

# **Nyngan Scandium Project**

## **Soils Assessment**

Prepared by

**Strategic Environmental &  
Engineering Consulting (SEEC) Pty Ltd**



**April 2016**

**Specialist Consultant Studies Compendium**

**Part 9**

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## Soils Assessment

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## EXECUTIVE SUMMARY

A soil investigation has been undertaken at the site of a proposed Scandium mine at Miandetta, near Nyngan, NSW. Due to access limitations the initial site investigation by SEEC was limited to seven test pits spread across the Site. Data from these test pits has been supplemented by additional data obtained during the drilling program.

The soils are alluvial in origin and represent the Pangee Land System which occurs on level plains of Quaternary alluvium derived from undulating erosional country east of Cobar. The soils overlie Silurian and Siluro-Devonian siltstones and sandstones. The site is underlain by Unit 1 of this Land System:

*Unit 1- Level Plains relief to 2m: Deep calcareous red earths with hardpan; isolated Gilgai areas*

The soil profile is reasonably consistent across the project site and comprises of near-surface sandy loam over a layer of gravelly sand clay loam to about 2,500 – 3,000 mm where bedrock is encountered.

The near-surface (<1,500 mm) soils are highly erodible by water and moderately erodible by wind. All soil layers are Type C (coarse) for the purpose of sediment basin sizing. Despite the soils' erodibility, the predicted soil loss is only about 100 t/h/yr (Soil Loss Class 1, very low) as the site is flat and in an area of low rainfall erosivity.

The base saturation of the soils indicates they are very high in the four dominant cations (Potassium, Calcium, Magnesium and Sodium). Soils are moderately to strongly alkaline, poorly structured and have very low organic matter content. Soils would benefit from amelioration to address strong alkalinity as well as organic matter content and poor structure prior to being used for revegetation.

The Land and Soil Capability Classification is Class 3; the land is capable of sustaining cultivation on a rotational basis.

Approximately 200,000m<sup>3</sup> of topsoil would require stockpiling; it is not proposed to strip subsoil.

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## 1. INTRODUCTION

SEEC have been commissioned by RW Corkery & Co Pty Ltd to prepare this Soils Assessment. It forms part of an Environmental Impact Assessment for the proposed Nyngan Scandium Project at Miandetta, west of Nyngan, NSW (**Figure 1**). This Soils Assessment describes the general nature of the soils, their susceptibility to erosion, their potential for use in land rehabilitation and the existing soil and land capability. Engineering properties of the soils are not described here.

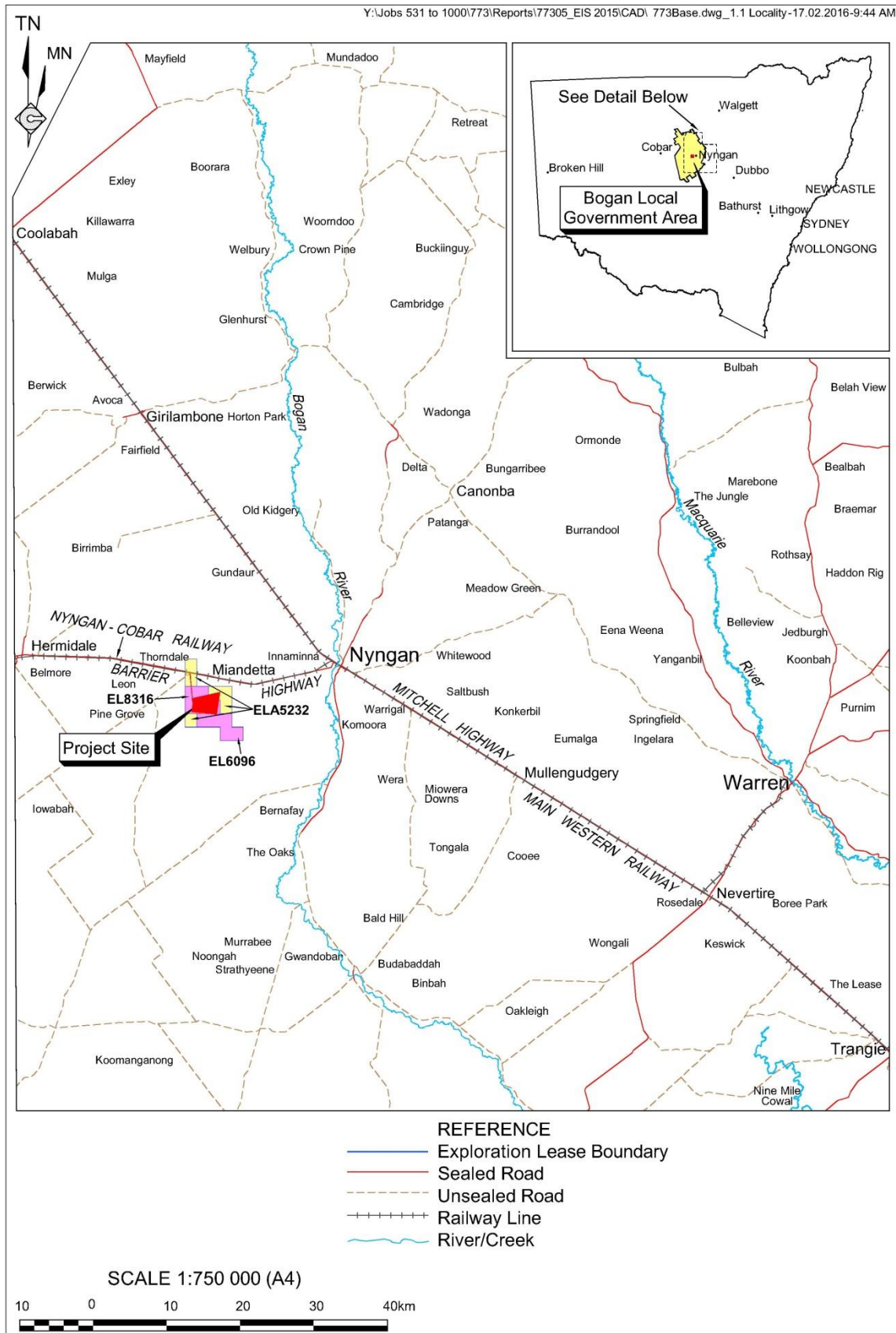
## 2. OVERVIEW OF THE PROPOSAL

The Proposal would incorporate the following (**Figure 2**).

