly weathered rock; mottled; not bleached; 90%red [2.5YR5/6] 10% very pale brown [10YR8/3]dry, 90%red [2.5YR4/6] 10%brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic

Profile 37 [SMU 2] - Mid to lower slope location; surface condition firm; surface stone absent

0-15cm; silty clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, dusky red [2.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; weak consistency dry; not hydrophobic; *abrupt to:-*

15-43cm; medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, dusky red [10R3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

43-100cm; medium to heavy clay; few roots present; lime stains present; no gypsum present; small manganese concretions present; pH 9.0; no gravel or stones observed; not mottled; not bleached; red [2.5YR5/6] dry, red [2.5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; firm consistency dry; not hydrophobic; *diffuse to:-*

100-270cm; medium to heavy clay; few roots present; lime stains present; some gypsum present; manganese stains present; pH 9.0; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic

Profile 38 [SMU 2] - Upper slope location; surface condition firm; some surface gravel to 8cm present

0-15cm; silty clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; hydrophobic; *abrupt to:-*

15-44cm; silty clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

44-108cm; medium clay; few roots present; lime stains present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR4/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

108-190cm; gritty medium clay; few roots present; no lime present; no gypsum present; manganese stains present; pH 9.5-10; much angular weathered rock to <1cm; mottled; not bleached; 80% brown [7.5YR5/4] with 20% very pale brown [10YR8/3] weathered rock dry, 80% strong brown [7.5YR4/6] 20% very pale brown [10YR8/4] moist; fabric smooth, massive; not hydrophobic; *diffuse to:-*

190-230cm; medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.5-10; much angular weathered rock to <1cm; not mottled; not bleached; very pale brown [10YR8/4] dry, light yellowish brown [10YR6/4] moist; fabric rough / smooth, massive; not hydrophobic.

Profile 39 [SMU 1] - Crest location; surface condition firm; some rounded and angular surface gravel <1cm present

0-16cm; silty clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5; angular gravel to 4cm; not mottled; not bleached; strong brown [7.5YR4/6] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; firm consistency dry; hydrophobic; *abrupt to:-*

16-26cm; light clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.0; some angular gravel to 3cm; not mottled; not bleached; strong brown [7.5YR4/6] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic

Profile 40 [SMU 1] - Crest location; surface condition firm; rounded and angular surface gravel <1cm common

0-12cm; loam fine sandy; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; some rounded gravel to 1cm; not mottled; not bleached; reddish brown [5YR5/4] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; weak consistency dry; not hydrophobic; *abrupt to:-*

12-33cm; light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.5; gravel to 8cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

33-62cm; medium clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.0; much gravel to 8cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [2.5YR3/3] moist; fabric rough, massive; not hydrophobic

Profile 41 SMU 2] - Upper slope location; surface condition firm; surface stone absent

0-26cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistency dry; hydrophobic; *gradual to:-*

26-54cm; medium to heavy clay; few roots present; lime concretions common; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

54-192cm; heavy clay; few roots present; lime concretions present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; red [2.5YR5/6] dry, red [2.5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

192-250cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; red [2.5YR5/6] dry, red [2.5YR5/6] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic

Profile 42 [SMU 2] – Crest / upper slope location; surface condition firm; surface stone absent

0-14cm; light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; weak consistency dry; not hydrophobic; *abrupt to:-*

14-50cm; light to medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 7.0; occasional rounded gravel to 8cm; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

50-91cm; light clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.0; angular gravel to 3cm common; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR4/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

91-180cm; gritty heavy clay; few roots present; no lime present; no gypsum present; much manganese staining present; pH 9.0; much angular gravel to 5cm; not mottled; not bleached; brown [7.5YR5/4] dry, reddish brown [5YR5/4] moist; fabric rough / smooth; massive; not hydrophobic

Profile 43 [SMU 2] - Upper slope location; surface condition firm; surface stone absent

0-17cm; silty light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/3] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

17-45cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

45-90cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 8.0; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

90-145cm; heavy clay; few roots present; some lime concretions present; no gypsum present; some manganese concretions present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistency dry; not hydrophobic; *diffuse to:-*

145-195cm; heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; mottled; not bleached; 50% red [2.5YR5/6] 50% reddish brown [5YR5/4] dry, 50% red [2.5YR4/6] 50% reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistency dry; not hydrophobic; *diffuse to:-*

195-250cm; medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; mottled; not bleached; 40% white [10YR8/1] 60% red [2.5YR5/6] dry, 40% light yellowish brown [10YR6/4] 60% reddish brown [2.5YR4/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic

Profile 44 [SMU 2] - Mid slope location; surface condition firm; surface stone absent

0-17cm; light to medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; occasional angular gravel to 2cm; not mottled; not bleached; reddish brown [5YR4/3] dry, dusky red [2.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

17-64cm; heavy clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/3] dry, dark reddish brown [2.5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very firm consistency dry; not hydrophobic; *gradual to:-*

64-230cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; red [2.5YR4/6] dry, reddish brown [2.5YR4/4] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-30mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

230-260cm; medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 5.0; no gravel or stones observed; mottled; not bleached; 95% red [2.5YR4/6] 5% [coating] very pale brown [10YR8/3] dry, 95% red [2.5YR4/6] 5%[coating] brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic

Profile 45 [SMU 2] - Lower slope location; surface condition hard setting; surface stone absent

0-14cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; some gravel <1cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

14-48cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 8.0; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; very firm consistency dry; not hydrophobic; *gradual to:-*

48-100cm; heavy clay; few roots present; lime concretions present; no gypsum present; no manganese present; pH 8.5-9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

100-230cm; heavy clay; few roots present; occasional lime concretions present; no gypsum present; no manganese present; pH 8.5-9.0; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR4/6] dry, yellowish red [5YR4/6] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

230-270cm; heavy clay; no roots observed; no lime present; no gypsum present; manganese stains and concretions present; pH 6.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR5/4] dry, strong brown [7.5YR4/6] moist; peds smooth-faced, highly pedal [100%], polyhedral / platy, 5-20mm in size; strong consistency dry; not hydrophobic

Profile 46 [SMU 2] - Mid slope location; surface condition firm; surface stone absent

0-14cm; silty clay; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5; occasional rounded and angular gravel <1cm; not mottled; not bleached; brown [7.5YR5/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

14-36cm; medium to heavy clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; occasional rounded and angular gravel <1cm; not mottled; not bleached; reddish brown [5YR4/3] dry, reddish brown [2.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

36-98cm; heavy clay; many roots present; scattered lime concretions present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

98-160cm; gritty medium clay; few roots present; no lime present; no gypsum present; many manganese stains present; pH 9.0; mainly gravel angular and blocky to 4cm; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR4/6] moist; fabric rough / smooth, massive; not hydrophobic; *diffuse to:-*

160-250cm; gritty medium to heavy clay; no roots observed; no lime present; no gypsum present; manganese stains present; pH 7.0; mainly gravel angular and blocky to 4cm; mottled; not bleached; 70% reddish brown [5YR5/4] 30% very pale brown [10YR8/3] dry, 70% yellowish red [5YR5/6] 30% reddish yellow [7.5YR6/6] moist; fabric rough / smooth, massive; not hydrophobic

Profile 47 [SMU 1] - Crest location; surface condition loose to firm; much angular surface gravel 1-5cm present

0-15cm; clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5; some angular gravel to 2cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR2.5/2] moist; peds rough-faced, moderately pedal [50%], polyhedral, <5mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

15-40cm; light clay; roots common; no lime present; no gypsum present; no manganese present; pH 5.5; much angular gravel to 2cm; not mottled; not bleached; reddish brown [5YR5/4] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; firm consistency dry; not hydrophobic; *gradual to:-*

40-66cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.0; some angular and rounded gravel to 2cm; mottled; not bleached; 50% red [2.5YR5/6] 50% yellowish brown [10YR5/4] dry, 50% red [2.5YR4/6] 50% dark yellowish brown [10YR4/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

66-116cm; mainly weathered rock - not sampled; few roots present

Profile 48 [SMU 2] - Mid to lower slope location; surface condition firm; surface stone absent

0-17cm; light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.5; occasional rounded gravel 1-2cm; not mottled; not bleached; brown [7.5YR5/4] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

17-69cm; medium clay; roots common; occasional lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, reddish brown [5YR4/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

69-174cm; medium clay; few roots present; main lime zone with stains and concretions; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

174-250cm; medium clay; no roots observed; no lime present; no gypsum present; manganese stains present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish yellow [5YR6/6] dry, reddish yellow [5YR5/6] dry, peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic

Profile 49 [SMU 2] - Drainage flat / level plain location; surface condition self-mulching/cracked; some angular surface gravel 1-2cm present

0-37cm; light clay; few roots present; no lime present; no gypsum present; no manganese present; pH 6.0-6.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistency dry; not hydrophobic; *gradual to:-*

37-101cm; medium to heavy clay; few roots present; many lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

101-208cm; medium to heavy clay; few roots present; no lime present; gypsum present; manganese concretions present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

208-250cm; medium clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; mottled; not bleached; 60% pale brown [10YR6/3] 30% red [2.5YR4/6] 10% brown [7.5YR5/4] dry, 60% pale brown [10YR6/3] 30% red [2.5YR4/6] 10% brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic;

Profile 50 [SMU 2] - Mid slope location; surface condition firm; surface stone absent;

0-20cm; light to medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral; 5-15mm in size; very firm consistency dry; not hydrophobic; *abrupt to:-*

20-70cm; medium to heavy clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.5; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, red [2.5YR4/6] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

70-110cm; heavy clay; few roots present; some lime concretions present; no gypsum present no manganese present; pH 8.5; no gravel or stones observed; mottled; not bleached; 80% reddish brown [2.5YR4/4] 20% reddish brown [5YR4/3] dry, 80% reddish brown [2.5YR4/4] 20% dark reddish brown [5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

110-190cm; heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

190-250cm; gritty medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 9.0; angular gravel to 2cm, square stones to 15cm in weathering rock; mottled; not bleached; 80% red [2.5YR5/6] 20% red [2.5YR4/6] dry, 80% red [2.5YR5/6] 20% yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic

Profile 51 [SMU 2] - Mid slope location; surface condition self-mulching/cracked; surface stone absent

0-30cm; light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

30-64cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present pH 7.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-30mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

64-99cm; medium to heavy clay; roots common; some lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry; yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; very firm consistency dry; not hydrophobic; *diffuse to:-*

99-250cm; heavy clay; few roots present; no lime present; no gypsum present; some small manganese concretions present with much staining at 250cm; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic

Profile 52 [SMU 2] - Upper slope location; surface condition hard setting; surface stone absent

0-24cm; light to medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [2.5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistency dry; hydrophobic; *gradual to:-*

24-76cm; medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; red [2.5YR4/6] dry, dark red [2.5YR3/6] moist; peds smooth-faced, highly pedal [100%], polyhedral; <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

76-162cm; heavy clay; few roots present; no lime present; some small gypsum crystals present; many manganese stains present; pH 7.0; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

162-210cm; gritty medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 7.0; much angular blocky gravel to 6cm; not mottled; not bleached; light yellowish brown [10YR6/4] dry, dark yellowish brown [10YR4/4] moist; fabric rough / smooth, massive; not hydrophobic

Profile 53 [SMU 1] - Crest location; surface condition loose; occasional rounded surface stones to 10cm present

0-27cm; sandy clay loam; many roots present; no lime present; no gypsum present; no manganese present; pH 6.5; some angular gravel to 2cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; weak consistency dry; hydrophobic; *abrupt to:-*

7-45cm; light to medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.5; much gravel and stone 4-15cm; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

45-70cm; medium clay; few roots present; no lime present; no gypsum present; many manganese stains present; pH 6.5; weathering rock; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR4/4] moist; fabric rough, massive; not hydrophobic; *abrupt to:-*

70-110cm; weathered rock / bed rock - not sampled ; few roots present

Profile 54 [SMU 2] - Lower slope location; surface condition firm; surface stone absent

0-25cm; - medium to heavy clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; occasional gravel <1cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

25-76cm; medium to heavy clay; many roots present; no lime present; no gypsum present; no manganese present; pH 8.0; no gravel or stones observed; not mottled; not bleached; red [2.5YR4/6] dry, dark reddish brown [2.5YR3/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

76-180cm; heavy clay; roots common; no lime present; no gypsum present; no manganese present; pH 8.5; no gravel or stones observed; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

180-250cm; medium to heavy clay; few roots present; no lime present; no gypsum present; no manganese present; pH 9.0; much gravel; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic

Profile 55 [SMU 2] - Mid slope location; surface condition firm; occasional blocky surface gravel 3-4cm

0-25cm; light clay; any roots present; no lime present; no gypsum present; no manganese present; pH 5.0; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, dark brown [10YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

25-89cm; medium to heavy clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; dusky red [10R3/4] dry, dusky red [10R3/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

89-137cm; heavy clay; roots common; no lime present; no gypsum present; some manganese staining present; pH 7.0; no gravel or stones observed; not mottled; not bleached; weak red [10R4/4] dry, dusky red [10R3/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-30mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

137-250cm; medium clay; few roots present; no lime present; no gypsum present; no manganese present; pH 8.5-9.0; mainly sandstone stones to 15cm; not mottled; not bleached; light brown [7.5YR6/4] dry, reddish brown [5YR4/4] moist; fabric rough / smooth, massive; not hydrophobic

Profile 56 [SMU 2] - Flat to lower slope location; surface condition loose; surface stone absent

0-26cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 8.5; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

26-74cm; medium to heavy clay; many roots present; some lime concretions and stains present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

74-180cm; heavy clay; roots common; many lime concretions present; no gypsum present; no manganese present; pH 9.5-10; occasional rounded gravel to <1cm; not mottled; not bleached; yellowish red [5YR4/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

180-260cm; heavy clay; no roots observed; some lime concretions towards the top of the layer; no gypsum present; many manganese concretions present; pH 9.5-10; no gravel or stones; observed; not mottled; not bleached; yellowish red [5YR4/6] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic

Profile 57 [SMU 2] - Lower slope location; surface condition firm / cracked; surface stone absent

0-20cm; - light to medium clay; roots common; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; strong brown [7.5YR4/6] dry, dark reddish brown [2.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

20-52cm; light to medium clay; few roots present; no lime present; no gypsum present; no manganese present; pH 7.0; occasional rounded gravel to <1cm; not mottled; not bleached; yellowish red [5YR4/6] dry, weak red [10R4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

52-76cm; medium to heavy clay; few roots present; many lime concretions present; no gypsum present; many manganese concretions and stains present; pH 7.0; much stone and weathered rock; mottled; not bleached; 60% yellowish brown [10YR5/4] 40% red [2.5YR4/8] dry, 60% yellowish brown [10YR5/4] 40% red [2.5YR4/6] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

76-112cm; weathered rock; not sampled; few roots present

Profile 58 [SMU 1] - Crest location; surface condition firm; some angular surface stone to 20cm

0-18cm; loam; many roots present; no lime present; no gypsum present; no manganese present; pH 7.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; hydrophobic; *abrupt to:-*

18-53cm; light medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 7.5; much angular gravel to 1cm; not mottled; not bleached; weak red [10R4/4] dry, weak red [10R4/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

53-88cm; gritty medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 7.5; mainly rounded and angular gravel, floaters to 30cm; mottled; not bleached; 60% yellowish red [5YR5/6] 40% light brown [10YR6/3] dry, 60% yellowish red [5YR4/6] 40% brown [10YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

88-132cm; Weathered rock; not sampled; few roots present.

Profile 59 [SMU 2] - Level plain location; surface condition loose/cracked; surface stone absent

0-33cm; medium to heavy clay; many roots present; no lime present; no gypsum present; no manganese present; pH 7.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

33-115cm; heavy clay; many roots present; lime stains present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/3] dry, reddish brown [5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

115-220cm; medium to heavy clay; few roots present; lime concretions and stains present; no gypsum present; manganese stains common; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR5/4] dry, weak red [10R4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic; *gradual to:-*

220-260cm; heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 5.0; no gravel or stones observed; mottled; not bleached; 50% brown [7.5YR5/4] 50% light brownish grey [10YR6/2] dry, 50% brown [7.5YR5/4] 50% light brownish grey [10YR6/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic

Profile 60 [SMU 2] - Level plain location; surface condition soft/cracked; surface stone absent

0-18cm; light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 5.5; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/3] dry, dark reddish brown [5YR2.5/2] moist; peds rough-faced, highly pedal [100%], polyhedral/platy, <5-10mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

18-75cm; heavy clay; roots common; some lime concretions present; no gypsum present; no manganese present; pH 9.0; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

75-250cm; heavy clay; few roots present; lime concretions present becoming less through the profile; no gypsum present; manganese stains present in base of profile; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] dry, peds smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; strong consistency dry; not hydrophobic

Profile 61 [SMU 2] - Level plain location; surface condition soft/cracked; surface stone absent

0-25cm; medium to heavy clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; hydrophobic; *abrupt to:-*

25-54cm; heavy clay; roots common; some lime stains present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

54-150cm; heavy clay; few roots present; sparsely scattered lime concretions present; no gypsum present; many manganese concretions present; pH 8.5-9; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, yellowish red [5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic; *diffuse to:-*

150-250cm; gritty medium to heavy clay; no roots observed; no lime present; no gypsum present; no manganese present; pH 5.5; weathered material with flat angular stones to 15 cm; mottled; not bleached; 50% reddish brown [5YR5/4] 50% very pale brown [10YR8/3] dry, 50% reddish brown [5YR4/4] 50% very pale brown [10YR7/4] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic.

