BIG ISLAND MINING PTY LTD
ABN 12 112 787 470

Dargues Reef Gold Project

SOILS AND LAND CAPABILITY Assessment

Prepared by

SEEC
(Strategic Environmental and Engineering Consulting)

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SOILS AND LAND CAPABILITY
Assessment

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EXECUTIVE SUMMARY

A detailed assessment of the soils within the Dargues Reef Gold Project, Project Site has been conducted by a Certified Professional Soil Scientist (CPSS) from SEEC. This process included an interpretation of the soil landscape units as described by SCA/DLWC (2002). Two soil landscape units were identified within the Project Site and, although they had variable topographic conditions, both showed very similar soil characteristics.

This study includes an assessment of the soils' inherent physical and chemical properties, an investigation into how the proposed Dargues Reef Gold Mine Project might impact those soils, and their potential for use in rehabilitation activities.

A total of 13 test pits were excavated. Topsoil was encountered to a depth of around 300mm to 350mm in most pits. Subsoil depth varied from about 1,100mm to 1,400mm, with weathered rock below.

Topsoils have weak structure so would require careful management during stripping and stockpiling. They are only moderately erodible but are significantly dispersible so would require erosion and sediment controls in accordance with recognised best practice.

Soils are prone to shrinking and swelling so would require careful management when used for earth structures such as dam walls, foundations or road subgrades to ensure adequate compaction and strength.

Soils were found to be non-saline and, although fundamentally low in fertility, have balanced nutrient status and are not prone to leaching. Soils are strongly acidic and might require treatment with lime and molybdenum to encourage pasture growth during rehabilitation activities.

Soil stripping, handling, stockpiling, rehabilitation and engineering recommendations are included in Section 8 of this report. Given the relative homogeneity of soils across the site, soil materials stripped from one area can be used in another location for rehabilitation purposes. This helps to facilitate rapid and progressive rehabilitation, reduces the need for stockpiling and minimises double-handling.

An assessment of the Project Site's pre-development Land Capability Class (Class IV to V for most lands) is included in this report. We anticipate that, given appropriate management, lands disturbed for mining could be restored to this same level of productivity.

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1. INTRODUCTION

SEEC have been commissioned by Big Island Mining Pty Ltd ("the Proponent") to provide an assessment of all soils-related issues associated with the Dargues Reef Gold Project ("the Project" – for a full description, refer to Section 2 and the *Environmental Assessment* prepared by RW Corkery & Co. Pty Limited) (**Figure 1**).

This report serves to identify specific soils-related constraints and opportunities that might affect the design, establishment, operation and post-operative rehabilitation of the Project. In conducting this assessment we have:

- conducted a review of existing soils-related data from relevant government agencies;
- mapped the Soil Landscapes at the site from nearby SCA/DLWC mapping and determined the suite of soil types across the site;
- conducted an extensive field survey of the landforms and soils of the Project Site, including collecting representative soil samples;
- obtained laboratory test results for representative soil samples to determine key soil characteristics;
- assessed the potential impacts of the Project on the local soils;
- determined how the inherent soil characteristics might affect the Project; and
- provided recommendations for soil management to minimise any identified impacts.

Field surveys were conducted by SEEC staff on 13th January 2010 and 17th February 2010 to investigate the Project Site's landforms and soils and collect representative soil samples for laboratory testing.

2. PROJECT DESCRIPTION

The Project would include the following components (**Figure 2**).

- Extraction of waste rock and ore material from the Dargues Reef deposit using underground sublevel open stope mining methods with a suitable crown pillar to prevent surface subsidence.
- Construction and use of surface infrastructure required for the underground mine, including a box cut, portal and decline, magazines, fuel store, ventilation rise and power and water supply.
- Construction and use of a processing plant and office area which would include an integrated Run-of-Mine (ROM) pad/temporary waste rock emplacement, crushing and grinding, gravity separation and floatation circuits, Proponent and mining contractor site offices, workshop, laydown area, ablutions facilities, stores, car parking, and associated infrastructure.

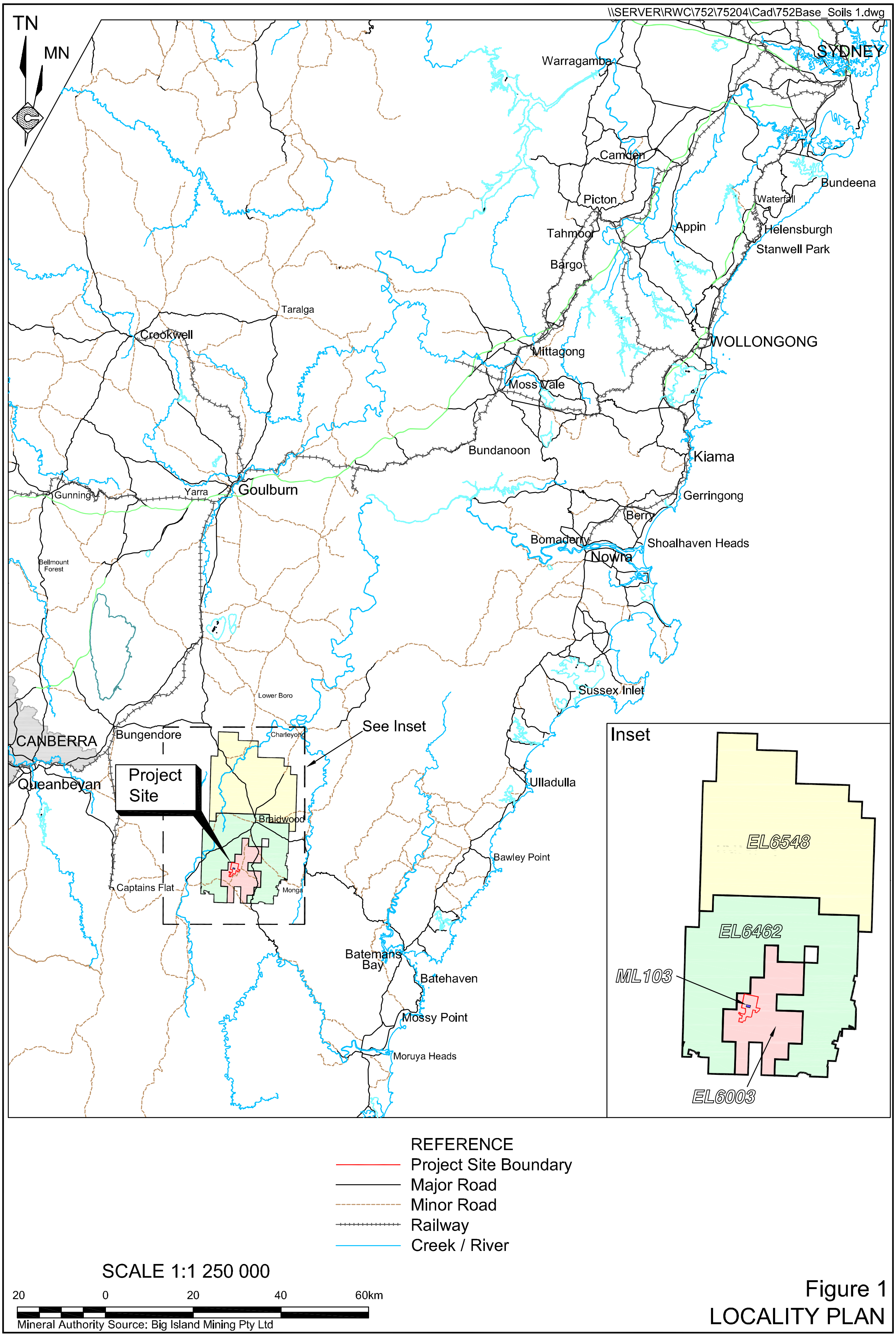

Figure 1
LOCALITY PLAN

Note: A colour version of this Figure is available on the Project CD

- Construction and use of a tailings storage facility.
- Construction and use of a water management system, including construction and use of eight dams and associated water reticulation system, to enable the harvesting and supply of water for mining-related operations. It is noted that the proposed water harvesting operations would be consistent with the Proponent's harvestable right.
- Construction and use of a site access road and intersection to allow site access from Majors Creek Road.
- Transportation of sulphide concentrate from the Project Site to the Proponent's customers via public roads surrounding the Project Site using covered semi-trailers.
- Construction and use of ancillary infrastructure, including soil stockpiles, core yards, internal roads and tracks and surface water management structures.
- Construction and rehabilitation of a final landform that would be geotechnically stable and suitable for a final land use of nature conservation and/or agriculture.

It is noted that during the life of the Project the Proponent proposes to undertake additional exploration drilling to further define identified mineralisation and identify additional mineralisation. Extraction of those resources does not form a part of this application. As a result, a subsequent application for approval to extract any identified resources may be prepared once sufficient information is available to adequately identify the proposed activities.

3. STUDY AREA

Although Big Island Mining Pty Ltd hold a total of some 396ha, for the purposes of this Surface Water Assessment, the Study Area was limited to those areas most likely to be disturbed by surface activities related to the Project. The footprint and extent of surface structures associated with the Project are shown in **Figure 2.** The Study Area for this Soils Assessment covers that area, including the proposed access road from Majors Creek Road into the Project Site, the Tailings Storage Facility and the proposed locations for harvestable-right dams (refer to the Surface Water Assessment for details). We estimate that the Study Area totals approximately 100ha.

The remaining lands, although owned by a Company associated with Big Island Mining Pty Ltd, are unlikely to be disturbed as part of this Project and, as such, are excluded from this Soils Assessment.

4. ENVIRONMENTAL SETTING

4.1 TOPOGRAPHY

Within the Study Area topography varies from gently-inclined ridges (slopes less than 5% or 1:20 V:H) to steep gullies and incised drainage lines (slopes up to 50% or 1:2 V:H). Steeper slopes are generally convex – i.e. steeper in footslope positions surrounding drainage lines. Elevation within the Study Area ranges from about 675m AHD to about 730m AHD.