- Establishment of infrastructure required for the Proposal, including a Site Access Road, power and water supply, levee bunds and administration area.
- Extraction of overburden and ore material from two open cuts and a surrounding borrow pit using conventional free dig mining methods on a campaign basis. Annual ore production would be up to 80 000t of high grade ore, and up to 95 000t of low grade ore. Mining would be undertaken for a period of up to 21 years.
- Use of extracted overburden for the construction of site infrastructure, including the Residue Storage Facility, levee bunds, haul roads and water management structures.
- Construction and use of a Processing Plant, incorporating a ROM Pad, feed preparation circuit, high pressure acid leach plant and associated infrastructure, including boilers, reagent and consumable stores and residue management systems, to produce up to approximately 38t per year of scandium oxide which would be transported from the Project Site in small, sealed containers with an indicative capacity of 100L. Processing would be undertaken for the life of the mining operations, namely 21 years.
- Construction and use of a Residue Storage Facility.
- Construction and use of water management structures, including a Raw Water Pond, Event Pond, External Decant Pond, Evaporation Pond, and Sediment Ponds.
- Construction and use of a transformer and electrical distribution network
- Construction of soil stockpiles (for use in rehabilitation works).
- Establishment of a Biodiversity Offset Area.

Disturbance associated with the mining and associated activities would be rehabilitated to create a geotechnically stable final landform, suitable for a final land use of light industry agriculture or nature conservation.

In addition, throughout the life of the Project, the Proponent proposes to undertake additional exploration drilling to further identify mineralisation. Should further mineable mineralisation be identified, and once sufficient information is available to adequately identify the proposed activities, a subsequent application for approval to extract these resources may be prepared.



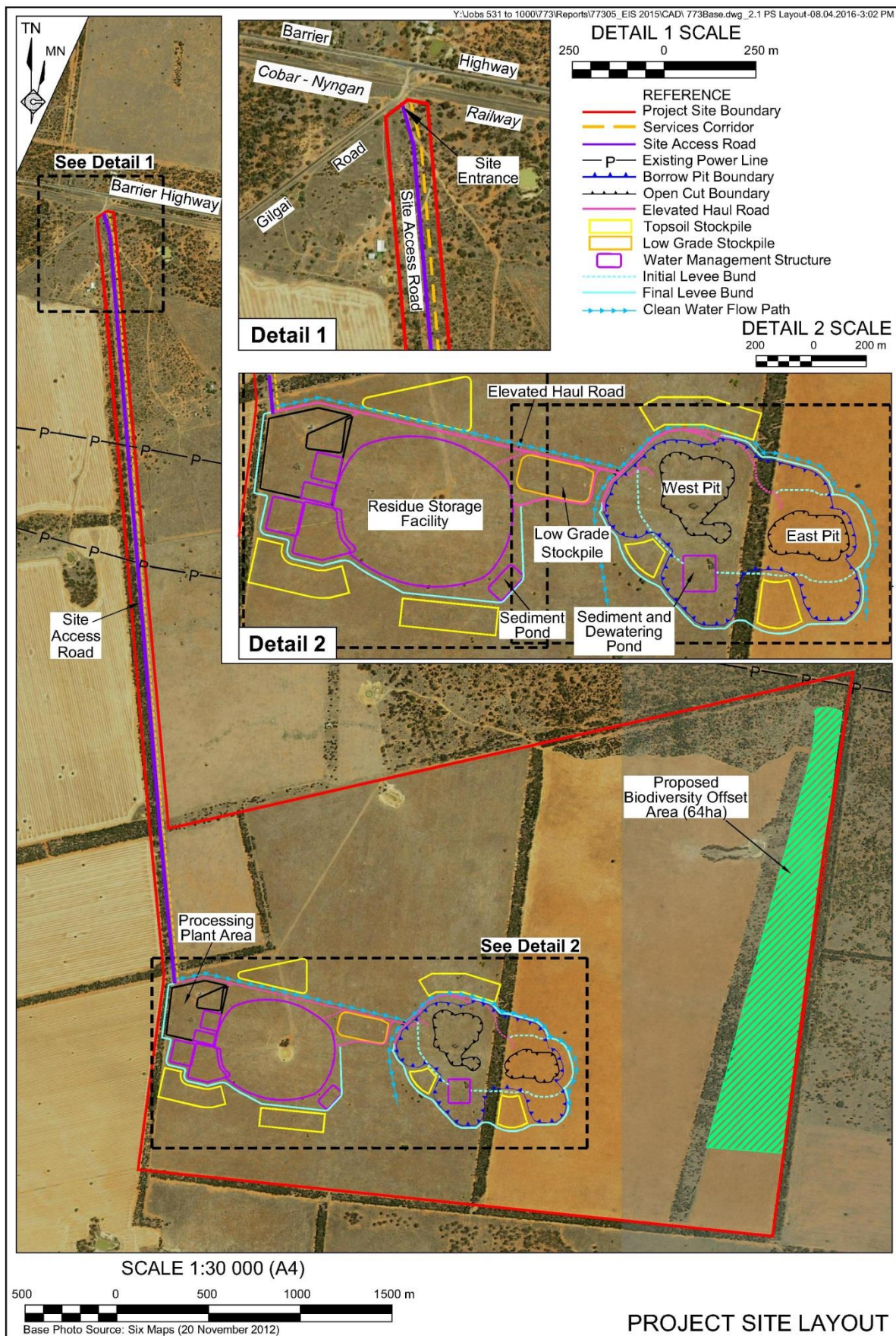


Figure 2 The Proposed Site Layout

### 3. SOIL INVESTIGATION

#### 3.1 MAPPING

Soil landscape mapping on a broad scale (land system mapping) is described in Walker P.J. (1991). It shows that the property (the whole site and the proposed development areas) lie on the Pangee Land System.

The mapping describes the Pangee Land System occurring on level plains of Quaternary alluvium derived from the undulating country east of Cobar. It overlies Silurian and Siluro-Devonian siltstones and sandstones. The site is underlain by Unit 1 of this Land System:

*Unit 1- Level Plains relief to 2m: Deep calcareous red earths with hardpan; isolated Gilgai areas*

#### 3.2 SITE – SPECIFIC INVESTIGATIONS

Soils were first investigated by SEEC in November 2011. At that time, a series of seven test pits were excavated with a backhoe in the locations shown in **Figure 3**. It was not possible to access the entire site during the 2011 site inspection so data from the initial investigation has been supplemented with information obtained from a subsequent geotechnical investigation (Knight Piesold (2015)).

The investigations show the soils conform to the expectations of the land system mapping. A typical soil profile consists of Sandy Loam A1 and A2 horizons overlying gravelly sandy clay loam at depth (the B-Horizon). The A1 Horizon ranged from 200mm to 350mm thickness. The A2 Horizon ranged in thickness up to about 900 mm. Bedrock (C-Horizon) was generally encountered at about 2,500mm to 3,000 mm but is significantly shallower in the northeast of the site, although that area is not within the mine site. The top of the bedrock is often highly weathered, essentially forming a sandy loam to clayey sand soil material as a BC horizon. The individual soil test pit logs are given in Appendix A.