Profile 62 [SMU 2] - Level plain location; surface condition firm; surface stone absent

0-32cm; light clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; occasional rounded gravel to <1cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

32-62cm; heavy clay; roots common; some lime stains present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

62-148cm; heavy clay; few roots present; scattered lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

148-280cm; heavy clay; few roots present; no lime present; much gypsum present; some manganese concretions present; pH 7.5; no gravel or stones observed; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral/platy, 5-15mm in size; strong consistency dry; not hydrophobic;

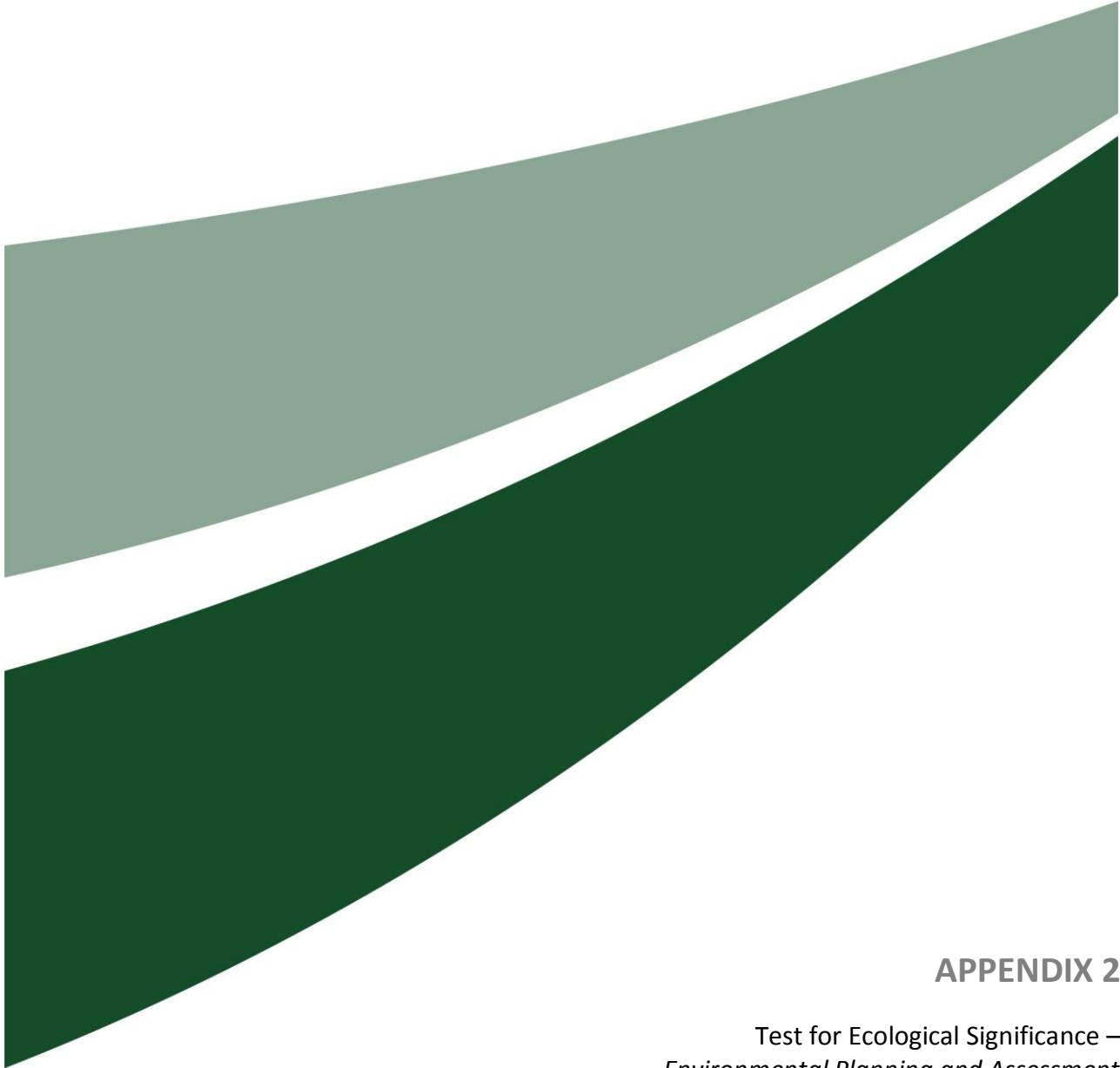
Profile 63 [SMU 2] - Level plain location; surface condition soft; surface stone absent

0-31cm; medium clay; many roots present; no lime present; no gypsum present; no manganese present; pH 6.0; no gravel or stones observed; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; firm consistency dry; hydrophobic; *abrupt to:-*

31-88cm; heavy clay; roots common; small lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR4/6] dry, red [2.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; <5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

88-142cm; medium to heavy clay; few roots present; scattered lime concretions present; no gypsum present; no manganese present; pH 9.5-10; no gravel or stones observed; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

142-250cm; gritty medium and heavy clay; few roots present; no lime present; no gypsum present; much manganese staining present; pH 9.5; mainly stones; not mottled; not bleached; very pale brown [10YR7/4] dry, light yellowish brown [10YR6/4] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistency dry; not hydrophobic.



APPENDIX 2

Test for Ecological Significance –
*Environmental Planning and Assessment
Act 1979*

Appendix 2 – Test for Ecological Significance – *Environmental Planning and Assessment Act 1979*

Part 3A of the *Environmental Protection & Assessment Act 1979* (EP&A Act) requires a test for ecological significance relating to the potential impacts of the Project on listed threatened species, Endangered Populations (EPs) or Threatened Ecological Communities (TECs). An assessment of potential impact on species, Endangered Populations (EPs) and Threatened Ecological Communities (TECs) listed under the *Threatened Species Conservation Act 1995* (TSC Act) as a result of the Project is undertaken in accordance with Section 5A of the EP&A Act.

A Test for Ecological Significance is provided below for *Diuris tricolor* as it was recorded within the Proposed Disturbance Area. The following assessment has been undertaken without any consideration of impact mitigation or offsetting opportunities or commitments.

Test for Ecological Significance under EP&A Act

Threatened Flora Species

Pine donkey orchid (*Diuris tricolor*) – Vulnerable TSC Act

- a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Pine donkey orchid (*Diuris tricolor*) was recorded within the Proposed Disturbance Area during the spring surveys in 2013. An estimated 700 individual plants were identified outside of the approved disturbance area and covered an area of approximately 0.51 hectares. Only 14 individual plants occur in the Proposed Disturbance Area (see Figure 2.4 of the main report).

A population of pine donkey orchid (*Diuris tricolor*) containing at least 234 plants was also recorded approximately 2 kilometres to the north of the Proposed Disturbance Area, occurring in an area of White Cypress Pine Woodland.

The distance between these two known occurrences is approximately 2 kilometres and it is unknown if pollination vectors would be able to travel the approximate 2 kilometre straight line distance between the known occurrences of the species. Additionally two existing tailings dams occur between the two known populations of the species and likely provide a barrier around which vectors would have to travel. The species or insect groups that pollinate *Diuris tricolor* are unknown but may be native bees or flies that could be attracted to the sweet smelling flowers.

As the pollination vectors and movement abilities of such vectors are unknown for *Diuris tricolor*, the occurrence recorded in the Proposed Disturbance Area and outside of the approved disturbance area may form a viable local population. However, only 14 plants occur within the Proposed Disturbance Area. The remaining estimated 686 plants of the potential population will not be impacted by the Project. It is unlikely that the removal of 14 plants will have an adverse effect on the life cycle of the species such that the potential population could be placed at risk of extinction.

- b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

- c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The spring 2013 surveys targeted all suitable habitat for *Diuris tricolor* within the Proposed Disturbance Area (refer to Figure 2.2 of the main report). A single potential population was recorded outside of the approved disturbance area covering approximately 0.51 hectares of land and containing at least 700 individual plants. Only 14 individual plants occur in the Proposed Disturbance Area (see Figure 2.3 of the main report).