4.2 DRAINAGE

4.2.1 Regional Drainage

The entire Project Site lies in the upper reaches of the Majors Creek catchment, which ultimately drains into the Deau River. The watershed boundary between the Shoalhaven and Deau River catchments traverses a ridge immediately north of the Project Site. All of the proposed mine-related infrastructure including the access road is sited within the Deau River catchment.

4.2.2 Study Site Drainage

Surface drainage follows a dendritic pattern, with the majority of the Study Area draining into Spring Creek, an intermittent watercourse which runs through the site as shown in **Figure 2**. Most drainage lines are significantly incised, with slope gradients increasing in mid- and lower-slope areas (i.e. convex slopes). This suggests that drainage line erosion is a natural and active force within this landscape.

There is also evidence of accelerated erosion as a result of past land use activities, with several major gullies on Spring Creek and its larger tributaries. Significant human-induced gully erosion along Spring Creek has partially stabilised as a result of recent, improved land-use practices and conservation works by the Soil Conservation Service.

Although not flowing at the time of our inspections, we are advised Spring Creek is spring-fed, with water surfacing in the base of Spring Creek at GR 0749119, 6063864 (GDA94). Further details of the surface water conditions are in the Surface Water Assessment.

4.2.3 Existing Dams

At present there are 14 farm dams within Big Island Mining Pty Ltd's 396ha holding. The locations and sizes of these dams are discussed in detail in the Surface Water Assessment.

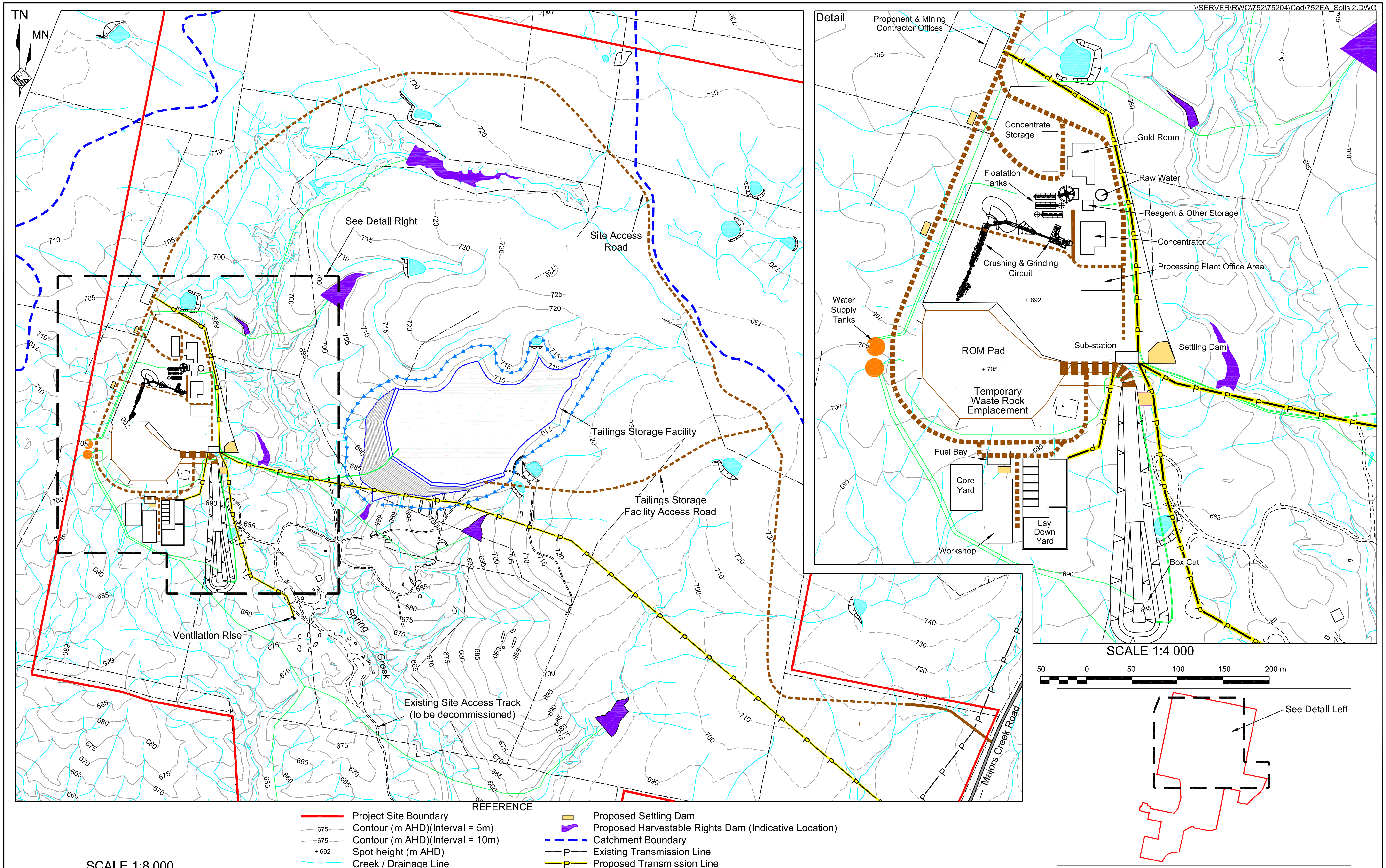

Figure 2
PROJECT SITE LAYOUT

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4.3 CLIMATE

Nearby Braidwood (Wallace Street Bureau of Meteorology Rainfall Station – Number 69010) has a warm temperate climate and experiences mean rainfall of 717mm/yr. Evaporation data from the same station is 1,017mm/yr. Rainfall is relatively consistent throughout the year although evaporation is significantly higher in summer, as shown in **Figure 3**.

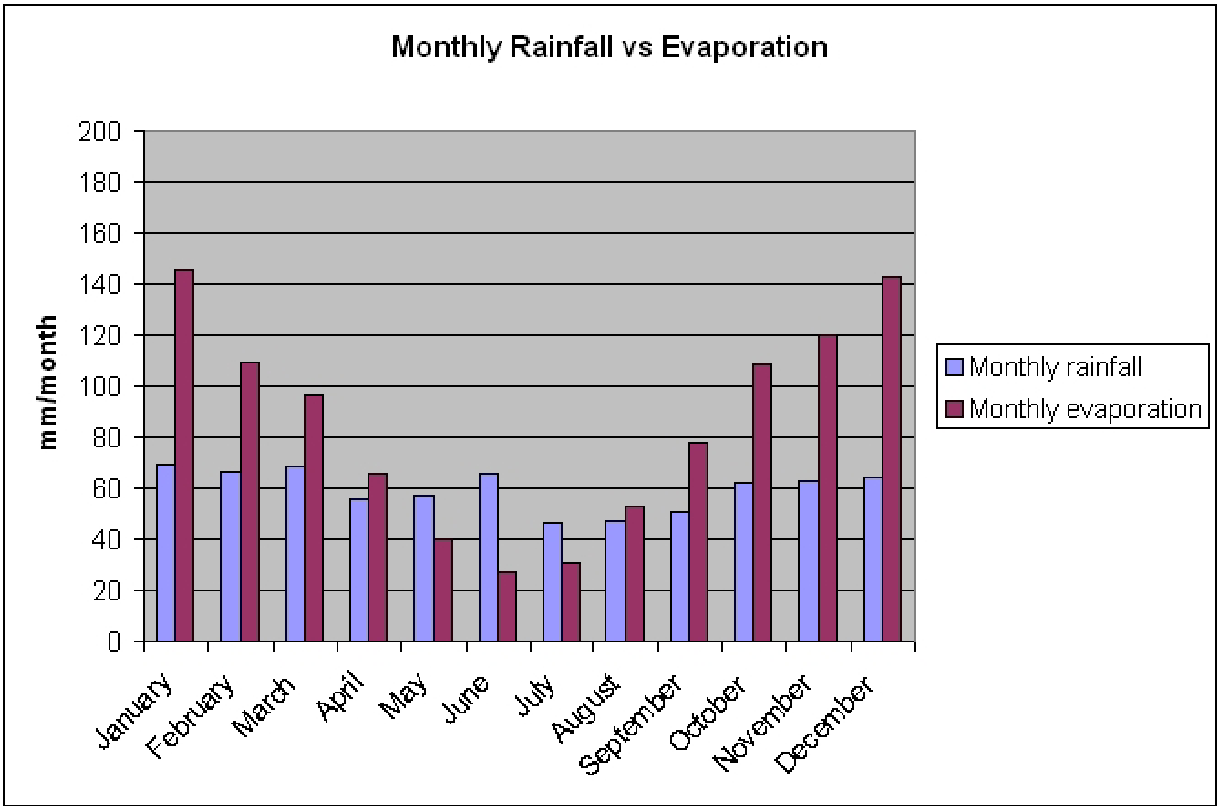

Figure 3 **Rainfall and Evaporation Comparison; Braidwood Rainfall Data (Station 69010)**

4.4 VEGETATION

Most of the northern section of the Project Site has been cleared of native trees and is under an excellent cover of pasture grasses. Scattered stands of native timber remain along some of the larger drainage lines, particularly south of the main mine infrastructure. The southern section of the Project Site has been extensively disturbed by prior mining activities and is dominated by woody weeds, regenerating wattles and areas of no vegetation. Vegetation and ecological issues are detailed in the Ecology Assessment (Gaia Research, 2010) and the *Environmental Assessment* (RW Corkery & Co. Pty. Limited, 2010).

4.5 LAND USE

The site has been used most recently for grazing. Gold prospecting and mining has occurred in the past and there is widespread evidence of this the form of old workings, disused shafts and spoil heaps, particularly in the southern section of the Project Site.