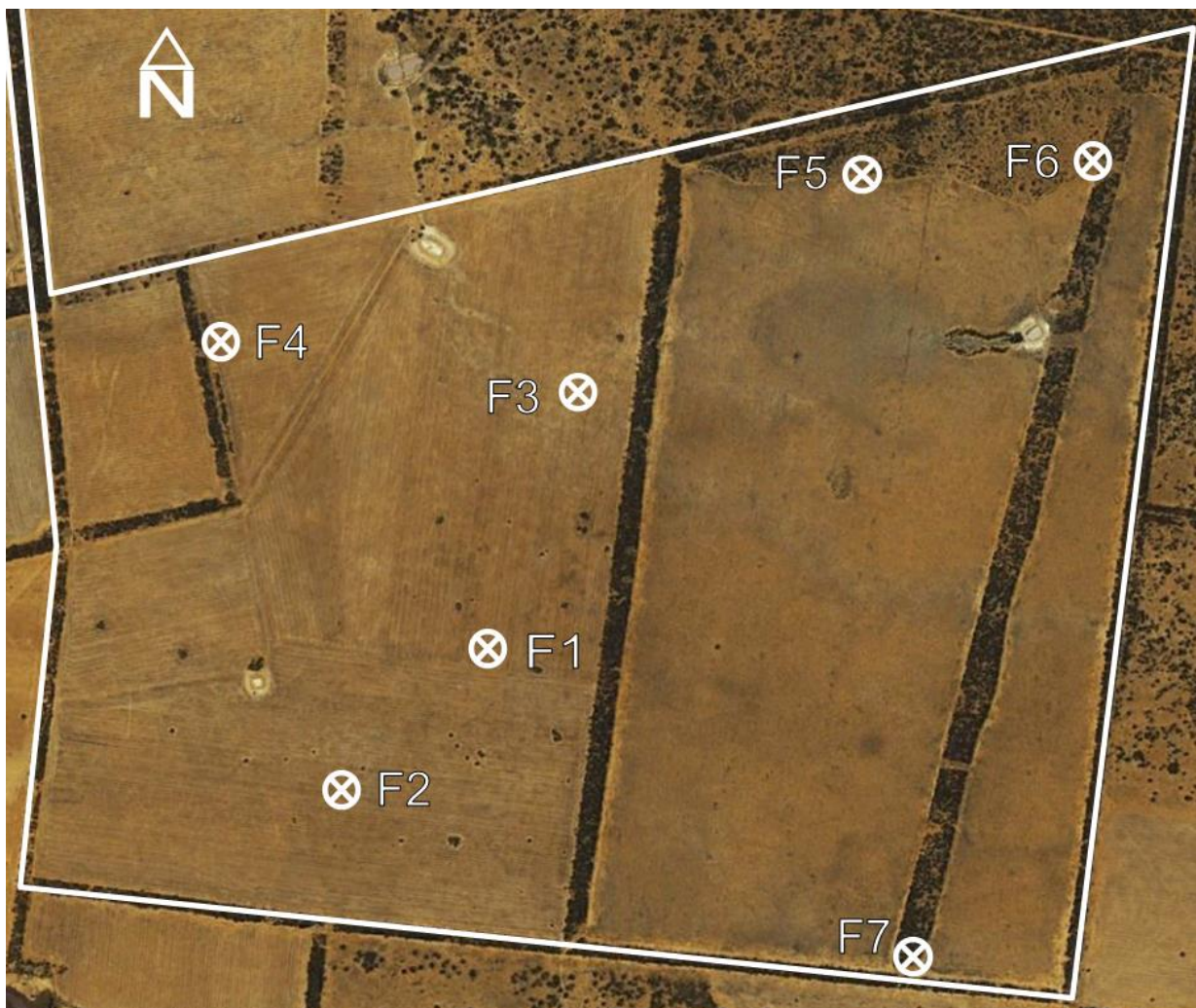
#### 3.3 LABORATORY TESTING

##### 3.3.1 Introduction

Soil samples from Test Pits F1, F3 and F5 were sent to the NSW Department of Lands' Scone Soil Laboratory for suites of chemical and mechanical tests (**Table 1**). Individual samples were composited as follows:

- Topsoil (A1 Horizon) from F1 and F5.
- Subsoil (A2 Horizon) from F1 and F3.
- Deep subsoil (B Horizon) from F3 and F5.

A single sample of weathered rock (BC-Horizon) was taken from Test Pit F1 at 3,000 mm. The laboratory test results are given in **Appendix B** and are described in detail in the following sections.