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The spring 2013 surveys recorded the likely extent of the *Diuris tricolor* potential population. The potential population, which occurs outside of the approved disturbance area covers approximately 0.51 hectares of land and contains at least 700 individual plants extends west beyond the Proposed Disturbance Area boundary (see Figure 2.3 of the main report). A total of 14 plants will be impacted by the Project. The removal of 14 individual plants from the Proposed Disturbance Area represents a very small fraction of the potential population. The level of increase in the degree of isolation of the potential population is considered negligible. The Project is unlikely to result in an increase in the level of fragmentation of the potential population.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

All suitable habitat for *Diuris tricolor* within the Proposed Disturbance Area was surveyed in spring 2013. A single potential population of the species was identified. It is considered unlikely that the species occurring in areas of the Proposed Disturbance Area where it was not identified during spring 2013.

As the second of two potential populations of *Diuris tricolor* known in the locality, the new potential population recorded during the spring 2013 surveys is likely to be important to the long-term survival of the species in the locality. However, as 14 of the estimated 700 individual plants are being removed from the potential population by the Project, the Project is not considered to pose a threat to the long-term survival of the species in the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

The Proposed Disturbance Area is not located in proximity to any areas of declared or recommended critical habitat areas. The Project is not likely to have an adverse effect on any critical habitat.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

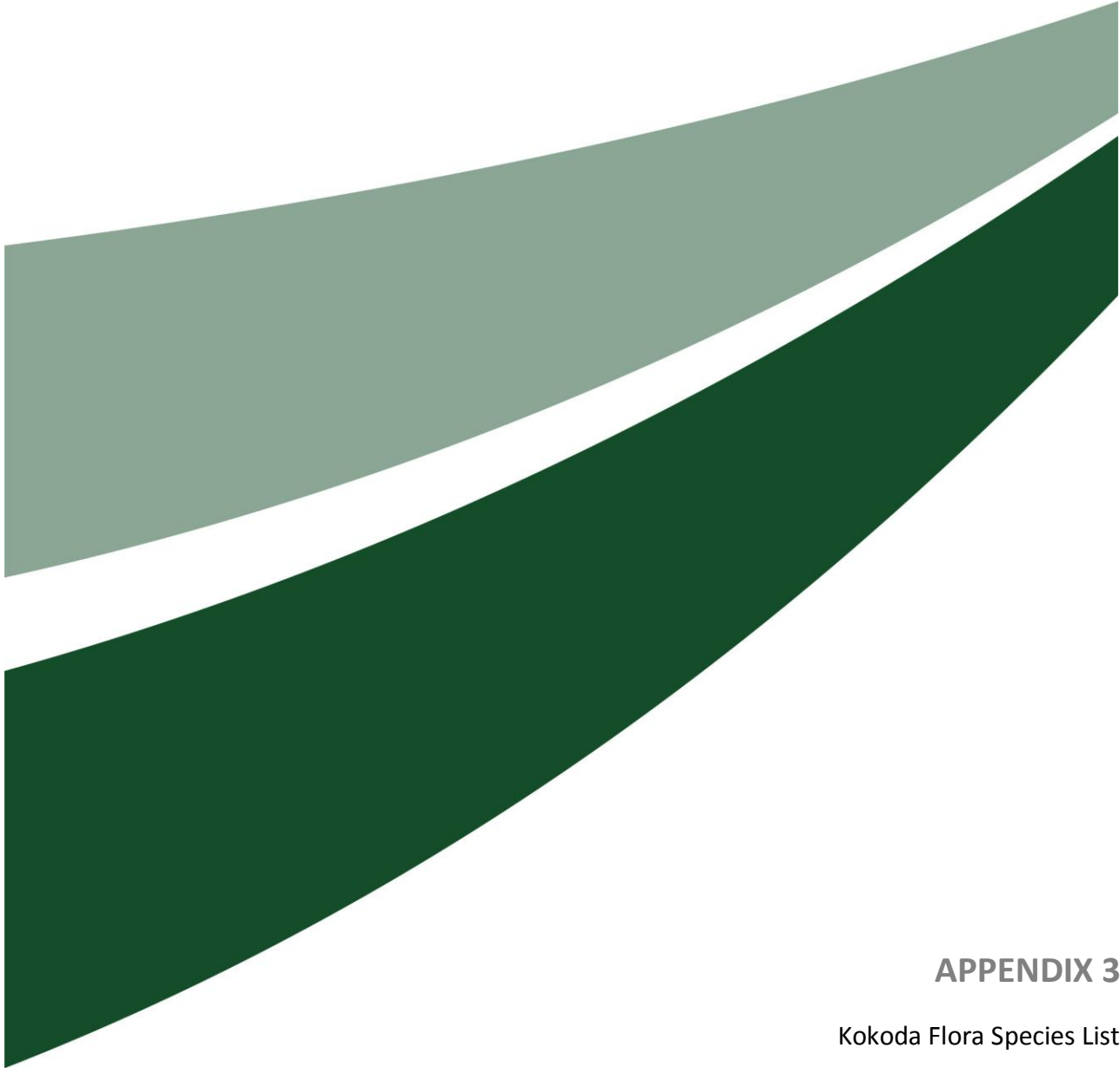
A recovery plan has not been prepared for this species. There are no threat abatement plans of relevance to the species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project would contribute to the operation of the following key threatening processes:

- Clearing of native vegetation.

Conclusion: The Project would result in the loss of 14 individual plants of the *Diuris tricolor* population in the Proposed Disturbance Area. The Project is considered unlikely to have a significant impact on *Diuris tricolor*.



APPENDIX 3

Kokoda Flora Species List

Appendix 3 – Kokoda Flora Species List

The following list was developed from surveys of the proposed Kokoda Offset Site. It includes all species of vascular plants observed within the proposed Kokoda Offset Site during fieldwork completed by Umwelt in 2013. Although substantial, the list will not be comprehensive, because not all species are readily detected at any one time of the year. Many species flower only during restricted periods of the year, and some flower only once in several years. In the absence of flowering material, many of these species cannot be identified, or even detected.

Names of classes and families follow a modified Cronquist (1981) System.

Any species that could not be identified to the lowest taxonomic level are denoted in the following manner:

- sp. specimens that are identified to genus level only;
- prob. specimens for which identification was considered highly likely but not definite;
and
- poss. specimens for which identification was considered likely but not definite.

The following abbreviations or symbols are used in the list:

- 1 to 6 modified Braun-Blanquet cover-abundance score;
- x species recorded in proximity to, but outside of, quantitative floristic quadrat, or opportunistically during the survey effort;
- asterisk (*) denotes species not native to the study area;
- subsp. subspecies;
- var. variety; and
- Bold** font denotes threatened plant species or populations.

All vascular plants recorded or collected were identified using keys and nomenclature in Harden (1992, 1993, 2000 & 2002) and Wheeler *et al.* (2002). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from *PlantNET* (Botanic Gardens Trust 2013), the on-line plant name database maintained by the National Herbarium of New South Wales.

Common names used follow Harden (1992, 1993, 2000 & 2002) where available, and draw on other sources such as local names where these references do not provide a common name.

Table 1 lists the flora species recorded across the proposed Kokoda Offset Site.