5. SOIL MAPPING

5.1 EXISTING INFORMATION

Published 1:100,000 or 1:250,000-scale soil landscape mapping is not available over the Study Area; only reconnaissance-level soil survey has been conducted in that area (C. Murphy, DECCW. pers. comm.). However, 1:100,000-scale soil landscape mapping is available over all lands administered by the Sydney Catchment Authority, and this includes the Upper Shoalhaven River catchment immediately to the north of the Study Area (SCA/DLWC, 2002). The proximity of reliable, published soil landscape mapping allows for interpolation of the soil landscapes over the Study Area (**Figure 4**).

5.2 SOIL MAPPING METHODOLOGY

On-ground observations were made over the Study Area and over the mapped areas within the Upper Shoalhaven River catchment immediately to the north to confirm continuity of climatic, vegetation and topographic conditions across the catchment boundary.

The soil landscape boundaries were then extended beyond the limit of the published soil landscape maps and interpolated over the Study Area according to their characteristics (**Figure 4**). An extensive soil survey was then conducted to confirm the soils within each of the delineated soil landscape units shown in **Figure 4** accord with the descriptions in the published soil landscape mapping.

5.3 SOIL SAMPLING DENSITY

The recommended density and level of observation for accurate delineation of soil types is detailed in DLWC, 2000. For moderately intensive construction and mine site planning, DLWC (2000) recommend:

- site and soil observations at 2 to 4 per hectare;
- soil profile investigations at 0.5 to 1 per hectare; and
- laboratory analysis of soils at 0.2 to 1 per hectare (or >1 per typical profile).

This allows for 1:5,000 scale soil mapping. In accordance with these guidelines, 13 profiles were excavated across the site focusing on those areas most likely to be affected by the development. We were also considerate of the need to describe a typical profile on each landform element (e.g. crest, midslope, lower slope, after McDonald *et al.*, 1990) within each of the two soil landscapes. Details of soil profile descriptions are contained in **Appendix 1**.

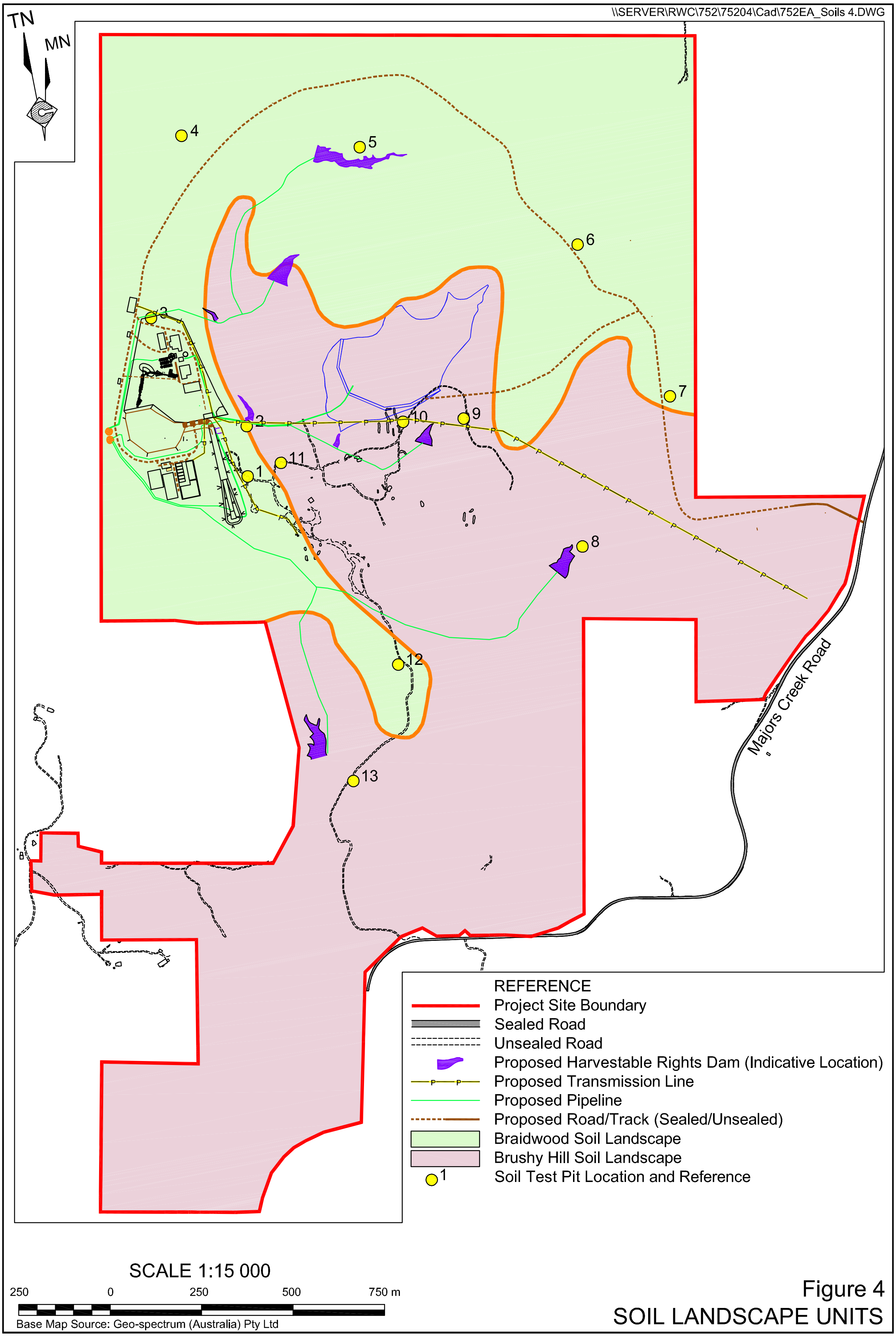

Figure 4
SOIL LANDSCAPE UNITS

5.4 SOIL MAPPING DELINEATIONS

5.4.1 Braidwood Soil Landscape

5.4.1.1 Description

SCA/DLWC (2002) describes the Braidwood Soil Landscape as "undulating rises on Devonian granite, hornblende-biotite granodiorite, and adamellite in the Braidwood Rises physiographic region. Vegetation is mostly cleared woodland, with a few isolated stands on rises. Occasional rock outcropping as granitic tors occur mainly on upper slopes and crests." Slopes range from 0 to 15% (Level to 1 in 6.7).

Soils consist of shallow Earthy Sands and Lithosols on rocky crests, Yellow and Red Podzolic Soils on upper, mid and lower slopes, with Solodic Soils on footslopes. Alluvial soils occasionally occur in gully infills. Acid sulphate soils are not known to occur within the Braidwood Soil Landscape.

This description is consistent with those areas identified in **Figure 4** as the Braidwood Soil Landscape.

5.4.1.2 Soil Profiles

Seven soil profiles were excavated in the Braidwood Soil Landscape in the locations shown in **Figure 4**. Soils were found to be relatively homogenous within the Braidwood Soil Landscape with only minor differences in horizon thickness according to slope position. Soil texture and colour were consistent in all profiles. A typical description is given in **Table 1**. Detailed soil logs of each profile are contained in **Appendix 1**.

Table 1
Typical Soil Profile Within Those Parts of the Study Area Identified as the Braidwood Soil Landscape

Layer	Depth range	Description
1	0 – 150mm	Topsoil. Dark brown, weakly pedal loam. No coarse fragments.
2	150 – 350mm	Topsoil. Greyish-brown, weakly pedal sandy loam to sandy clay loam. No coarse fragments.
3	350 – 800mm	Subsoil. Yellowish-brown, moderately to strongly pedal sandy clay. No coarse fragments.
4	800 – 1,400mm+	Subsoil. Mottled yellow/grey/brown moderately to strongly pedal clayey sand. Evidence of weathering rock with increasing depth. 5 to 10% coarse fragments, increasing with depth.

5.4.2 Brushy Hill Soil Landscape

5.4.2.1 Description

SCA/DLWC (2002) describes the Brushy Hill Soil Landscape as

> "rolling low hills on granite, granodiorite and adamellite in the Braidwood Rises physiographic region. Rock outcropping is fairly common, especially on crests and upper slopes, where granitic tors occur. The original open forests and woodlands have been extensively cleared for grazing pastures."

Slopes range from 10 to 20% (1 in 10 to 1 in 5).

Soils consist of shallow Lithosols on rocky crests and around tors, with Yellow and Red Podzolic Soils on upper, mid and lower slopes. Acid sulphate soils are not known to occur within the Brushy Hill Soil Landscape.

5.4.2.2 Soil Profiles

Six soil profiles were excavated in the Brushy Hill Soil Landscape in the locations shown in **Figure 4**. Soils were found to be relatively homogenous within the Brushy Hill Soil Landscape with only minor differences in horizon thickness according to slope position. Soil texture and colour were consistent in all profiles. A typical description is given in **Table 2**. Detailed soil logs of each profile are contained in **Appendix 1**.

Table 2
Typical Soil Profile Within Those Parts of the Study Area Identified as the Brushy Hill Soil Landscape

Layer	Depth range	Description
1	0 – 110mm	Topsoil. Dark brown, weakly pedal loam. No coarse fragments.
2	110 – 300mm	Topsoil. Mid-brown, weakly pedal sandy loam. No coarse fragments.
3	300 – 650mm	Subsoil. Yellowish-brown, mottled, moderately pedal sandy clay. <5% coarse fragments.
4	650 – 1,100mm+	Subsoil. Greyish-yellow-brown, gritty clayey sand. Massive to weakly pedal. >5% coarse fragments as weathering granite. Layer continues to at least 1,500mm in some areas.

5.5 EXISTING CONTAMINATION

During our site inspection we did not note any obvious evidence of existing soil contamination, even around old gold workings. The present land use (cattle grazing) is relatively benign and unlikely to have caused any soil contamination. As such, the risk that the proposed mine might disturb existing soil contamination is low.