**Figure 3**      **Location of SEEC Test Pits (SEEC Investigation November 2011)**

**Table 1**  
**Laboratory Testing Schedule**

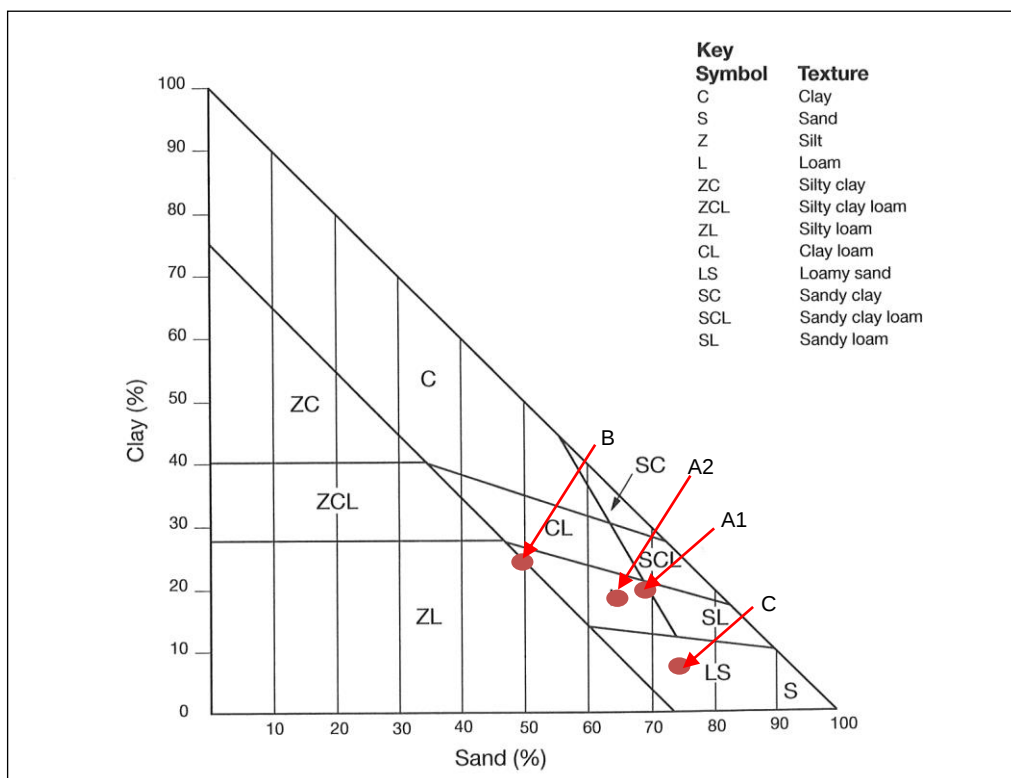
| Test Pit/Layer                                                                                                                                                                                                                                                                                                                                                                                                   | Physical Tests     | Chemical Tests            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------------------|
| F1/a F5/a (A1-Horizon)                                                                                                                                                                                                                                                                                                                                                                                           | PSA, D%, EAT, OC%, | pH, EC, CEC, Exch Cations |
| F3/b F1/b (A2-Horizon)                                                                                                                                                                                                                                                                                                                                                                                           | PSA, D%, EAT, OC%, | pH, EC, CEC, Exch Cations |
| F5/c F3/c (B-Horizon)                                                                                                                                                                                                                                                                                                                                                                                            | PSA, D%, EAT, OC%, | pH, EC, CEC, Exch Cations |
| F1/d (C-Horizon)                                                                                                                                                                                                                                                                                                                                                                                                 | PSA, D%, EAT, OC%, |                           |
| Key to Abbreviations:                                                                                                                                                                                                                                                                                                                                                                                            |                    |                           |
| PSA = Particle size analysis<br>D% = Dispersion percentage<br>EAT = Emerson aggregate test<br>OC% = Organic carbon percentage<br>EC = Electrical conductivity<br>CEC = Cation exchange capacity<br>Exch Cations = Exchangeable cations (Sodium, Potassium, Calcium, Magnesium)<br>Note: The site layer identifications are: Layer a = A1-horizon, Layer b = A2-horizon, Layer c = B-Horizon, Layer d = C-Horizon |                    |                           |

### 3.3.2 Soil Texture

**Table 2** contains the results of the particle size analyses (soil texture). It shows the A1-Horizon lies on the border of sandy clay loam, clay loam, loam and sandy loam (refer to **Figure 4**). The A2 Horizon is a loam. These overlie the C-Horizon which lies on the border of gravelly silty clay loam, gravelly silty loam and gravelly loam. Weathering bedrock is a sandy loam/loamy sand (C-Horizon).

**Table 2**  
**Soil Texture (Particle Size Analysis)**

| Test Pit / Layer                                        | Percent Clay | Percent Silt | Percent Sand | Percent Gravel | Texture                                                                 |
|---------------------------------------------------------|--------------|--------------|--------------|----------------|-------------------------------------------------------------------------|
| F1/a F5/a (A1-Horizon)                                  | 21           | 9            | 70           | 0              | border of sandy clay loam, clay loam, loam and sandy loam               |
| F3/b F1/b (A2-Horizon)                                  | 20           | 14           | 65           | 1              | loam                                                                    |
| F5/c F3/c (B-Horizon)                                   | 16           | 12           | 33           | 39             | border of gravelly silty clay loam, gravelly silty loam, gravelly loam. |
| F1/d (C-Horizon)                                        | 12           | 11           | 75           | 2              | loamy sand                                                              |
| Source: Texture classes from Hazelton and Murphy (2007) |              |              |              |                |                                                                         |



**Figure 4 Soil Horizons Plotted on Soil Texture Triangle<sup>1</sup>**

### 3.3.3 Soil Erodibility

#### 3.3.3.1 K-Factor (sheet erosion)

**Table 3** contains the results of K-Factor analyses, derived using the method described in Rosewell (1993) and Rosewell (2005). Soil erodibility (K-factor) ranges from 0.031 (B-Horizon, moderate) to 0.054 (A2-Horizon, high). The A1 and A2 Horizons are both highly erodible.

**Table 3**  
**Soil Erodibility**

| Test Pit/ Layer        | K-Factor | Relative Erodibility |
|------------------------|----------|----------------------|
| F1/a F5/a (A1-Horizon) | 0.051    | High                 |
| F3/b F1/b (A2-Horizon) | 0.054    | High                 |
| F5/c F3/c (B-Horizon)  | 0.031    | Moderate             |
| F1/d (C-Horizon)       | 0.050    | High                 |

#### 3.3.3.2 Wind Erosion

**Table 4** summarises the key laboratory test results as they relate to the soils' susceptibility to wind erosion. All soils have a moderate susceptibility to wind erosion; the Wind Erodibility Index is 193t/ha (Hazelton and Murphy, 2007)

<sup>1</sup> Hazelton and Murphy (2007), adapted from Soil Science, University of Sydney, 1991

**Table 4**  
**Susceptibility to Wind Erosion.**

| Test Pit/ Layer           | Texture                                                                           | Wind Erodibility Grouping | Wind Erodibility Index (t/ha) |
|---------------------------|-----------------------------------------------------------------------------------|---------------------------|-------------------------------|
| F1/a F5/a<br>(A1-Horizon) | border of sandy clay loam, clay loam, loam and sandy loam. calcareous             | 4L                        | 193                           |
| F3/b F1/b<br>(A2-Horizon) | loam calcareous                                                                   | 4L                        | 193                           |
| F5/c F3/c<br>(B-Horizon)  | border of gravelly silty clay loam, gravelly silty loam, gravelly loam calcareous | 4L                        | 193                           |

### 3.3.3.3 Soil Loss and Erosion Hazard

The estimated potential annual soil losses<sup>2</sup> (Landcom, 2004) have been calculated using SOLOSS 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:

- R-factor (rainfall factor): 1,200 in Rainfall Zone 11 (Landcom, 2004).
- Maximum K-factors from **Table 3**.
- Typical 3% slope gradient and a slope length of 300 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 5**.

**Table 5**  
**Soil Loss Calculations**

| Test Pit/ Layer           | Maximum K-factor<br>(from Table 2) | Typical Slope Gradient | Calculated Soil Loss (t/ha/yr) | Soil Loss Class (from Landcom, 2004) |
|---------------------------|------------------------------------|------------------------|--------------------------------|--------------------------------------|
| F1/a F5/a<br>(A1-Horizon) | 0.051                              | 3%                     | 103                            | Class 1 Very Low                     |
| F3/b F1/b<br>(A2-Horizon) | 0.054                              | 3%                     | 97                             | Class 1 Very Low                     |
| F5/c F3/c<br>(B-Horizon)  | 0.031                              | 3%                     | 59                             | Class 1 Very Low                     |
| F1/d<br>(C-Horizon)       | 0.050                              | 3%                     | 95                             | Class 1 Very Low                     |

Under the guidelines and recommendations contained in Landcom (2004), construction activities in Rainfall Zone 11 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 (which it is).