Table 1 – Flora Species Recorded Across the Proposed Kokoda Offset Site

Family/ Subfamily	Scientific Name	Common Name	KQ01	KQ02	KQ03	KQ04	KQ05	KQ06	KQ07	KQ08	KQ09	KQ10	KQ11	KQ12	KQ13	KQ14	KQ15	KQ16	KQ17	KQ18	KQ19	KQ20	KQ21	KQ22	KQ23	KQ24	KQ25	KQ26	KQ27	KQ28	KQ29	KT1	KT2	OPPS
Coniferopsida																																		
Cupressaceae	<i>Callitris endlicheri</i>	black cypress pine	3		3	3	3		1	3	4	3	4	1	3		3	2	4								3		x	4	x		x	x
Cupressaceae	<i>Callitris glaucophylla</i>	white cypress pine																															x	
Filicopsida																																		
Adiantaceae	<i>Cheilanthes distans</i>	bristly cloak fern																		3		3		4	2	2	2			2	2	x		
Adiantaceae	<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	poison rock fern	3			2	2	2	2	2	2	3	2	2	2	3	2	3	3	2		2		4		3				2			x	
Magnoliopsida (Flowering Plants) – Liliidae (monocots)																																		
Anthericaceae	<i>Arthropodium milleflorum</i>	vanilla lily																												2				
Anthericaceae	<i>Dichopogon strictus</i>	chocolate lily																							2			2						
Anthericaceae	<i>Laxmannia gracilis</i>	slender wire lily									1															1								
Anthericaceae	<i>Thysanotus patersonii</i>	twining fringe-lily										1		1			1	1	1											2	2			
Anthericaceae	<i>Tricoryne elatior</i>	yellow autumn-lily																		1										2				
Colchicaceae	<i>Wurmbea dioica</i> subsp. <i>dioica</i>	early Nancy																				3		2						2		x	x	
Cyperaceae	<i>Bolboschoenus</i> sp.										3																							
Cyperaceae	<i>Fimbristylis dichotoma</i>	common fridge-sedge						2																										
Cyperaceae	<i>Lepidosperma laterale</i>											4																						
Iridaceae	<i>*Romulea rosea</i>	onion weeds																		2	2	2										x	x	
Juncaceae	<i>Juncus homalocaulis</i>							2																										
Juncaceae	<i>Juncus</i> sp.					1	3	2		3			2		3	3									3		3			2	2	x		
Orchidaceae	<i>Acianthus collinus</i>																													2				
Orchidaceae	<i>Caladenia carnea</i>	pink fingers																												2				

Family/ Subfamily	Scientific Name	Common Name	KQ01	KQ02	KQ03	KQ04	KQ05	KQ06	KQ07	KQ08	KQ09	KQ10	KQ11	KQ12	KQ13	KQ14	KQ15	KQ16	KQ17	KQ18	KQ19	KQ20	KQ21	KQ22	KQ23	KQ24	KQ25	KQ26	KQ27	KQ28	KQ29	KT1	KT2	OPPS
Orchidaceae	<i>Caladenia gracilis</i>	musky caladenia																															x	
Orchidaceae	<i>Caladenia tentaculata</i>	fringed spider orchid																															x	
Orchidaceae	<i>Calochilus robertsonii</i>	purplish beard orchid																		1													x	
Orchidaceae	<i>Cyanicula caerulea</i>	blue caladenia																												2				
Orchidaceae	<i>Microtis unifolia</i>	common onion orchid																													x			
Orchidaceae	<i>Pterostylis mutica</i>	midget greenhood																				1											x	
Orchidaceae	<i>Pterostylis nana</i>	dwarf greenhood																												2				
Orchidaceae	<i>Pterostylis</i> sp.										2									2														
Poaceae	* <i>Aira cupaniana</i>	silvery hairgrass						1		2					1																			
Poaceae	<i>Aristida leichhardtiana</i>		2							3											3													
Poaceae	<i>Aristida ramosa</i>	purple wiregrass						3	3							4	3				3	4	5	4	4	3	3		3		3	x	x	
Poaceae	<i>Aristida</i> sp.			3		3	3							3	3					5								2						
Poaceae	<i>Austrostipa bigeniculata</i>											2																						
Poaceae	<i>Austrostipa scabra</i> subsp. <i>falcata</i>		3		3			3	3		2		3	3	3		3	3	2		2			3					2		3			
Poaceae	<i>Austrostipa setacea</i>	corkscrew grass					3	3																										
Poaceae	<i>Bothriochloa decipiens</i>	red grass						3																										
Poaceae	<i>Bothriochloa macra</i>	red grass						3								1					1												x	
Poaceae	<i>Bothriochloa</i> sp.														1																			
Poaceae	* <i>Briza minor</i>	shivery grass	1				2								1	2																		
Poaceae	* <i>Bromus molliformis</i>															1																		
Poaceae	<i>Chloris truncata</i>	windmill grass			1	2		2							1	2										3							x	
Poaceae	<i>Chloris ventricosa</i>	tall chloris					1																											
Poaceae	<i>Dichelachne</i> sp.													2																				

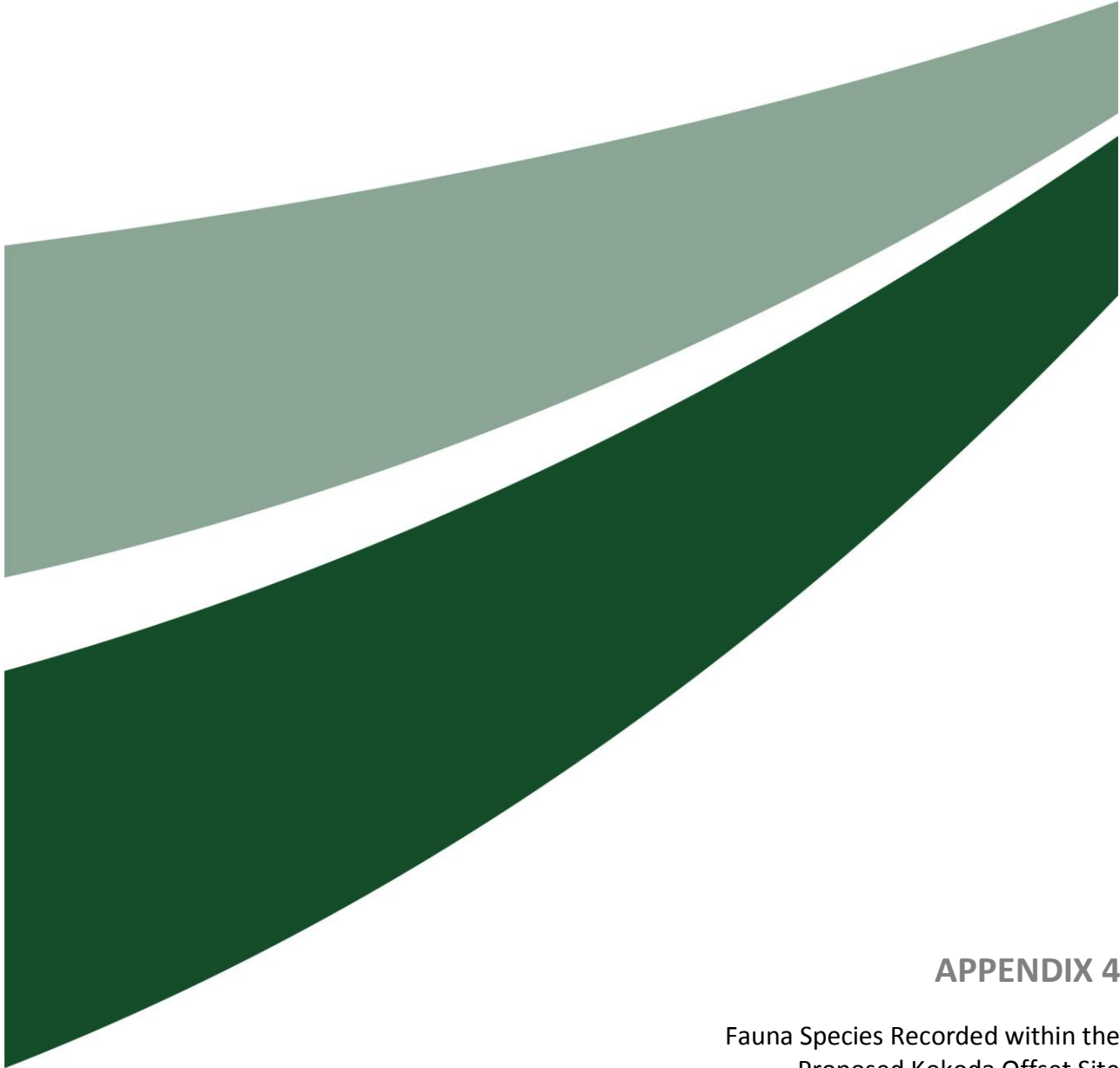
Family/ Subfamily	Scientific Name	Common Name	KQ01	KQ02	KQ03	KQ04	KQ05	KQ06	KQ07	KQ08	KQ09	KQ10	KQ11	KQ12	KQ13	KQ14	KQ15	KQ16	KQ17	KQ18	KQ19	KQ20	KQ21	KQ22	KQ23	KQ24	KQ25	KQ26	KQ27	KQ28	KQ29	KT1	KT2	OPPS	
Poaceae	<i>Digitaria diffusa</i>						2	2	2							2	1																		
Poaceae	* <i>Echinochloa microstachya</i>	prickly barnyard grass																3																	
Poaceae	<i>Elymus scaber</i>							3	3						1	2		2			3	2										x			
Poaceae	<i>Eragrostis brownii</i>	Browns lovegrass					2															2		1										x	
Poaceae	<i>Eragrostis elongata</i>	clustered lovegrass					2	2								3						2	2		3										
Poaceae	<i>Eragrostis</i> sp.								2	2			2																						
Poaceae	<i>Microlaena stipoides</i> var. <i>stipoides</i>	weeping grass													1									3		2	2				3	2	x		
Poaceae	<i>Panicum effusum</i>	poison or hairy panic	1																							2		2							
Poaceae	<i>Panicum</i> sp.						1																												
Poaceae	<i>Rytidosperma fulvum</i>	wallaby grass																													3				
Poaceae	<i>Rytidosperma setaceum</i>								3	3			3	3	2		2													2					
Poaceae	<i>Rytidosperma</i> sp.		2		3	3					2	1				2																			
Poaceae	<i>Sporobolus creber</i>	slender rat's tail grass		3		2																													
Poaceae	* <i>Vulpia bromoides</i>	squirrel tail fesque					1																												
Magnoliopsida (Flowering Plants) – Magnoliidae (Dicots)																																			
Acanthaceae	<i>Brunoniella australis</i>	blue trumpet								1															2										
Aizoaceae	* <i>Galenia pubescens</i>	galenia																											2						
Amaranthaceae	<i>Alternanthera denticulata</i>	lesser joyweed		1			1																							1					
Amaranthaceae	<i>Ptilotus</i> sp.																																	x	
Apiaceae	<i>Hydrocotyle laxiflora</i>	stinking pennywort																		2						1	3		3	2	3			x	
Apiaceae	<i>Hydrocotyle</i> sp.					2	2						1	2	2			2																	