6. SOIL TESTING AND IMPACT ANALYSIS

6.1 ANALYSED SAMPLES

Soil samples from specific layers in representative profiles were sent to the Department of Lands Scone Research Centre for soil testing. **Table 3** details the location from which each sample was collected and the suite of tests performed on each. The raw results as published by the Department of Lands Scone Research Centre are included in **Appendix 2**. Note that soils were found to be quite homogenous across the site and across the two soil landscapes. As such, only those samples considered to be representative of wider conditions were tested for key characteristics.

Table 3
Suite of Laboratory Tests Performed on Each Representative Soil Sample

Test Pit	Layer	Soil Landscape	Landform	Physical Tests	Chemical Tests
1	1	Braidwood	Mid to lower slope	Texture	pH, EC, CEC, Exch Cations, P
1	2	Braidwood	Mid to lower slope	PSA, D%, EAT, OC%	
3	2	Braidwood	Upper to mid slope	PSA, D%, EAT, OC%	
3	4	Braidwood	Upper to mid slope	PSA, D%, EAT, OC%, LL%, PL%, LS%	
4	3	Braidwood	Mid to lower slope	PSA, D%, EAT, OC%, LL%, PL%, LS%	
8	3	Brushy Hill	Mid to lower slope	Texture	pH, EC, CEC, Exch Cations, P
10	1	Brushy Hill	Upper to mid slope	Texture	pH, EC, CEC, Exch Cations, P
10	2	Brushy Hill	Upper to mid slope	PSA, D%, EAT, OC%	pH, EC, CEC, Exch Cations, P

Key to Abbreviations:

- PSA = Particle size analysis
- D% = Dispersion percentage
- EAT = Emerson aggregate test
- OC% = Organic carbon percentage
- Texture = Soil field texture
- EC = Electrical conductivity
- CEC = Cation exchange capacity
- Exch Cations = Exchangeable cations (Sodium, Potassium, Calcium, Magnesium)
- P = Available phosphorus
- LL% = Liquid Limit
- PL% = Plastic Limit
- LS% = Linear Shrinkage

6.2 ANALYSIS OF PHYSICAL TEST RESULTS

6.2.1 Soil Erodibility – K-Factor

Table 4 contains the results of K-Factor analyses on five soil samples, derived using the method described in Rosewell (1993). Soil erodibility (K-factor) ranges from 0.021 to 0.039, which are all moderate values (Rosewell and Edwards, 1988). All soils across the site are moderately erodible and standard erosion and sediment control practices should be employed during land disturbance. Standard soil conservation techniques should be adequate to minimise erosion during rehabilitation activities.

Table 4
Soil Erodibility (from Rosewell, 1993 and Rosewell and Edwards, 1988)

Test Pit	Layer	K-Factor	Relative erodibility
1	2	0.036	Moderate
3	2	0.039	Moderate
3	4	0.021	Moderate
4	3	0.028	Moderate
10	2	0.035	Moderate

6.2.2 Soil Erodibility – Wind Erosion

Table 5 summarises the key laboratory test results as they relate to the soils' susceptibility to wind erosion. All soils have low susceptibility to wind erosion.

Table 5
Summary of Laboratory Test Results for Susceptibility to Wind Erosion.

Test pit	Layer	Texture	Relative fine sand content (%)	Relative coarse sand content (%)	Profile drainage	Wind erodibility rating
1	2	Sandy clay loam	26	35	Moderate	Low
3	2	Sandy loam	37	40	Moderate	Low
3	4	Sandy clay	16	27	Moderate	Low
4	3	Sandy clay	15	33	Moderate	Low
10	2	Sandy loam	33	36	Moderate	Low
(adapted from Wells and King, 1989 as described in Hazelton and Murphy, 1992).						

6.2.3 Soil Loss and Erosion Hazard

The annual soil loss was calculated using SOILOSS 5.3 (Rosewell, 2005), which is based on the Revised Universal Soil Loss Equation (RUSLE). For the purposes of this analysis, the following inputs were used (as recommended in Landcom, 2004).

- R-factor (rainfall factor): 2500 in Rainfall Zone 7.
- Maximum K-factors for each soil landscape (from **Table 4**).

- Typical slope gradients for each landscape unit, plus a slope length of 80 m.
- A rill:interill ratio of 3:1.
- P-factor (Conservation practice) of 1.3 (i.e. assuming no specific conservation practices).
- C-factor (Ground cover factor) of 1.0 (i.e. assuming bare soils).

The results of this analysis are contained in **Table 6**.

Table 6
Soil Loss Calculations Using the RUSLE and SOILOSS 5.3 (Rosewell, 2005)

Landscape Unit	Maximum K-factor (from Table 4)	Typical Slope Gradient	Calculated Soil Loss (t/ha/yr)	Soil Loss Class (from Landcom, 2004)
Braidwood	0.039	8%	260	3 (low-moderate)
Brushy Hill	0.035	15%	576	5 (high)

Under the guidelines and recommendations contained in Landcom (2004), construction activities in rainfall zone 7 can occur at any time of year using the standard suite of Best Management Practices (BMPs) for erosion and sediment control if the soil loss class is 4 or less. For soil loss class 5, additional measures are required for any land disturbance between 1 December and 28 February.

All lands identified as Braidwood Soil Landscape (**Figure 4**) are soil loss class 4 or less. However, on the Brushy Hill Soil Landscape, lands above 13% slope are soil loss class 5 or higher. As such, any land disturbance on slopes greater than 13% would either need to accord with the timing restrictions detailed above or have additional erosion control measures implemented over and above the standard suite of BMPs. This is discussed further in **Section 8.3**.

6.2.4 Soil Dispersibility

Emerson Aggregate Test (EAT) results in **Table 7** indicate that topsoils are slightly dispersible, whereas subsoils can range from slightly to significantly dispersible.

Table 7
Emerson Aggregate Test Results and Analysis (from Charman, 1978)

Test pit	Layer	EAT Result	Dispersibility
1	2 (topsoil)	5	Slightly dispersible
3	2 (topsoil)	5	Slightly dispersible
3	4 (subsoil)	2(1)	Moderately to highly dispersible
4	3 (subsoil)	5	Slightly dispersible
10	2 (topsoil)	3(1)	Slightly dispersible

Further to the EAT results in **Table 7**, an analysis of dispersibility is presented in **Table 8** using the method in Landcom (2004) to identify whether soils are "significantly dispersible". Two samples, one topsoil and one subsoil, were found to be significantly dispersible. Both of these samples came from lower slope positions suggesting that dispersibility needs to be taken into account for any earthworks or soil disturbance in and around drainage lines. This will include the construction of any dams.

Table 8
Soil Dispersion Laboratory Results and Analysis

Test Pit	Layer	Dispersion Percentage (%)	PSA Clay %	PSA Silt %	Dispersion significance*	Sediment type
1	2	55	10	21	11.3	Type D (dispersible)
3	2	67	6	12	8.0	Type C (coarse)
3	4	52	36	11	21.6	Type D (dispersible)
4	3	22	29	19	8.5	Type F (fine)
10	2	47	10	11	7.3	Type C (coarse)

* Note: The percent of the whole soil dispersible is calculated from the mechanically-dispersed PSA and the dispersion percent as follows: (Clay % + Half of the silt %) x Dispersion percent. If this value exceeds 10%, the soil is considered to be "significantly dispersible" – i.e. it is a Type D (dispersible) soil according to Landcom (2004).

6.2.5 Soil Engineering Properties

6.2.5.1 Introduction

As discussed in Section 6.2.4, dispersibility and EAT results suggest that soils on lower slope positions and around drainage lines are prone to structural decline when saturated. Further analysis to investigate soil structural properties follows.

6.2.5.2 Leakage Potential

Hazelton and Murphy (1992) suggest that if the total dispersed clay (i.e. dispersed clay percentage x dispersion percentage) falls below 5%, the material is likely to leak if used for earthworks. **Table 9** presents an analysis of leakage potential, showing that soils are unlikely to leak if used for earth structures (and also assuming adequate compaction).

Table 9
Analysis of Leakage Potential (from Hazelton and Murphy, 1992)

Test Pit	Layer	Dispersion Percentage (%)	PSA Clay % (dispersed sample)	Total dispersed clay	Leakage potential
1	2	55	13	7.2	Not significant
3	2	67	10	6.7	Not significant
3	4	52	41	21.3	Not significant
4	3	22	36	7.9	Not significant
10	2	47	14	6.58	Not significant

6.2.5.3 Liquid Limit

The liquid limit of a soil relates to its compressibility and indicates its inherent ability to support loads or remain trafficable when wet. It can also be an indicator of soil reactivity (i.e. shrink/swell soils) (Mills *et al.*, 1980). **Table 10** shows the results of liquid limit testing on two subsoil samples, suggesting that soils are most likely reactive and might shrink and swell with changing moisture regimes. Adequate compaction will be essential to minimise soil movement in earth structures and foundations (for roads and buildings).

Table 10
Results of Liquid Limit Testing

Test pit	Layer	Liquid limit	Rating
3	4	66%	High compressibility, high shrink/swell potential
4	3	65%	High compressibility, high shrink/swell potential

6.2.5.4 Plasticity

The Plasticity Index is calculated as the difference between the Liquid Limit and the Plastic Limit. It gives an indication of soils that might be prone to slumping or mass movement (Hicks, 1991). **Table 11** shows the results of plasticity testing on representative subsoils, indicating that they are highly compressible, have a high shrink/swell potential in changing moisture regimes and could be prone to slumping (i.e. USCS Class CH). This will affect recommendations for batter slope gradients in earth structures, particularly where roads cross drainage lines.

Table 11
Results of Plasticity Index Analysis

Test pit	Layer	Plastic Limit	Liquid limit	Plastic Index	Rating
3	4	20%	66%	46 (very high)	Very high compressibility, very high shrink/swell potential
4	3	20%	65%	45 (high)	High compressibility, high shrink/swell potential

6.2.5.5 Linear Shrinkage

Soils with high linear shrinkage values generally shrink when dry. Without adequate design in engineering to compensate, this can impact the stability of foundations (Hicks, 1991, Mills *et al.*, 1980). **Table 12** presents the results and analysis of linear shrinkage testing of representative subsoils within the Project Site. These results suggest soils are only marginally prone to shrinking and expanding with changing moisture regimes.