<sup>2</sup> i.e. to establish relative risk assuming no erosion control measures are used

### 3.3.4 Soil Dispersibility

Emerson Aggregate Test (EAT) testing was done to identify potential dispersibility (Hazleton and Murphy, 2007). The results are in **Table 6**.

**Table 6**  
**Emerson Aggregate Test Results and Analysis**

| Test Pit/ Layer        | EAT Result | Dispersibility  |
|------------------------|------------|-----------------|
| F1/a F5/a (A1-Horizon) | 2(1)       | Some dispersion |
| F3/b F1/b (A2-Horizon) | 3(1)       | Not dispersible |
| F5/c F3/c (B-Horizon)  | 3(1)       | Not dispersible |
| F1/d (C-Horizon)       | 2(1)       | Some dispersion |

Further to the EAT results in **Table 6**, an analysis of dispersibility is presented in **Table 7** using the method in Landcom (2004) to identify whether soils are “significantly dispersible”. None of the samples were found to be significantly dispersible and are all Type C (coarse).

**Table 7**  
**Soil Dispersion and Soil Type**

| Test Pit / Layer       | Dispersion Percentage (%) | PSA Clay (%) | PSA Silt % | Half Silt + Clay % | Dispersion significance* | Sediment type** |
|------------------------|---------------------------|--------------|------------|--------------------|--------------------------|-----------------|
| F1/a F5/a (A1-Horizon) | 25                        | 15           | 11         | 26                 | 5                        | Type C          |
| F3/b F1/b (A2-Horizon) | 25                        | 13           | 15         | 28                 | 5                        | Type C          |
| F5/c F3/c (B-Horizon)  | 44                        | 13           | 12         | 25                 | 8                        | Type C          |
| F1/d (C-Horizon)       | 33                        | 10           | 13         | 23                 | 6                        | Type C          |

Notes:

\*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).

\*\* If total silt and clay is less than 33% then soils are Type C (Landcom, 2004)

### 3.3.5 Analysis of Chemical Test Results

#### 3.3.5.1 Sodidity

The Exchangeable Sodium Percentage (ESP) was calculated to determine the sodicity of the soils (Hazleton and Murphy, 2007) (**Table 8**). The A2 and B-Horizons are both marginally sodic; the B-Horizon is strongly sodic. This is not expected to be a significant issue, however, because of the relatively low clay and silt content in the soils.

**Table 8**  
**Exchangeable Sodium Percentage (ESP)**

| Test Pit / Layer          | Sodium (Na)<br>(me/100g) | CEC  | ESP % | Sodicity         |
|---------------------------|--------------------------|------|-------|------------------|
| F1/a F5/a<br>(A1-Horizon) | 0.7                      | 15.1 | 5     | Non sodic        |
| F3/b F1/b<br>(A2-Horizon) | 1.0                      | 18.2 | 6     | Marginally sodic |
| F5/c F3/c<br>(B-Horizon)  | 2.8                      | 22.0 | 13    | Strongly sodic   |

### 3.3.5.2 Salinity

The results of electrical conductivity testing of representative soil samples are included in **Table 9**, along with an analysis of their salinity levels (Hazleton and Murphy, 2007). Testing shows all horizons are non-saline.

**Table 9**  
**Electrical Conductivity and Salinity**

| Test Pit / Layer          | EC <sup>3</sup> (dS/m) | Soil texture                | Multiplier factor | ECe <sup>4</sup> (dS/m) | Salinity   |
|---------------------------|------------------------|-----------------------------|-------------------|-------------------------|------------|
| F1/a F5/a<br>(A1-Horizon) | 0.13                   | Sandy Loam                  | 11                | 1.43                    | Non saline |
| F3/b F1/b<br>(A2-Horizon) | 0.09                   | Loam                        | 10                | 0.9                     | Non saline |
| F5/c F3/c<br>(B-Horizon)  | 0.17                   | Gravelly silty<br>clay loam | 9                 | 1.53                    | Non saline |

### 3.3.5.3 Cation Exchange Capacity (CEC)

CEC is the capacity of the soil to hold and exchange cations. It is a major controlling agent of the soil's structure, nutrient availability for plant growth and its ability to hold onto nutrients in fertilisers. The results are given in **Table 10** and show that the soils have moderate CEC (Hazleton and Murphy, 2007).

**Table 10**  
**Cation Exchange Capacities**

| Test Pit/ Layer        | CEC  | Classification |
|------------------------|------|----------------|
| F1/a F5/a (A1-Horizon) | 15.1 | Moderate       |
| F3/b F1/b (A2-Horizon) | 18.2 | Moderate       |
| F5/c F3/c (B-Horizon)  | 22   | Moderate       |

<sup>3</sup> Electrical Conductivity

<sup>4</sup> Electrical Conductivity of Saturated Extract

#### 3.3.5.4 Base Saturation

Base saturation (BS) 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 (Hazleton and Murphy, 2007). **Table 11** shows the results of base saturation analysis for these soils, showing that:

- Nutrient status is good in all samples, and
- Only minimal leaching of nutrients has occurred in the past.

**Table 11**  
**Base Saturations**

| Test Pit/ Layer        | Base Saturation % | Classification |
|------------------------|-------------------|----------------|
| F1/a F5/a (A1-Horizon) | 91                | Very High      |
| F3/b F1/b (A2-Horizon) | 91                | Very High      |
| F5/c F3/c (B-Horizon)  | 96                | Very High      |

#### 3.3.5.5 pH

The results of pH testing are shown in **Table 12**. The soils are moderately to very strongly alkaline (Hazleton and Murphy, 2007).

**Table 12**  
**pH Results**

| Test Pit/ Layer        | pH  | Classification         |
|------------------------|-----|------------------------|
| F1/a F5/a (A1-Horizon) | 7.9 | Moderately Alkaline    |
| F3/b F1/b (A2-Horizon) | 8.5 | Strongly Alkaline      |
| F5/c F3/c (B-Horizon)  | 9.4 | Very strongly Alkaline |

#### 3.3.5.6 Organic Matter

Organic matter is largely responsible for the physical and chemical fertility of a soil. The results (see **Table 13**) show that soils across the site have consistently very low organic matter content (Hazleton and Murphy, 2007). This is reflected in the weak soil structure.