Family/ Subfamily	Scientific Name	Common Name	KQ01	KQ02	KQ03	KQ04	KQ05	KQ06	KQ07	KQ08	KQ09	KQ10	KQ11	KQ12	KQ13	KQ14	KQ15	KQ16	KQ17	KQ18	KQ19	KQ20	KQ21	KQ22	KQ23	KQ24	KQ25	KQ26	KQ27	KQ28	KQ29	KT1	KT2	OPPS
Asclepiadaceae	<i>*Gomphocarpus fruticosus</i>	narrow-leaved cotton bush																						1										
Asteraceae	<i>*Arctotheca calendula</i>	Capeweed	3	3			2	2		1					2	2				2	2			3	x	5		4			3	x	x	
Asteraceae	<i>Calotis hispidula</i>	Bogan flea						2																					1					
Asteraceae	<i>Calotis lappulacea</i>	yellow burr-daisy																													x		x	
Asteraceae	<i>Cassinia aculeata</i>	dolly bush																												1				
Asteraceae	<i>Cassinia laevis</i>	cough bush									1		1	1																3				
Asteraceae	<i>Chrysocephalum apiculatum</i>	common everlasting, yellow but																		1														
Asteraceae	<i>*Cirsium vulgare</i>	spear thistle								2						1								1	2		2		2					
Asteraceae	<i>Cotula australis</i>	common cotula																							3	2	3		3		2		x	
Asteraceae	<i>Craspedia variabilis</i>											2																						
Asteraceae	<i>Cymbonotus lawsonianus</i>						2	2	3												3		3	3	3	2	1	2				x	x	
Asteraceae	<i>*Hypochaeris radicata</i>	catsear	3	2			1	3	2						2	3			2	3	3	3	3	3	3	2	4	3	2	2	2	x	x	
Asteraceae	<i>Microseris lanceolata</i>	yam daisy																															x	
Asteraceae	<i>Ozothamnus diosmifolius</i>	white dogwood				3				2																			1					
Asteraceae	<i>Senecio</i> sp.													1		1																		
Asteraceae	<i>Solenogyne bellioides</i>																			3	3	3			2		2				x			
Asteraceae	<i>Solenogyne</i> sp.								2																									
Asteraceae	<i>*Soliva sessilis</i>	bindyi	2	1												2																		
Asteraceae	<i>*Sonchus oleraceus</i>	common sowthistle	1					1				1															2	1	1					
Asteraceae	<i>Vittadinia pterochaeta</i>	rough fuzzweed						2																										
Asteraceae	<i>Vittadinia</i> sp.												1																					
Boraginaceae	<i>*Echium plantagineum</i>	Patersons curse														3	3	1					2	2			3						x	
Boraginaceae	<i>*Echium</i> sp.			3																														

Family/ Subfamily	Scientific Name	Common Name	KQ01	KQ02	KQ03	KQ04	KQ05	KQ06	KQ07	KQ08	KQ09	KQ10	KQ11	KQ12	KQ13	KQ14	KQ15	KQ16	KQ17	KQ18	KQ19	KQ20	KQ21	KQ22	KQ23	KQ24	KQ25	KQ26	KQ27	KQ28	KQ29	KT1	KT2	OPPS
Campanulaceae	<i>Wahlenbergia communis</i>	tufted bluebell						2														2	2		2									
Caryophyllaceae	* <i>Petrorhagia nanteuillii</i>						1	2																										
Caryophyllaceae	* <i>Stellaria media</i>	common chickweed					2			2					2						2	2	2	2	2	2	2	2				x		
Casuarinaceae	<i>Allocasuarina verticillata</i>	drooping sheoak	2							2		3							2															x
Chenopodiaceae	<i>Einadia hastata</i>	berry saltbush																											2					
Chenopodiaceae	<i>Einadia nutans</i> subsp. <i>nutans</i>				3										2			3											3					
Clusiaceae	<i>Hypericum gramineum</i>	small St John's wort	2				1	2	1			3						1								1								
Crassulaceae	<i>Crassula sieberiana</i>	Australian stonecrop																			2	2	2			2			2		2		x	
Dilleniaceae	<i>Hibbertia obtusifolia</i>	hoary guinea flower							3						2			3						1										
Dilleniaceae	<i>Hibbertia</i> sp.																1																x	x
Droseraceae	<i>Drosera glanduligera</i>	pimpernel sundew																		2		3	3	2	2							x		
Droseraceae	<i>Drosera peltata</i>																			3		3	2	2	3						2	x		
Epacridaceae	<i>Astroloma humifusum</i>	native cranberry									2		2	2																2	1			
Epacridaceae	<i>Brachyloma daphnoides</i>	Daphne heath				2					3																1			2	1			
Epacridaceae	<i>Lissanthe strigosa</i>	peach heath					1			3	2	1		2	3	2											1		1	3				
Euphorbiaceae	<i>Chamaesyce drummondii</i>	caustic weed			1																													
Fabaceae (Faboideae)	<i>Daviesia acicularis</i>																												1					
Fabaceae (Faboideae)	<i>Glycine tabacina</i>								2									2																
Fabaceae (Faboideae)	<i>Hardenbergia violacea</i>	false sarsaparilla				2																												
Fabaceae (Faboideae)	* <i>Medicago sativa</i>	lucerne		1																	2													
Fabaceae (Faboideae)	* <i>Medicago</i> sp.																			2	3	2	3	3	3			3				x	x	

Family/ Subfamily	Scientific Name	Common Name	KQ01	KQ02	KQ03	KQ04	KQ05	KQ06	KQ07	KQ08	KQ09	KQ10	KQ11	KQ12	KQ13	KQ14	KQ15	KQ16	KQ17	KQ18	KQ19	KQ20	KQ21	KQ22	KQ23	KQ24	KQ25	KQ26	KQ27	KQ28	KQ29	KT1	KT2	OPPS	
Fabaceae (Faboideae)	<i>Pultenaea</i> sp.										1																			x					
Fabaceae (Faboideae)	<i>Swainsona bracteata</i>														1																				
Fabaceae (Mimosoideae)	<i>Acacia decora</i>	western golden wattle				x			1																		x							x	
Fabaceae (Mimosoideae)	<i>Acacia doratoxylon</i>	currawang	3			2				2	2	3			2				2							3						x		x	
Fabaceae (Mimosoideae)	<i>Acacia paradoxa</i>	kangaroo thorn				1				1							2														3			x	
Geraniaceae	* <i>Erodium cicutarium</i>	common crowfoot																								2		3					x		
Geraniaceae	<i>Geranium</i> sp.								2																										
Goodeniaceae	<i>Goodenia</i> sp.							3						2	1			2									1								
Haloragaceae	<i>Gonocarpus tetragynus</i>		2					2				2		2	2	2	2		2								2			2	1				
Haloragaceae	<i>Haloragis heterophylla</i>						2																												
Haloragaceae	<i>Haloragis</i> sp.					1																													
Lamiaceae	<i>Ajuga australis</i>	austral bugle							3																										
Loranthaceae	<i>Amyema</i> sp.																														2			x	
Malvaceae	<i>Sida corrugata</i>								1																					2	1	1			
Myrtaceae	<i>Calytrix tetragona</i>										3		1																						
Myrtaceae	<i>Eucalyptus albens</i>	white box							4																									x	
Myrtaceae	<i>Eucalyptus dealbata</i>	tumbledown red gum													3												3								
Myrtaceae	<i>Eucalyptus dwyeri</i>	Dwyers red gum	2			3	3		3	3	3	2	2	2		1	3	3	3		x		x			3						2	x		x
Myrtaceae	<i>Eucalyptus macrorhyncha</i>	red stringybark													3			3												x					
Myrtaceae	<i>Eucalyptus melliodora</i>	yellow box													3			2																	
Myrtaceae	<i>Eucalyptus microcarpa</i>	inland grey box			4		4				x		2	2			3				x		x		1		3			4	4	4	x	x	x
Myrtaceae	<i>Eucalyptus moluccana</i>	grey box								2																									
Myrtaceae	<i>Eucalyptus sideroxylon</i>	mugga ironbark				4				3	3		4	4			x															2			x