Table 12
Results and Analysis of Linear Shrinkage Results

Test pit	Layer	Linear Shrinkage	Rating
3	4	14.5%	Medium – Marginal expansion.
4	3	13.0%	Medium – Marginal expansion.

6.3 ANALYSIS OF CHEMICAL TEST RESULTS

6.3.1 Electrical Conductivity and Salinity

The results of electrical conductivity testing of representative soil samples are included in **Table 13**, along with an analysis of their salinity levels. Testing shows that salinity was not identified within the Project Site.

Table 13
Results and Analyses of Key Soil Chemical Properties

Test Pit	Layer	EC (dS/m)	Soil texture	Multi-plier factor	ECe	Salinity	pH	Condition
1	1	0.04	Loam	10	0.4	Non-saline	5.4	Strongly acidic
8	3	0.03	Sandy clay	9	0.27	Non-saline	5.7	Moderately acidic
10	1	0.15	Sandy loam	11	1.65	Non-saline	4.6	Very strongly acidic
10	2	0.01	Clayey sand	17	0.17	Non-saline	5.5	Strongly acidic

Note that analytical methodology and relative interpretation of both EC and pH values is described in Hazelton and Murphy (1992) using various sources.

6.3.2 Soil pH

Table 13 contains the results of pH testing of four representative samples from within the Mine Site area. pH varied from 5.7 (moderately acidic) to 4.6 (very strongly acidic). While acidity such as this does not adversely affect the growth of specifically-adapted native species, sensitive pasture species might experience some decline unless lime and molybdenum are applied at the time of sowing and, if required, through regular applications.

To lift pH by half a unit (0.5 pH units), lime should be added at approximately 1.2 t/ha (Charman and Murphy, 2007).

6.3.3 CEC and Exchangeable Cations

6.3.3.1 Results

Tables 14, 15 and **16** include the results and analysis of testing for Cation Exchange Capacity (CEC) and exchangeable cations. Full laboratory results are presented in **Appendix 2**.

Table 14
Cation Exchange Capacity (CEC) and Key Cation Ratios

Test Pit	Layer	CEC		Ca:Mg Ratio		Exchangeable Sodium Percentage	
		Value (me/100g)	Class	Value	Class	Value (me/100g)	Class
1	1	9.4	Low	3.3	Calcium low	5.3	Non-sodic
8	3	15.6	Moderate	0.5	Calcium deficient	9.0	Sodic
10	1	5.7	Very low	4.8	Balanced	1.8	Non-sodic
10	2	6.8	Low	1.8	Calcium low	10.3	Sodic

Analysis from Metson (1961), Eckert (1987) and Northcote and Skene (1972), as described in Hazelton and Murphy (1992).

Table 15
Exchangeable Cation Laboratory Test Results and Analysis

Test Pit	Layer	Calcium		Magnesium		Potassium		Sodium	
		Value me/100g	Class	Value me/100g	Class	Value me/100g	Class	Value me/100g	Class
1	1	4.3	Low	1.3	Moderate	0.1	Very low	0.5	Moderate
8	3	3.2	Low	6.5	High	0.2	Low	1.4	High
10	1	2.4	Low	0.5	Low	0.2	Low	0.1	Low
10	2	2.5	Low	1.4	Moderate	0.1	Very low	0.7	Moderate
Analysis from NSW Agriculture and Fisheries (1989), described in Hazelton and Murphy (1992).									

Table 16
Analysis of Cation Concentrations

Test Pit	Layer	Aluminium		Calcium		Magnesium		Potassium	
		% of CEC	Desirable range	% of CEC	Desirable range	% of CEC	Desirable range	% of CEC	Desirable range
1	1	3%	< 5	46%	65 – 80	14%	10 – 15	1%	1 – 5
8	3	10.3%	< 5	21%	65 – 80	42%	10 – 15	1%	1 – 5
10	1	1%	< 5	42%	65 – 80	9%	10 – 15	4%	1 – 5
10	2	1%	< 5	37%	65 – 80	21%	10 – 15	1%	1 – 5
Analysis from Metson (1961), described in Hazelton and Murphy (1992).									

6.3.3.2 Cation Exchange Capacity (CEC)

CEC indicates the soil's ability to hold and exchange cations and is a major controlling factor for soil structural stability and nutrient availability for plant growth. It also influences soil pH and the soil's reaction to fertilizers and ameliorants (Hazelton and Murphy, 1992).

All samples except one were found to have either very low or low CEC. The deeper subsoils were found to have moderate CEC, indicative of their greater clay content when compared to the upper layers in the soil and, hence, their greater ability to retain cations.

The laboratory test results for CEC indicate that topsoils are nutrient-poor and likely to quickly leach any nutrients (e.g. those applied in fertilizers). Their coarse, sandy nature and low amounts of clay support this indication. Subsoils have greater clay content and higher CEC, suggesting they would retain leached nutrients and make them available for plants. As a result, deeper-rooting (to below 500mm beneath natural ground level) plants should be favoured in any rehabilitation plan, as they would be more likely to succeed in extracting any available nutrients. Tubestock would be preferable to seed for the establishment of trees.

CEC results suggest soils are unlikely to leach excess nutrients into groundwater, as they would be retained in the clay-rich subsoils.

Low CEC, as found here particularly in the topsoils, is generally associated with poor soil structure and acidic pH conditions. Throughout the Project Site, topsoils were found to have weak, blocky structure and were uniformly acidic (**Table 13**).

6.3.3.3 Calcium:Magnesium Ratio and Exchangeable Calcium

Table 14 contains the results of a comparison of the Calcium and Magnesium percentages within each sample. Samples ranged from calcium deficient to balanced. Note that low calcium to magnesium ratios (< 2) can be indicative of clay dispersion in a soil and this is supported by the dispersibility (**Section 6.2.4**) and exchangeable sodium percentage (**Section 6.3.3.4**) analyses.

6.3.3.4 Exchangeable Sodium Percentage

The two topsoil samples tested were found to be non-sodic, whereas the two subsoil samples tested were found to be sodic. This is consistent with the previous analysis that subsoils are prone to dispersion (**Section 6.2.4**). Sodic soils can also be prone to tunnelling and gully erosion. Any earth structures built using the natural soils onsite would require significant compaction (to at least 95% standard proctor) and sealing to minimise water ingress.

6.3.3.5 Potassium

Potassium values were found to be uniformly low (**Table 15**), although when expressed as a percentage of the overall CEC (**Table 16**), potassium was found to be balanced. As such, potassium is unlikely to be a limiting factor for plant growth.

6.3.3.6 Magnesium

Magnesium values ranged from low to high (**Table 15**), with a general trend of increasing concentrations lower in the soil profile (i.e. increases with depth). Although magnesium levels outside the desirable range (**Table 16**) might affect plant growth, the relative calcium deficiency in the calcium:magnesium ratio in most of these soils is far more significant (**Table 14**).

6.3.3.7 Aluminium

Aluminium levels as a percentage of the overall CEC (**Table 16**) were nearly all low except for one sample where they exceeded the desirable range. This sample had the highest clay content of those tested for aluminium (note that higher aluminium levels broadly correlate with higher clay percentages because clay particles are laminar structures of aluminium and silica).

Providing soil pH remains between 5.5 and 8.0, the presence or absence of aluminium is not considered to be an issue for plant growth. However, pH outside this range can lead to aluminium becoming soluble and being taken in by plant roots. Most introduced plant species are not adapted to high levels of dissolved aluminium and would rapidly decline as a result.

The pH of all samples is close to the accepted limit for aluminium toxicity. While this is unlikely to impact the growth of well-adapted species (i.e. mainly natives), it could be detrimental to pasture species and seed growth. Pastures would benefit from an application of lime to raise the pH slightly.

6.3.3.8 Base Saturation and Leaching

Base saturation is determined by the sum of potassium, calcium, magnesium and sodium, expressed as a percentage of the total CEC. It provides an indication of how closely nutrient status approaches potential fertility and the extent of leaching that has occurred of base cations from the soil (Hazelton and Murphy, 1992). **Table 17** shows the results of base saturation analysis for these soils, showing that:

- Despite their relative infertility, nutrient status is good in all samples,
- all soils would be suitable for pasture growth, and
- only minimal leaching of nutrients has occurred in the past.

The CEC results (**Table 15** and **Section 6.3.3.2**) were also indicative of nutrient retention and minimal leaching. These soils are unlikely to leach nutrients.

Table 17
Base Saturation and Analysis of Likely Extent of Leaching

Test Pit	Layer	Base saturation	Rating	Likely extent of leaching
1	1	66%	High	Weakly leached
8	3	72%	High	Very weakly leached
10	1	56%	Moderate	Weakly leached
10	2	69%	High	Weakly leached

Analysis by Metson (1961), described in Hazelton and Murphy (1992).

6.3.4 Available Phosphorus and Organic Content

Laboratory test results for available phosphorus in nine samples are contained in **Table 18**, along with an analysis of the relative values. All soils except one were found to have very low phosphorus levels, suggesting they are highly infertile. One sample returned a very high result, suggesting high fertility. However, this is not consistent with other results and is assumed to be an anomaly.

Table 18
Available Phosphorus Test Results and Analysis

Test Pit	Layer	Available Phosphorus (mg/kg)	Rating
1	1	3	Very low
8	3	<1	Very low
10	1	28	Very high
10	2	3	Very low

Organic matter is largely responsible for the physical and chemical fertility of a soil. Five samples were tested for organic carbon, and these values were multiplied by 1.76 following the method described in Hazelton and Murphy (1992) to derive the organic matter values in **Table 19**. The results show that soils across the site have consistently low organic matter content. This is reflected in the weak soil structure. However this is unlikely to affect the re-establishment of native grasses, which are typically adapted to the natural soil conditions.