**Table 13**  
**Organic Matter Results and Analysis**

| Test Pit/ Layer        | Organic Matter (g/100g) | Rating        |
|------------------------|-------------------------|---------------|
| F1/a F5/a (A1-Horizon) | 0.50                    | Very Low      |
| F3/b F1/b (A2-Horizon) | 0.16                    | Extremely Low |
| F5/c F3/c (B-Horizon)  | 0.13                    | Extremely Low |
| F1/d (C-Horizon)       | 0.05                    | Extremely Low |

### **3.3.6 Soil Structure**

The soils are massive with little structure. Stripping these soils could damage their limited structure if it was carried out when they were too wet or too dry.

### **3.3.7 Soil Drainage**

The soils have high sand content and (at depth) high gravel content but enough clay and silt to limit the permeability to no more than moderate. Therefore, they are classified as Hydrological Group C (Landcom, 2004).

## **3.4 SOILS SUMMARY**

### **3.4.1 A1-Horizon (Topsoil)**

The A1-Horizon (topsoil) is a sandy loam. It is characterised as follows:

- Type C for the purpose of sediment basin design
- Non sodic
- Non saline
- Moderately alkaline
- Moderate CEC
- Saturated with cations
- Very low in organic matter
- Highly erodible by water and moderately erodible by wind.

### **3.4.2 A2-Horizon**

The A2-Horizon is a sandy loam. It is characterised as follows:

- Type C for the purpose of sediment basin design
- Marginally sodic
- Non saline
- Strongly alkaline
- Moderate CEC
- Saturated with cations
- Extremely low in organic matter
- Highly erodible by water and moderately erodible by wind.

### **3.4.3 B-Horizon**

The B-Horizon is a gravelly sandy clay loam. It is characterised as follows:

- Type C for the purpose of sediment basin design
- Highly sodic (the fine matrix)
- Non saline
- Very strongly alkaline
- Moderate CEC
- Saturated with cations
- Extremely low in organic matter
- Moderately erodible by water and wind.

## 4. RECOMMENDATIONS FOR SOIL MANAGEMENT

### 4.1 SOIL STRIPPING

Topsoil (A-Horizon) stripping depth would be limited to 300 mm and the soil stored in stockpiles no more than 2 m in height. This would ensure any existing seed stock is protected and that the soil's structure is maintained. It is not proposed to strip any subsoil.

Weeds would be sprayed before stripping and soils would be stripped when moist only (not dry or wet). Handling would be kept to a minimum to maintain what little structure the soils have. Stockpiles would be immediately seeded to encourage a good cover of native grass. This would prevent weed contamination.

### 4.2 SOIL QUANTITIES

Knight Piesold Consulting have estimated the following volumes of topsoil to be stripped and stockpiled (**Table 14**).

**Table 14**  
**Topsoil Stripping Volumes**

| Locations                            | Area (m <sup>2</sup> ) | Stripping (m) | Swell factor (%) | Volume (m <sup>3</sup> ) |
|--------------------------------------|------------------------|---------------|------------------|--------------------------|
| Process Plant Footprint              | 387,002                | 0.3           | 20%              | 139,321                  |
| Levee Footprint around Process Plant | 50,942                 | 0.3           | 20%              | 18,339                   |
| Levee / Road between Plant and Pit   | 5,441                  | 0.3           | 20%              | 1,959                    |
| Open Pit                             | 95,836                 | 0.3           | 20%              | 34,501                   |
| Contractor Area                      | 4,011                  | 0.3           | 20%              | 1,444                    |
| Open Pit Sediment Pond               | 5,314                  | 0.3           | 20%              | 1,913                    |
| Open Pit Levee Bund                  | 5,442                  | 0.3           | 20%              | 1,959                    |
| <b>TOTAL AROUND PROCESSING AREA</b>  | <b>440,664.09</b>      |               |                  | <b>158,639.07</b>        |
| <b>TOTAL AROUND PIT</b>              | <b>113,322.26</b>      |               |                  | <b>40,796.01</b>         |

Assuming this material is stockpiled no more than 2m high to maintain the soil's integrity, and that the side slopes are no more than 1V:4H, then there would be three stockpiles near the Processing Area approximately 163 m long with a 4m wide crest and three stockpiles near the Extraction Area approximately 82 m long and 4m wide at the crest.

### 4.3 SOIL REUSE

If rich enough, ore would be processed and the waste sent to the tailings storage facility. Eventually the tailings storage facility would require capping with reclaimed topsoil. If the ore proves barren it would be placed in the waste rock emplacement. This too would be eventually be graded to a suitable landform and topsoiled. Access and haul roads would be rehabilitated. Topsoil should be managed when it is neither too wet nor too dry.

## 4.4 REVEGETATION

Rehabilitated slopes and exposed soils that would not be re-worked within two months would require revegetation to provide a minimum cover of at least 70 percent (Landcom, 2004).

The soils are sandy and are likely to become smooth and hardset if over-worked. The final surface should be left scarified and, together with the use of locally-sourced mulch (if readily available) would help ensure sufficient moisture is captured without the need for deep furrowing or “moonscaping” (which can both lead to long-term problems, as detailed in Landloch, 2005). Soils should not be stripped when too wet or too dry (if possible) and would benefit from an application of gypsum to improve structure.

Amelioration to lower pH by approximately 1 pH unit is also recommended.

The soils have very high base saturation levels (**Table 11**). Therefore, rather than using chemical fertilisers, the fertility of the soils would be best improved by incorporating organic matter if locally available. Using organic matter would also be more compatible with the re-introduction of native species. It could be sourced from composting cleared vegetation or from off-site.

## 5. LAND AND SOIL CAPABILITY ASSESSMENT

### 5.1 LAND AND SOIL CAPABILITY RATING

The Site's Land and Soil Capability (LSC) is assessed by considering its biophysical features and individual hazards (OEI, 2012) (**Table 15**). The most limiting LSC rating is Class 3 and applies to both water and wind erosion and to soil structural decline hazard.