Family/ Subfamily	Scientific Name	Common Name	KQ01	KQ02	KQ03	KQ04	KQ05	KQ06	KQ07	KQ08	KQ09	KQ10	KQ11	KQ12	KQ13	KQ14	KQ15	KQ16	KQ17	KQ18	KQ19	KQ20	KQ21	KQ22	KQ23	KQ24	KQ25	KQ26	KQ27	KQ28	KQ29	KT1	KT2	OPPS
Oxalidaceae	<i>Oxalis perennans</i>						1	2												2	2	2	3	3	2	2	2	3				x	x	
Oxalidaceae	<i>Oxalis</i> sp.		2																															
Plantaginaceae	* <i>Plantago lanceolata</i>	lambs tongues																		1														
Polygonaceae	<i>Persicaria lapathifolia</i>	pale knotweed								1																								
Polygonaceae	<i>Rumex brownii</i>	swamp dock																					2				2	1	2		1		x	
Primulaceae	* <i>Anagallis arvensis</i>	scarlet/blue pimpernel	1	3				2							2					2	2			2			2	2				x	x	
Ranunculaceae	<i>Ranunculus pachycarpus</i>	thick fruit buttercup																									1							x
Rubiaceae	<i>Asperula conferta</i>	common woodruff																		2	2				3									
Rubiaceae	<i>Galium gaudichaudii</i>	rough bedstraw																			2							3		2				
Rubiaceae	<i>Galium</i> sp.																									2								
Sapindaceae	<i>Dodonaea viscosa</i> subsp. <i>spatulata</i>					1																												
Scrophulariaceae	* <i>Orobanche minor</i>							1				2	2			1																		
Solanaceae	* <i>Solanum nigrum</i>	black-berry nightshade	1																							1								
Solanaceae	<i>Solanum</i> sp.																									1								
Stackhousiaceae	<i>Stackhousia monogyna</i>	creamy candles																																x
Stackhousiaceae	<i>Stackhousia</i> sp.						1																											
Sterculiaceae	<i>Brachychiton populneus</i> subsp. <i>populneus</i>	kurrajong	9											1	2																		x	x
Urticaceae	* <i>Urtica urens</i>	small nettle																							1									
Urticaceae	<i>Urtica incisa</i>	stinging nettle																												2				



APPENDIX 4

Fauna Species Recorded within the
Proposed Kokoda Offset Site

Appendix 4 – Fauna Species Recorded within the Proposed Kokoda Offset Site

The following list was developed from field surveys of the proposed Kokoda Offset Site as detailed in Section 3.3 of the main report. It includes all species of vertebrate fauna recorded within the proposed Kokoda Offset Site during field surveys by Umwelt.

The following abbreviation or symbols are used to identify the method of detection in the appendix table:

x	Identified from visual sighting or characteristic call;
#	Where possible the number of individuals of threatened species was recorded;
S	Identified from scat sample(s) in field;
D	‘Definite’ identification from scat or hair sample by Barbara Triggs;
Pr	‘Probable’ identification from scat or hair sample by Barbara Triggs;
H	Identified from hair funnel sample(s);
T	Identified from tracks and/or traces such as burrows, nests or feathers;
C	‘Confident’ identification by Fly by Night Bat Surveys Pty Ltd;
P	‘Probable’ identification by Fly by Night Bat Surveys Pty Ltd; and
Po	‘Possible’ identification by Fly by Night Bat Surveys Pty Ltd.

Any species that could not be identified to the species taxonomic level are denoted in the following manner:

sp.	specimens that are identified to genus level only;
?	specimens for which identification was uncertain;
prob.	specimens for which identification was considered highly likely but not definite; and
poss.	specimens for which identification was considered likely but not definite.

The following abbreviations or symbols are used in the list:

asterisk (*)	denotes species not indigenous to the study area;
subsp.	subspecies;
TSC Act	<i>Threatened Species Conservation Act 1995</i> ;
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> ;
MIG	Listed migratory species under the EPBC Act;
V	Vulnerable;
E	Endangered; and
Bold	Threatened and Migratory Species.

Birds recorded were identified using descriptions in Slater *et al.* (2003) and the scientific and common name nomenclature of Birds Australia. Reptiles recorded were identified using keys and descriptions in Cogger (2000), Swan *et al.* (2004), Weigel (1990) and Wilson and Swan (2008) and the scientific and common name nomenclature of Cogger (2000).

Amphibians recorded were identified using keys and descriptions in Cogger (2000), Robinson (1998), Anstis (2002) and Barker *et al.* (1995) and the scientific and common name nomenclature of Cogger (2000). Mammals recorded were identified using keys and descriptions in Strahan (2002), Churchill (1998, 2008) and Menkhorst and Knight (2004) and the scientific and common name nomenclature of Strahan (2002) for non-bat species and Churchill (1998, 2008) for bats.

Scientific Name	Common Name	Conservation Status		Autumn 2013	Spring 2013
		EPBC Act	TSC Act		
AMPHIBIANS					
Hylidae					
Litoria latopalmata	Gunthers Frog			x	
Litoria peronii	Perons Tree Frog				x
Myobatrachidae					
Crinia parinsignifera	Eastern Sign-bearing Froglet			x	x
Crinia signifera	Common Froglet				x
Limnodynastes dumerilii	Eastern Banjo Frog				x
Limnodynastes tasmaniensis	Spotted Grass Frog				x
Neobatrachus sudelli	Sudells Frog				x
Uperoleia laevigata	Smooth Toadlet				x
REPTILES					
Agamidae					
Pogona barbata	Bearded Dragon				x
Chelidae					
Chelodina longicollis	Snake-necked Turtle			x	
Scincidae					
Cryptoblepharus carnabyi					x
Trachydosaurus rugosus	Shingleback Lizard				x
Varanidae					
Varanus varius	Lace Monitor				x
BIRD					
Acanthizidae					
Acanthiza apicalis	Inland Thornbill				x
Acanthiza chrysorrhoa	Yellow-rumped Thornbill			x	x
Acanthiza lineata	Striated Thornbill			x	
Acanthiza nana	Yellow Thornbill				x
Acanthiza pusilla	Brown Thornbill			x	
Acanthiza reguloides	Buff-rumped Thornbill			x	x
Aphelocephala leucopsis	Southern Whiteface				x

Scientific Name	Common Name	Conservation Status		Autumn 2013	Spring 2013
		EPBC Act	TSC Act		
<i>Chthonicola sagittata</i>	Speckled Warbler		V		1,1,2,1,1,1,1,2,3
<i>Gerygone fusca</i>	Western Gerygone				x
<i>Smicrornis brevirostris</i>	Weebill				x
Accipitridae					
<i>Accipiter fasciatus</i>	Brown Goshawk				x
<i>Aquila audax</i>	Wedge-tailed Eagle			x	x
<i>Elanus axillaris</i>	Black-shouldered Kite			x	
Aegothelidae					
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar				x
Alcedinidae					
<i>Dacelo novaeguineae</i>	Laughing Kookaburra			x	x
Anatidae					
<i>Anas gracilis</i>	Grey Teal				x
<i>Anas superciliosa</i>	Pacific Black Duck			x	x
<i>Aythya australis</i>	Hardhead				x
<i>Chenonetta jubata</i>	Wood Duck			x	x
Ardeidae					
<i>Ardea pacifica</i>	White-necked Heron				x
<i>Egretta novaehollandiae</i>	White-faced Heron				x
Artamidae					
<i>Artamus cyanopterus</i>	Dusky Woodswallow				x
<i>Artamus superciliosus</i>	White-browed Woodswallow				x
<i>Cracticus nigrogularis</i>	Pied Butcherbird				x
<i>Cracticus tibicen</i>	Australian Magpie			x	x
<i>Cracticus torquatus</i>	Grey Butcherbird				x
<i>Strepera graculina</i>	Pied Currawong			x	x
Cacatuidae					
<i>Cacatua galerita</i>	Sulphur-crested Cockatoo			x	x
<i>Calyptorhynchus lathami</i>	Glossy Black-cockatoo		V		2
<i>Eolophus roseicapillus</i>	Galah			x	x
Campephagidae					
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike			x	x
<i>Lalage sueurii</i>	White-winged Triller				x
Charadriidae					
<i>Elseyornis melanops</i>	Black-fronted Dotterel				x
<i>Vanellus miles</i>	Masked Lapwing			x	x
Climacteridae					
<i>Climacteris affinis</i>	White-browed Treecreeper			x	x