Table 19
Organic Matter Results and Analysis

Test Pit	Layer	Soil Depth (mm)	Organic Matter (g/100g)	Rating
1	2	150 – 270	1.51	Low
3	2	150 – 400	0.42	Extremely low
3	4	800 – 1,100	0.19	Extremely low
4	3	450 – 1,200	0.32	Extremely low
10	2	100 – 250	0.69	Very low

6.4 SOIL STRUCTURE

Soils were found to be weakly pedal in their upper horizons (i.e. in the topsoil to about 300mm depth), with structure improving to strongly pedal, polyhedral and blocky peds below 300mm. In lower horizons, clay weathering is influencing the development of soil structure.

Stripping of topsoils could damage their inherently weak structure if it was carried out when they were too wet or too dry. Subsoil structure is unlikely to be affected by stripping and stockpiling activities.

6.5 SOIL DRAINAGE AND PERMEABILITY

Soil conditions suggest they are moderately well to imperfectly drained over the entire soil profile. Topsoils are relatively sandy, so promote fairly rapid infiltration of initial rainfall. However, more clayey lower horizons and solid, underlying granite impede the movement of water to lower levels.

We anticipate that initial saturated hydraulic conductivity rates (K_{sat}) would be approximately 5 to 60mm/hr but would decrease during prolonged rain events to approximately 5 to 10mm/hr. as the lower soil layers become limiting (Charman and Murphy, 2007).

We anticipate that the underlying granite would impede the flow of soil water into deeper groundwater stores and some water could potentially move laterally through the landscape, surfacing as occasional springs. We are advised that a spring occurs in Spring Creek as discussed in **Section 4.2.2**.

6.6 ACID SULFATE SOILS

Acid sulphate soils do not occur in areas above 10m AHD and, as such, they are not present anywhere on the Mine Site.

6.7 CONTAMINATION POTENTIAL

Topsoils are relatively sandy and permeable and would quickly transport any contaminated material into the subsoils if exposed. Subsoils contain significant clay volumes that minimise leaching (Section 6.3.3.8) and would, therefore, minimise the risk of contamination leaching into groundwater in the event of an accidental exposure.

However, to mitigate the risk of soil and groundwater contamination, tailings structures would need to be lined to make them effectively impermeable. Any risk areas (e.g. storage and handling areas or pipelines transporting potentially-contaminating materials) should be sealed and bunded to minimise the risk of soil contamination in the event of an accidental spill.

6.8 SUBSIDENCE

Subsoils are potentially dispersive and prone to instability. As such, we expect they might be prone to local subsidence if the underlying rock strata was modified.

7. LAND CAPABILITY ASSESSMENT

7.1 THE NSW LAND CAPABILITY SYSTEM

The NSW Land Capability Classification system was developed by Emery (1985) to categorise portions of land based on their inherent soil and landscape characteristics and their suitability for different types of rural land use. Land capability classes range from I through to VIII.

- Class I lands are suitable for regular cultivation using basic soil conservation practices and are recognised as prime agricultural lands.
- Classes II to III are suitable for cropping but with increasing requirements for conservation farming practices.
- Classes IV to VI are best suited to grazing activities but with increasing requirements for improvement and/or pasture protection.
- Class VII lands are best left protected by trees due to a very significant risk of degradation if cleared.
- Class VIII lands are unsuitable for any agricultural purpose (e.g. swamps, cliffs etc.).

In assessing land capability, factors such as climate, soil type, slope, landform, erosion risk, salinity, soil chemistry, drainage, flooding and rock outcropping are considered. Note that land capability can vary across a single property.

7.2 SITE ASSESSMENT

The Project Site includes a range of land capability classes from Class IV on gently-sloped plateau surfaces to Class VII in eroded gullies around Spring Creek and its tributaries. The majority of lands are Class IV and V. Generally, those lands identified in **Figure 4** as the Braidwood Soil Landscape are Class IV and those lands identified as the Brushy Hill Soil Landscape are Class V.

The primary factors influencing these delineations are:

- Temperate climate.
- Sandy-clay soils with moderate waterholding potential and reasonable structure.
- Gentle slopes on ridges, increasing around drainage lines. Generally hilly terrain.
- Moderate soil fertility and nutrient status, which promotes pasture growth.
- Minimal leaching potential.
- Strongly acidic soils.
- No salinity.
- Minimal waterlogging problems and no shallow water tables or flood risk.
- Occasional rock outcrop.

Emery (1985) notes that Class IV lands are best used for grazing but can be occasionally tilled.

Emery (1985) notes that Class V lands are not suitable for any cultivation, they require more careful management than Class IV lands to minimise the erosion risk, but they are generally productive grazing lands. Structural earthworks might be needed to control runoff in steeper country.

8. RECOMMENDATIONS FOR SOIL MANAGEMENT

8.1 TOPSOIL STRIPPING AND STOCKPILING RECOMMENDATIONS

The boundary between topsoils and subsoils occurs at around 350mm depth on the Braidwood Soil Landscape and 300mm on the Brushy Hill Soil Landscape (**Figure 4**). As such we recommend the following:

- Topsoil stripping depth should be set at 350mm on those areas mapped as Braidwood Soil Landscape (**Figure 4**).
- Topsoil stripping depth should be set at 300mm on those areas mapped as Brushy Hill Soil Landscape (**Figure 4**).
- Topsoil should only be stripped when it is moderately moist, not when it is very wet or very dry, to preserve soil structure as much as possible.
- If topsoil is to be stockpiled, it should be done separately from other materials.
- Any topsoil stockpiles should be constructed as low, flat, elongated mounds no more than 2m high. They should be located on gently-sloped (less than 10%) lands. These stockpiles should be hydromulched (or equivalent) to achieve at least 70% vegetation cover (or equivalent) within 10 days of formation.
- Topsoil can be relocated from one part of the site to another if required (e.g. for use in progressive rehabilitation). Topsoils can be used with subsoils from a different soil landscape unit if required. Topsoils were found to be relatively homogenous across the entire site.
- Although soils are not overly prone to wind erosion and dust rise, stripping should preferably occur on non-windy days.
- Topsoil and subsoil layers should be stripped separately and used in rehabilitation activities in a similar stratigraphical order.

8.2 SUBSOIL STRIPPING AND STOCKPILING RECOMMENDATIONS

Subsoils extend from the base of the topsoil to approximately 1.1 to 1.4m depth below natural ground level. Below that level, soils consist of mainly weathering granitic rock and a massive, sugary texture. As such we recommend the following:

- Subsoil stripping should cover between 350 and 1,400mm depth on those areas mapped as the Braidwood Soil Landscape (**Figure 4**).
- Subsoil stripping should cover between 300 and 1,100mm depth on those areas mapped as Brushy Hill Soil Landscape (**Figure 4**).

- If subsoils are to be stockpiled, it should be done separately from other materials.
- Do not mix subsoils with weathering material from below the prescribed depths (1,400 and 1,100mm on the Braidwood and Brushy Hill Soil Landscapes respectively). Weathering material should be stockpiled separately.
- Any subsoil stockpiles should be constructed as flat, elongated mounds no more than 3m high. They should be located on gently-sloped (less than 10%) lands. These stockpiles should be hydromulched (or equivalent) to achieve at least 70% vegetation cover (or equivalent) within 10 days of formation.
- Subsoil can be relocated from one part of the site to another if required (e.g. for use in progressive rehabilitation). Subsoils were found to be relatively homogenous across the entire site.
- Although soils are not overly prone to wind erosion and dust rise, stripping should preferably occur on non-windy days.
- Topsoil and subsoil layers should be stripped separately and used in rehabilitation activities in a similar stratigraphical order.

8.3 EROSION AND SEDIMENT CONTROL

Sampling and testing suggests that soils at the site are all moderately erodible. However, slope gradients in some areas of the site would necessitate specialised management techniques in order to accord with the guidelines and recommendations in Landcom (2004). As such, we recommend the following:

- A Soil and Water Management Plan (SWMP) be developed for the site to address erosion and sediment control issues during site establishment and operation.
- Erosion and sediment control planning and implementation should accord with the guidelines and recommendations in Landcom (2004) and DECC (2008).
- Sediment basins should be designed to the criteria in Landcom (2004) and DECC (2008) to capture and retain Type D (dispersible) sediments. Note that flocculation will probably be necessary to achieve adequate settling of entrained sediment.
- The following portions of the site should be considered to be “high erosion hazard” areas:
  - Any “waterfront lands” as defined by the Water Management Act or the NSW Office of Water; and
  - Any areas steeper than 13%.
- On the abovementioned “high erosion hazard” lands, stripping, earthworks and other activities that involve soil disturbance should be confined to the period from 1 March to 30 November (while still involving a normal suite of erosion and sediment controls).

- On the abovementioned "high erosion hazard" lands, soils should not be exposed to erosion (i.e. to rainfall or flow) any time the three-day weather forecast suggests rain is likely in the period from 1 December to 28 February. This provision should be built into the SWMP to accord with Landcom (2004) and DECC (2008).
- Slope lengths should be kept to 80m maximum. Use contour banks or other water diversion structures as necessary. This provision should be built into the SWMP to accord with Landcom (2004) and DECC (2008).
- Run-on from upslope should be diverted away from disturbed areas. This provision should be built into the SWMP to accord with Landcom (2004) and DECC (2008).

8.4 ONSITE EFFLUENT DISPOSAL

All soils assessed across the Project Site are suitable for the disposal of treated effluent, assuming all other standard requirements for onsite effluent disposal are met (e.g. buffer distances to watercourses). The proponent could operate an onsite treatment and disposal facility for effluent generated by mine staff if desired, or could install a pump out septic tank for sewage which would be pumped out regularly by a qualified contractor.