**Table 15**  
**LSC Hazard assessments**

| Hazard                                   | Description                                                                                                                                                                  | LSC Class Rating |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| <b>Water erosion (Slope Class)</b>       | The site has slopes between 1 and 3%.                                                                                                                                        | Class 3          |
| <b>Wind erosion</b>                      | Surface soil is fine sandy loam to sandy clay loam with 20% clay (class low)<br>Mean annual rainfall is <500mm<br>Wind erosive power is low<br>Exposure is high (open plain) | Class 3          |
| <b>Soil structure decline hazard</b>     | Surface soil is sandy loam to sandy clay loam with 20% clay.                                                                                                                 | Class 3          |
| <b>Soil acidification hazard</b>         | Surface soils are sandy loam to sandy clay loam.<br>pH (CaCl <sub>2</sub> ) is 7.4<br>Mean annual rainfall is <550 mm                                                        | Class 2          |
| <b>Salinity hazard</b>                   | Recharge potential is low<br>Discharge potential is low<br>Soils are non to slightly saline                                                                                  | Class 1          |
| <b>Water logging hazard</b>              | Soils are moderately drained                                                                                                                                                 | Class 2          |
| <b>Shallow soil and rockiness hazard</b> | Soil depth is >100cm.<br>There is no bedrock exposure                                                                                                                        | Class 1          |
| <b>Mass movement hazard</b>              | Mean annual rainfall is >500 mm<br>No mass movement present                                                                                                                  | Class 1          |

## 5.2 CLASS 3 LANDS

The following description of Class 3 lands is adapted from OEH (2012).

*Class 3 land has limitations that must be managed to prevent soil and land degradation. However, the limitations can be overcome by a range of widely available and readily implemented land management practices. It will be important to minimise soil disturbance to only that necessary for works and to maintain stubble cover and good organic matter levels.*

*Class 3 land includes land that is capable of sustaining cultivation on a rotational basis. This land can be readily used for a range of crops including cereals, oilseeds and pulses. Productivity will vary with the soil's fertility.*

*Severe problems can arise if land management practices do not address the limitations of Class 3 land. For example, severe soil erosion can be caused by regular cultivation without effective erosion control measures, poor water quality can be caused by water erosion and dust storms can result from wind erosion.*

*Off-site impacts of land management could be significant if limitations are not managed adequately; for example, water erosion, water quality and sedimentation, wind erosion and air quality. The land can be subject to sheet, rill and gully erosion as well as wind erosion and soil structure decline. However, these limitations can be controlled by land management practices that are readily available and easily implemented. These include conservation tillage and farming practices such as retaining stubble, reducing tillage, sowing with minimum ground disturbance and the use of pasture rotations in the cropping system.*

*Windbreaks and ground cover should be retained in areas prone to wind erosion. If possible, some timber should be retained in strips or clumps to reduce wind velocity.*

## 6. ONSITE WASTEWATER DISPOSAL

The soils are well suited to effluent disposal. The B-Horizon is classified as a Category 3 soil according to AS/NZS 1547:2012 which suggests it has indicative permeability of 0.5 to 1.5 m/day. Disposal of primary or secondary-treated effluent would be possible in absorption beds.

## 7. REFERENCES

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# APPENDICES

|                   |                                |
|-------------------|--------------------------------|
| <b>Appendix A</b> | <b>Test Pit Logs</b>           |
| <b>Appendix B</b> | <b>Laboratory Test Results</b> |

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# Appendix A

## Test Pit Logs

(No. of pages including blank pages = 6)

## Engineering Log, Excavations

SEEC

Job N<sup>o</sup>: 11000219

|          |                                        |                 |                            |
|----------|----------------------------------------|-----------------|----------------------------|
| Client:  | R.W. Corkery & Co. Pty Limited         | Date excavated: | 27 <sup>th</sup> July 2011 |
| Project: | Nyngan Scandium Project, Nr. Miandetta | Logged by:      | TSH                        |
|          |                                        | Datum:          |                            |
|          |                                        | Slope (%):      | <5                         |

| Location -31.608572, 146.991754 |                    |           |              |                                                     |                    |                        | <b>Test Pit N<sup>o</sup> F1</b> |
|---------------------------------|--------------------|-----------|--------------|-----------------------------------------------------|--------------------|------------------------|----------------------------------|
| Method                          | Sampling / testing | Depth (m) | Layer Change | Material description                                | Moisture condition | Consistency / strength | Remarks                          |
| EB                              | F1A                |           |              | Reddish brown clayey sand                           | D                  | St                     |                                  |
|                                 | F1B                |           |              | Orange silty sand                                   | MM                 | F                      |                                  |
|                                 | F1C                | 1.0       |              | Light orange gravelly sandy clay (ironstone gravel) | MM                 | St                     |                                  |
|                                 | F1D                |           |              | Gravelly Sand                                       |                    | VD                     |                                  |
|                                 |                    | 2.0       |              |                                                     |                    |                        |                                  |
|                                 |                    | 3.0       |              |                                                     |                    |                        |                                  |
|                                 |                    | 4.0       |              |                                                     |                    |                        |                                  |

| Location -31.612548, 146.986870 |                    |           |              |                                  |                    |                        | <b>Test Pit N<sup>o</sup> F2</b> |
|---------------------------------|--------------------|-----------|--------------|----------------------------------|--------------------|------------------------|----------------------------------|
| Method                          | Sampling / testing | Depth (m) | Layer Change | Material description             | Moisture condition | Consistency / strength | Remarks                          |
| EB                              | F2A                |           |              | Reddish brown clayey sand        | D                  | St                     |                                  |
|                                 | F2B                |           |              | Orange silty sand                | MM                 | St                     |                                  |
|                                 | F2C1               | 1.0       |              | Light orange slightly silty clay |                    | VSt                    |                                  |
|                                 |                    | 2.0       |              |                                  |                    | St                     |                                  |
|                                 |                    | 3.0       |              |                                  |                    | VSt                    |                                  |
|                                 |                    | 4.0       |              |                                  |                    |                        |                                  |

| Key                                      |                                                   |                                                                                                                                                                                    |                 |
|------------------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Method                                   | Sampling/testing                                  | Consistency / strength                                                                                                                                                             |                 |
| N natural exposure                       | HP hand penetrometer test (kPa)                   | VS very soft                                                                                                                                                                       | Fb friable      |
| A hand auger                             | DCP dynamic cone penetrometer test (blows/150 mm) | S soft                                                                                                                                                                             | VL very loose   |
| ES excavation, shovel                    | O other                                           | F firm                                                                                                                                                                             | L loose         |
| EB excavation, backhoe                   |                                                   | St stiff                                                                                                                                                                           | MD medium dense |
| ED excavation, bulldozer blade           |                                                   | VSt very stiff                                                                                                                                                                     | D dense         |
| EG excavation, grader                    |                                                   | H hard                                                                                                                                                                             | VD very dense   |
| G gully                                  |                                                   | The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726-1993, Geotechnical Site Investigations |                 |
| C undisturbed core sample 50 mm diameter |                                                   |                                                                                                                                                                                    |                 |
| O other                                  |                                                   |                                                                                                                                                                                    |                 |
|                                          | <b>Moisture condition</b>                         |                                                                                                                                                                                    |                 |
|                                          | D dry                                             |                                                                                                                                                                                    |                 |
|                                          | MM moderately moist                               |                                                                                                                                                                                    |                 |
|                                          | M moist                                           |                                                                                                                                                                                    |                 |
|                                          | W wet                                             |                                                                                                                                                                                    |                 |