Scientific Name	Common Name	Conservation Status		Autumn 2013	Spring 2013
		EPBC Act	TSC Act		
<i>Climacteris picumnus victoricae</i>	Brown Treecreeper		V		1,1,2,2,2,1,2,2,1,1,4
Columbidae					
<i>Geopelia cuneata</i>	Diamond Dove				x
<i>Geopelia striata</i>	Peaceful Dove				x
<i>Ocyphaps lophotes</i>	Crested Pigeon			x	x
<i>Phaps chalcoptera</i>	Common Bronzewing			x	x
Corcoracidae					
<i>Corcorax melanorhamphos</i>	White-winged Chough			x	x
<i>Struthidea cinerea</i>	Apostlebird			x	x
Corvidae					
<i>Corvus coronoides</i>	Australian Raven			x	x
Cuculidae					
<i>Chalcites lucidus</i>	Shining Bronze-cuckoo				x
Estrildidae					
<i>Stagonopleura guttata</i>	Diamond Firetail		V		1,2,5
Falconidae					
<i>Falco berigora</i>	Brown Falcon				x
<i>Falco cenchroides</i>	Nankeen Kestrel				x
<i>Falco subniger</i>	Black Falcon		V		1
Hirundinidae					
<i>Cheramoeca leucosterna</i>	White-backed Swallow				x
<i>Hirundo neoxena</i>	Welcome Swallow			x	x
<i>Petrochelidon nigricans</i>	Tree Martin				x
Maluridae					
<i>Malurus cyaneus</i>	Superb Fairy-wren			x	x
Megaluridae					
<i>Cincloramphus mathewsi</i>	Rufous Songlark				x
Meliphagidae					
<i>Anthochaera carunculata</i>	Red Wattlebird			x	x
<i>Entomyzon cyanotis</i>	Blue-faced Honeyeater				x
<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater				x
<i>Lichenostomus fuscus</i>	Fuscous Honeyeater				x
<i>Lichenostomus leucotis</i>	White-eared Honeyeater			x	x
<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater			x	x
<i>Manorina melanocephala</i>	Noisy Miner			x	x
<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater				x
<i>Plectorhyncha lanceolata</i>	Striped Honeyeater				x
Meropidae					
<i>Merops ornatus</i>	Rainbow Bee-eater	MIG			1

Scientific Name	Common Name	Conservation Status		Autumn 2013	Spring 2013
		EPBC Act	TSC Act		
Monarchidae					
<i>Grallina cyanoleuca</i>	Magpie-lark			x	x
<i>Myiagra inquieta</i>	Restless Flycatcher			x	x
Motacillidae					
<i>Anthus novaeseelandiae</i>	Australian Pipit			x	x
Nectariniidae					
<i>Dicaeum hirundinaceum</i>	Mistletoebird				x
Neosittidae					
<i>Daphoenositta chrysoptera</i>	Varied Sittella		V		1,1
Pachycephalidae					
<i>Colluricincla harmonica</i>	Grey Shrike-thrush			x	x
<i>Falcunculus frontatus</i>	Crested Shrike-tit				x
<i>Pachycephala pectoralis</i>	Golden Whistler			x	x
<i>Pachycephala rufiventris</i>	Rufous Whistler			x	x
Pardalotidae					
<i>Pardalotus punctatus</i>	Spotted Pardalote			x	x
<i>Pardalotus striatus</i>	Striated Pardalote				x
Petroicidae					
<i>Eopsaltria australis</i>	Eastern Yellow Robin			x	x
<i>Melanodryas cucullata cucullata</i>	Hooded Robin		V		1
<i>Microeca fascinans</i>	Jacky Winter				x
<i>Petroica rosea</i>	Rose Robin			x	
Phalacrocoracidae					
<i>Microcarbo melanoleucos</i>	Little Pied Cormorant			x	x
Podargidae					
<i>Podargus strigoides</i>	Tawny Frogmouth				X
Pomatostomidae					
<i>Pomatostomus superciliosus</i>	White-browed Babbler			x	x
<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler		V	2,2,4,5,5,6	5,1,2,3,1,2,5,10,5,18,4
Psittacidae					
<i>Glossopsitta pusilla</i>	Little Lorikeet		V	20, 5	
<i>Northiella haematogaster</i>	Bluebonnet				x
<i>Platycercus eximius</i>	Eastern Rosella			x	x
<i>Polytelis swainsonii</i>	Superb Parrot	V	V		2,25,11,12,3,1,6,4,1,8,10,2,19,7,6,1,10,4,2,7,7,11,3

Scientific Name	Common Name	Conservation Status		Autumn 2013	Spring 2013
		EPBC Act	TSC Act		
<i>Psephotus haematonotus</i>	Red-rumped Parrot			x	x
Rhipiduridae					
<i>Rhipidura albiscapa</i>	Grey Fantail			x	x
<i>Rhipidura leucophrys</i>	Willie Wagtail			x	x
Strigidae					
<i>Ninox novaeseelandiae</i>	Southern Boobook			x	
Sturnidae					
<i>Sturnus vulgaris</i> *	Common Starling				x
Timaliidae					
<i>Zosterops lateralis</i>	Silvereye			x	x
Tytonidae					
MAMMALS					
Bovidae					
* <i>Capra hircus</i>	Goat				x
* <i>Ovis aries</i>	Sheep			x	x
Canidae					
* <i>Vulpes vulpes</i>	Red Fox			x	x
Emballonuridae					
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheathtail-bat		V		Po
Felidae					
* <i>Felis catus</i>	Cat				x
Leporidae					
* <i>Lepus capensis</i>	Brown Hare				x
* <i>Oryctolagus cuniculus</i>	Rabbit				x
Macropodidae					
<i>Macropus giganteus</i>	Eastern Grey Kangaroo				x
<i>Macropus rufogriseus</i>	Red-necked Wallaby				x
<i>Wallabia bicolor</i>	Swamp Wallaby				x
Molossidae					
<i>Mormopterus planiceps</i>	Southern Freetail-bat			C	C
<i>Tadarida australis</i>	White-striped Freetail-bat			C	C
Muridae					
* <i>Rattus sp.</i>	A Rat				X
PHALANGERIDAE					
<i>Trichosurus vulpecula</i>	Common Brushtail Possum			x	x
Pseudocheiridae					
<i>Pseudocheirus peregrinus</i>	Common Ringtail Possum			x	
Suidae					
* <i>Sus scrofa</i>	Pig				x
Tachyglossidae					
<i>Tachyglossus aculeatus</i>	Short-beaked Echidna				x

Scientific Name	Common Name	Conservation Status		Autumn 2013	Spring 2013
		EPBC Act	TSC Act		
Vespertilionidae					
<i>Chalinolobus gouldii</i>	Goulds Wattled Bat			C	C
<i>Chalinolobus morio</i>	Chocolate Wattled Bat			C	C
<i>Chalinolobus picatus</i>	Little Pied Bat		V		Po
<i>Nyctophilus sp.</i>	A Smooth-nosed Bat			C	C
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bent-wing Bat		V	C	C
<i>Scotorepens balstoni</i>	Inland Broad-nosed Bat			P	C
<i>Vespadelus regulus</i>	Southern Forest Bat			P	
<i>Vespadelus vulturnus</i>	Little Forest Bat			C	C

Table 2 – Total Species per Fauna Group Recorded by Umwelt during Surveys in 2013

Fauna Group	Total Number of Species	Conservation Status		Kokoda 2013	
		EPBC Act	TSC Act	Autumn	Spring
Amphibians	8	0	0	2	7
Reptiles	4	0	0	1	3
Birds	93	1	10	47	86
Mammals	24	1	3	13	23
Total	129	2	13	63	119



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