Whatever system is chosen, we recommend the following:

- The system should be designed to manage 2,970 L/day total. This is based on 60 full-time staff, each producing 45 L/day of wastewater (2,700 L/day) and 10 visitors or delivery driver per day, each producing 27 L/day of wastewater (270 L/day) (from Department of Health, 2001).
- If a pump out septic system is chosen:
  - Capacity of 11,880 L for a 4-day pump-out cycle or at least 20,790 L for a weekly pump-out cycle.
  - An alarm should be fitted to the collection well to warn when it was approaching capacity.
  - A record should be maintained in the site office of pump-out cycles.
  - A copy of the effluent pump-out contract should be maintained in the site office at all times for review by a government authority.
- If an onsite treatment and disposal system is selected:
  - The disposal area should be sized and designed by a qualified geotechnical or environmental consultant to maintain appropriate buffer distances to relevant features.
  - The disposal area should be fenced to limit human exposure or damage (e.g. by vehicles or stock).
  - A monitoring and maintenance schedule (as recommended by the manufacturer of the treatment system) should be implemented.

8.5 USE OF SOIL MATERIALS FOR REHABILITATION

8.5.1 Suitability of Materials

Top- and sub- soil that has been stripped and/or stockpiled is suitable for use in rehabilitation activities. Soils across the site are fairly homogenous and, as such, soil materials from one part of the site can readily be used on another part for rehabilitation. Soils should be re-used in a natural stratigraphic order (i.e. topsoil overlying subsoil). Note that the presence of weeds in soils might affect their suitability for some rehabilitation activities and the advice of an ecologist should be sought first.

Laboratory testing suggests that soils would benefit from an application of lime, molybdenum and organic material to manage soil acidity and weak structure, particularly if they are to be used for pasture growth. Although soils are not highly fertile, their nutrient status is fairly balanced and they are suitable for native trees if required. Soils are not likely to leach nutrients after use in rehabilitation activities providing subsoil is laid down below topsoil. The lack of structure in topsoils can limit the success of revegetation from seed. The seedbed conditions should be improved by an addition of organic material or use tubestock instead.

8.5.2 Recommendations

When using the natural soil materials for rehabilitation purposes, we recommend the following:

- Soil materials from one part of the site can readily be used on another part for rehabilitation.
- Soils should be re-used in a natural stratigraphic order (i.e. topsoil overlying subsoil).
- Expert ecologist advice should be sought when re-using soils to minimise the spread of weeds.
- If rehabilitated areas are to be used for growing pastures:
  - Raise soil pH by 0.5 pH units by adding lime at approximately 1.2 t/ha (exact rate to be determined by targeted soil testing).
  - Add molybdenum to the soil using a commercially-available solution such as molybdenum trioxide (at approximately 75 g/ha; again, conduct targeted testing and seek expert advice first).
  - Improve the seedbed conditions by mixing organic material (e.g. manure or mulched vegetation) with the topsoil.
- If rehabilitated areas are to be used for growing trees:
  - Preferably plant from tubestock rather than seed to overcome natural soil structure problems.
  - Protect tubestock from damage using fencing or individual shrouds.
  - Provide a surface cover of organic material (e.g. mulch) to help protect new trees, supply nutrients and promote water infiltration.

8.6 EARTHWORKS AND SOIL STABILITY

To address issues associated with soil structure, dispersibility, sodicity and reactivity, we recommend the following when using these soils for earth structures (e.g. dam walls, foundations, road subgrades):

- Soils should be significantly compacted to at least 95% of maximum dry density.
- Concrete structures, foundations etc. should be designed for USCS Class CH (inorganic, high-plasticity clay) soils.
- Road subgrades might require additional stiffening (e.g. using Tensar geogrid or rock layers), importation of suitable material to achieve adequate strength or lime stabilisation (or a combination of these).
- Batter slopes on any earth structures (including dam walls and road fill batters) should not exceed 3:1 (H:V).
- Waterholding structures such as dams (including tailings structures) should be sealed using bentonite or similar to minimise the risk of water ingress into the natural soil wall. Soils are inherently prone to tunnelling failure when exposed to repeated wetting and drying.
- Individual dams should not be drawn down by more than 0.3 m per day.
- Dam walls should incorporate at least 1 m of freeboard from the top water level to the top of the wall.
- Gypsum or hydrated lime should be incorporated into the upstream side of any dam walls to improve soil structure and help reduce the risk of failure.
- Dam levels should be monitored to quickly identify any subsidence or instability that might compromise their safety or integrity.

8.7 SOIL CONTAMINATION

To minimise the risk of soil contamination from mining activities we recommend the following:

- The tailings storage facility be lined so it is effectively impermeable.
- The tailings storage facility be sized to wholly contain the 1:100-year ARI rainfall volume to minimise the risk of it ever overtopping (note this also assumes any upstream flow is diverted around the tailings storage facility).
- Any storage or handling areas for potentially-contaminating materials (e.g. fuels, solvents, chemicals) should be sealed with a concrete floor and bunded to 110% of the volume of the largest storage container.
- A Chemical and Hydrocarbon Management Plan for chemical and hydrocarbon handling, storage and use should be included as part of the Mine Operations Plan.

9. CONCLUSIONS

Providing the recommendations for soil management described in Section 8 of this report are included in the management plan for the Dargues Reef Gold Mining Project, there is a minimal risk of long-term impacts to the soils of this site.

We anticipate that the rehabilitated site would retain a similar land capability (Class IV to V for most of the site; Emery, 1985) as presently exists.

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Appendices

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Appendix 1

Soil Test Pit Logs

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Test Pit Number:	1	GPS Reference:	0748798 6063028 (GDA94)
Slope Gradient:	6%	Slope Position:	Lower slope
Soil Landscape:	Braidwood		
Layers	**Depth**	**Description**	
Layer 1:	0-150mm	Dark brown, weakly pedal loam. No coarse fragments.	
Layer 2:	150-270mm	Greyish-brown, weakly pedal sandy clay loam. No coarse fragments.	
Layer 3:	270-800mm	Yellowish brown, moderately pedal fine sandy clay. No coarse fragments.	
Layer 4:	800-1,100mm+	Mottled yellowish brown and light greyish brown, moderately pedal weathering granite (clayey sand). Some coarse fragments.	
Notes:	Adjacent to proposed box cut.		

Test Pit Number:	2	GPS Reference:	0748821 6063166 (GDA94)
Slope Gradient:	10%	Slope Position:	Lower slope / gully
Soil Landscape:	Braidwood		
Layers	**Depth**	**Description**	
Layer 1:	0-200mm	Dark brown, weakly pedal loam. No coarse fragments.	
Layer 2:	200-350mm	Dark greyish brown, moderately pedal light to medium clay loam. No coarse fragments.	
Layer 3:	350-700mm	Yellowish brown, moderately pedal sandy clay. No coarse fragments.	
Layer 4:	700-2,000mm+	Light yellowish brown to greyish brown, moderately pedal sandy clay grading into weathering granite (clayey sand). No coarse fragments.	
Notes:	Existing gully.		

Test Pit Number:	3	GPS Reference:	0748624 6063500 (GDA94)
Slope Gradient:	5%	Slope Position:	Upper to midslope
Soil Landscape:	Braidwood		
Layers	**Depth**	**Description**	
Layer 1:	0-150mm	Dark brown, weakly pedal sandy loam. No coarse fragments.	
Layer 2:	150-400mm	Greyish brown, weakly pedal loamy sand. No coarse fragments.	
Layer 3:	400-800mm	Yellowish brown, moderately pedal sandy light clay. No coarse fragments.	
Layer 4:	800-1,100mm+	Weathering granite. Light yellowish to greyish brown clayey sand. Weakly pedal. No coarse fragments.	
Notes:	Some rock outcropping on nearby ridges.		

Test Pit Number:	4	GPS Reference:	0748812 6063974 (GDA94)
Slope Gradient:	3%	Slope Position:	Upper to mid slope
Soil Landscape:	Braidwood		

Layers	**Depth**	**Description**
Layer 1:	0-150mm	Dark brown, weakly pedal sandy loam. No coarse fragments.
Layer 2:	150-300mm	Greyish brown, weakly pedal sandy loam. No coarse fragments.
Layer 3:	300-700mm	Yellowish brown, moderately pedal sandy clay. No coarse fragments.
Layer 4:	700-1,200mm+	Weathering granite. Yellow, grey and brown, weakly pedal clayey sand.
Notes:	Scattered rock outcropping as small tors.	

Test Pit Number:	5	GPS Reference:	0749282 6063848 (GDA94)
Slope Gradient:	5%	Slope Position:	Lower slope
Soil Landscape:	Braidwood		

Layers	**Depth**	**Description**
Layer 1:	0-200mm	Dark brown, weakly pedal loam. No coarse fragments.
Layer 2:	200-450mm	Yellowish to olive brown, moderately pedal sandy clay. No coarse fragments.
Layer 3:	450-1,200mm+	Yellowish and greyish brown, moderately pedal sandy clay. No coarse fragments.
Notes:	Adjacent to watercourse.	

Test Pit Number:	6	GPS Reference:	0749816 6063467 (GDA94)
Slope Gradient:	6%	Slope Position:	Crest / upper slope
Soil Landscape:	Braidwood		

Layers	**Depth**	**Description**
Layer 1:	0-100mm	Dark brown, weakly pedal sandy loam. No coarse fragments.
Layer 2:	100-300mm	Greyish brown weakly pedal sandy loam. No coarse fragments.
Layer 3:	300-600mm	Reddish to olive brown mottled, moderately pedal sandy clay. No coarse fragments.
Layer 4:	600-1,400mm+	Light yellowish brown, weakly pedal clayey sand (weathering granite).
Notes:	n/a	

Test Pit Number:	7	GPS Reference:	0749976 6063012 (GDA94)
Slope Gradient:	15%	Slope Position:	Upper slope / ridge
Soil Landscape:	Brushy Hill		

Layers	**Depth**	**Description**
Layer 1:	0-200mm	Dark brown, weakly pedal sandy loam. No coarse fragments.
Layer 2:	200-400mm	Grey-brown, moderately pedal, granular sandy loam. No coarse fragments.
Layer 3:	400-1,000mm	Greyish-yellow-brown, moderately pedal sandy clay. <5% coarse fragments.
Layer 4:	1,000-1,400mm+	Gritty, yellowish-grey-brown and mottled clayey sand. 5% coarse fragments as weathering granite.
Notes:		

Test Pit Number:	8	GPS Reference:	0749662 6062660 (GDA94)
Slope Gradient:	20%	Slope Position:	Lower slope
Soil Landscape:	Brushy Hill		
Layers	**Depth**	**Description**	
Layer 1:	0-130mm	Dark brown, weakly pedal sandy loam. No coarse fragments.	
Layer 2:	130-350mm	Greyish brown, weakly to moderately pedal sandy light clay. No coarse fragments.	
Layer 3:	350-700mm	Yellowish brown, moderately pedal, fine sandy clay. No coarse fragments.	
Layer 4:	700-1,400mm+	Weathering granite. Light yellowish and greyish brown, pedal clayey sand. Some coarse fragments.	
Notes:	Nearby rock outcropping.		

Test Pit Number:	9	GPS Reference:	0749413 6063065 (GDA94)
Slope Gradient:	14%	Slope Position:	Mid to lower slope
Soil Landscape:	Brushy Hill		
Layers	**Depth**	**Description**	
Layer 1:	0-150mm	Dark brown, weakly pedal loam. No coarse fragments.	
Layer 2:	150-300mm	Dark greyish brown, moderately pedal sandy loam. No coarse fragments.	
Layer 3:	300-800mm	Yellowish brown, moderately pedal sandy clay. No coarse fragments.	
Layer 4:	800-1,100mm+	Light yellowish brown to greyish brown, massive to weakly pedal weathering granite (clayey sand). <5% coarse fragments.	
Notes:	n/a		

Test Pit Number:	10	GPS Reference:	0749245 6063090 (GDA94)
Slope Gradient:	5%	Slope Position:	Spur, midslope
Soil Landscape:	Brushy Hill		
Layers	**Depth**	**Description**	
Layer 1:	0-100mm	Dark brown, weakly pedal, fine sandy loam. No coarse fragments.	
Layer 2:	100-250mm	Yellowish brown, weakly to moderately pedal sandy clay loam. No coarse fragments.	
Layer 3:	250-550mm	Yellowish brown, moderately pedal sandy clay. No coarse fragments.	
Layer 4:	550-1,000mm+	Yellowish brown, weakly pedal clayey sand (weathering granite).	
Notes:	n/a		

Test Pit Number:	11	GPS Reference:	0748894 6063050 (GDA94)
Slope Gradient:	6%	Slope Position:	Small ridge
Soil Landscape:	Brushy Hill		
Layers	**Depth**	**Description**	
Layer 1:	0-50mm	Dark brown, weakly pedal loam. No coarse fragments.	
Layer 2:	50-200mm	Mid brown, weakly pedal sandy loam to sandy clay loam. No coarse fragments.	
Layer 3:	200-1,000mm	Yellowish-brown, moderately pedal sandy clay loam. 5% coarse fragments.	
Layer 4:	1,000-1,500mm+	Yellowish brown, moderately pedal sandy clay. 10% coarse fragments as weathering granite.	
Notes:	Close to existing workings although soils are undisturbed. No signs of contamination.		

Test Pit Number:	12	GPS Reference:	0749093 6062450 (GDA94)
Slope Gradient:	10-15%	Slope Position:	Upper slope / ridge
Soil Landscape:	Brushy Hill		
Layers	**Depth**	**Description**	
Layer 1:	0-150mm	Dark brown, weakly pedal loam. Well-drained with slight reddish hue. No coarse fragments.	
Layer 2:	150-350mm	Dark brown, granular, moderately pedal sandy loam. No coarse fragments.	
Layer 3:	350-800mm	Dark yellowish brown and mottled, moderately pedal sandy clay. <5% coarse fragments.	
Layer 4:	800-1,200mm+	Yellowish-grey-brown, gritty clayey sand. Massive to weakly pedal. <5% coarse fragments.	
Notes:	n/a		

Test Pit Number:	13	GPS Reference:	0748907 6062167 (GDA94)
Slope Gradient:	5%	Slope Position:	Lower slope
Soil Landscape:	Brushy Hill		
Layers	**Depth**	**Description**	
Layer 1:	0-200mm	Dark brown to dark reddish brown, weakly pedal loam. No coarse fragments.	
Layer 2:	200-300mm	Mid brown, moderately pedal sandy loam. <2% coarse fragments.	
Layer 3:	300-900mm	Yellowish-brown, mottled, moderately pedal sandy clay. <5% coarse fragments.	
Layer 4:	900-1,500mm+	Gritty, grey-brown and yellowish-brown massive to weakly pedal clayey sand. 5% coarse fragments as weathering granite.	
Notes:	Adjacent to proposed dam site.		

Appendix 2

Soil Laboratory Test Results

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Land and Property Management Authority

Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO: SCO10/067R1

REPORT TO: Andrew Macleod
SEEC
PO Box 1098
Bowral NSW 2576

REPORT ON: Eight soil samples
Ref: 09000285

PRELIMINARY RESULTS ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 7 April 2010

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

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

G Holman
(Technical Officer)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666 Fax: 02 6545 2520 ABN 33 537 762 019 | www.lpma.nsw.gov.au

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/067R1
Client Reference: Andrew Macleod
SEEC
PO Box 1098
Bowral NSW 2576

Lab No	Method	C1A/4	C2A/3	C5A/3 CEC & exchangeable cations (me/100g)						C8A/2	
	Sample Id	EC (dS/m)	pH	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	Texture
1	1, 1 0-150	0.04	5.4	9.4	0.5	0.1	4.3	1.3	0.3	3	loam
2	1, 2 150-270	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
3	3, 2 150-400	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
4	3, 4 800-1100	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
5	4, 3 450-1200	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
6	8, 3 350-700	0.03	5.7	15.6	1.4	0.2	3.2	6.5	1.6	<1	heavy clay
7	10, 1 0-100	0.15	4.6	5.7	0.1	0.2	2.4	0.5	<0.1	28	sandy loam
8	10, 2 100-250	0.01	5.5	6.8	0.7	0.1	2.5	1.4	<0.1	3	sandy clay loam

nt = not tested

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/067R1
Client Reference: Andrew Macleod
SEEC
PO Box 1098
Bowral NSW 2576

Lab No	Method	P7B/2 Particle Size Analysis (%)					P8A/2	P9B/2	P2B/2	P3A/1	P6A/1
	Sample Id	clay	silt	f sand	c sand	gravel	D%	EAT	LL (%)	PL (%)	LS (%)
1	1, 1 0-150	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
2	1, 2 150-270	13	17	26	35	9	55	5	nt	nt	nt
3	3, 2 150-400	10	8	37	40	5	67	5	nt	nt	nt
4	3, 4 800-1100	41	5	16	27	11	52	2(1)	66	20	14.5
5	4, 3 450-1200	36	13	15	33	3	22	5	65	23	13.0
6	8, 3 350-700	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
7	10, 1 0-100	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
8	10, 2 100-250	14	10	33	36	7	47	3(1)	nt	nt	nt

nt = not tested

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/067R1
Client Reference: Andrew Macleod
SEEC
PO Box 1098
Bowral NSW 2576

Lab No	Method	P7C/2 Particle Size Analysis - mechanical disp (%)					C6A/2
	Sample Id	clay	silt	f sand	c sand	gravel	OC (%)
1	1, 1 0-150	nt	nt	nt	nt	nt	nt
2	1, 2 150-270	10	21	25	35	9	0.86
3	3, 2 150-400	6	12	36	41	5	0.24
4	3, 4 800-1100	36	11	16	26	11	0.11
5	4, 3 450-1200	29	19	15	34	3	0.18
6	8, 3 350-700	nt	nt	nt	nt	nt	nt
7	10, 1 0-100	nt	nt	nt	nt	nt	nt
8	10, 2 100-250	10	11	35	37	7	0.39

nt = not tested

END OF TEST REPORT

Appendix 3

Environmental Assessment Requirements Addressed In This Report

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Table A3.1
Director-General's Requirements
(Department of Planning – 23 April 2010)

Paraphrased Requirement	Relevant EA Section(s)
SOIL AND WATER	
Including: • a detailed site water balance: • a detailed groundwater model; • potential water quality impacts on the environment and other land users; and • a description of the final landform water management;	Refer to surface water and groundwater assessment reports.

Table A3.2
Coverage of Environmental Issues

Government Agency	Paraphrased Requirement		Relevant EA Section(s)
CONTAMINATED LAND & SOILS			
Department of Environment, Climate Change & Water (01/04/10)	The EA must identify any likely impacts on soil or land resulting from the construction or operation of the project, including the likelihood of:		
	a.	disturbing any existing contaminated soil,	5.5
	b.	contamination of soil by operation of the activity,	6.7 and 8.7
	c.	subsidence or instability,	6.8
	d.	soil erosion, and	8.3
	e.	disturbing acid sulfate or potential acid sulfate soils.	6.6
	The EA must describe and assess the effectiveness or adequacy of any soil management and mitigation measures during construction and operation of the project including:		
	a.	erosion and sediment control measures,	8.3
	b.	proposals for site remediation – see Managing Land Contamination, Planning Guidelines SEPP 55 – Remediation of Land (DUAP and NSW EPA 1998), and	Not applicable – see 8.7
	c.	proposals for the management of these soils – see Assessing and Managing Acid Sulfate Soils (NSW EPA 1995) (note that this is the only methodology accepted by the DECCW).	Not applicable- see 6.6.

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