Comments: This log must be read with the accompanying report by SEEC

## Engineering Log, Excavations

**SEEC**

**Job N<sup>o</sup>: 11000219**

|          |                                        |                 |                            |
|----------|----------------------------------------|-----------------|----------------------------|
| Client:  | R.W. Corkery & Co. Pty Limited         | Date excavated: | 27 <sup>th</sup> July 2011 |
| Project: | Nyngan Scandium Project, Nr. Miandetta | Logged by:      | TSH                        |
|          |                                        | Datum:          |                            |
|          |                                        | Slope (%):      | <5                         |

| Location -31.600999, 146.995428 |                    |           |              |                                  |                    | <b>Test Pit N<sup>o</sup> F3</b> |         |
|---------------------------------|--------------------|-----------|--------------|----------------------------------|--------------------|----------------------------------|---------|
| Method                          | Sampling / testing | Depth (m) | Layer Change | Material description             | Moisture condition | Consistency / strength           | Remarks |
| EB                              |                    |           |              | Reddish brown clayey sand        | D                  | St                               |         |
|                                 | F3B                |           |              | Orange clayey silty sand         | MM                 | St                               |         |
|                                 |                    | 1.0       |              |                                  |                    |                                  |         |
|                                 | F3C                |           |              | Light orange gravelly sandy clay |                    | VSt                              |         |
|                                 |                    | 2.0       |              |                                  |                    |                                  |         |
|                                 |                    | 3.0       |              |                                  |                    |                                  |         |
|                                 |                    | 4.0       |              |                                  |                    |                                  |         |

| Location -31.599509, 146.982478 |                    |           |              |                                  |                    | <b>Test Pit N<sup>o</sup> F4</b> |         |
|---------------------------------|--------------------|-----------|--------------|----------------------------------|--------------------|----------------------------------|---------|
| Method                          | Sampling / testing | Depth (m) | Layer Change | Material description             | Moisture condition | Consistency / strength           | Remarks |
| EB                              | F4A                |           |              | Reddish brown clayey sand        | D                  | St                               |         |
|                                 |                    |           |              | Orange silty sand                | MM                 | St                               |         |
|                                 |                    | 1.0       |              |                                  |                    |                                  |         |
|                                 | F5C                |           |              | Light orange gravelly sandy clay |                    | VSt                              |         |
|                                 |                    | 2.0       |              |                                  |                    |                                  |         |
|                                 |                    | 3.0       |              |                                  |                    |                                  |         |
|                                 |                    | 4.0       |              |                                  |                    |                                  |         |

| Key                                      |                                                   |                                                                                                                                                                                    |                 |
|------------------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Method                                   | Sampling/testing                                  | Consistency / strength                                                                                                                                                             |                 |
| N natural exposure                       | HP hand penetrometer test (kPa)                   | VS very soft                                                                                                                                                                       | Fb friable      |
| A hand auger                             | DCP dynamic cone penetrometer test (blows/150 mm) | S soft                                                                                                                                                                             | VL very loose   |
| ES excavation, shovel                    | O other                                           | F firm                                                                                                                                                                             | L loose         |
| EB excavation, backhoe                   |                                                   | St stiff                                                                                                                                                                           | MD medium dense |
| ED excavation, bulldozer blade           |                                                   | VSt very stiff                                                                                                                                                                     | D dense         |
| EG excavation, grader                    |                                                   | H hard                                                                                                                                                                             | VD very dense   |
| G gully                                  |                                                   | The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726-1993, Geotechnical Site Investigations |                 |
| C undisturbed core sample 50 mm diameter |                                                   |                                                                                                                                                                                    |                 |
| O other                                  |                                                   |                                                                                                                                                                                    |                 |
|                                          | <b>Moisture condition</b>                         |                                                                                                                                                                                    |                 |
|                                          | D dry                                             |                                                                                                                                                                                    |                 |
|                                          | MM moderately moist                               |                                                                                                                                                                                    |                 |
|                                          | M moist                                           |                                                                                                                                                                                    |                 |
|                                          | W wet                                             |                                                                                                                                                                                    |                 |

Comments: This log must be read with the accompanying report by SEEC

**SEEC****Job N<sup>o</sup>: 11000219**

Date excavated: 27<sup>th</sup> July 2011  
 Logged by: TSH  
 Datum:  
 Slope (%): <5

| Location |                    |           | -31.594499, 147.013197 |                                          | Test Pit N <sup>a</sup> F6 |                      |         |
|----------|--------------------|-----------|------------------------|------------------------------------------|----------------------------|----------------------|---------|
| Method   | Sampling / testing | Depth (m) | Layer Change           | Material description                     | Moisture condition         | Consistency strength | Remarks |
| EB       | F6B                |           |                        | Orange silty sand                        | D                          | St                   |         |
|          | F6C                |           |                        | Light orange gravelly sandy clay         | MM                         | St                   |         |
|          |                    |           |                        | Highly weathered shale some red staining |                            | VSt                  |         |
|          |                    | 1.0       |                        |                                          |                            |                      |         |
|          |                    |           |                        |                                          |                            |                      |         |
|          |                    |           |                        |                                          |                            |                      |         |
|          |                    | 2.0       |                        |                                          |                            | H                    |         |
|          |                    |           |                        |                                          |                            |                      |         |
|          |                    |           |                        |                                          |                            |                      |         |
|          |                    | 3.0       |                        |                                          |                            |                      |         |
|          |                    |           |                        |                                          |                            |                      |         |
|          |                    |           |                        |                                          |                            |                      |         |
|          |                    |           |                        |                                          |                            |                      |         |
|          |                    |           |                        |                                          |                            |                      |         |
|          |                    |           |                        |                                          |                            |                      |         |
|          |                    | 4.0       |                        |                                          |                            |                      |         |

| Key                                      |                                                   |                                                                                                                                                                                    |                 |  |  |
|------------------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|--|--|
| Method                                   | Sampling/testing                                  | Consistency / strength                                                                                                                                                             |                 |  |  |
| N natural exposure                       | HP hand penetrometer test (kPa)                   | VS very soft                                                                                                                                                                       | Fb friable      |  |  |
| A hand auger                             | DCP dynamic cone penetrometer test (blows/150 mm) | S soft                                                                                                                                                                             | VL very loose   |  |  |
| ES excavation, shovel                    | O other                                           | S firm                                                                                                                                                                             | L loose         |  |  |
| EB excavation, backhoe                   |                                                   | St stiff                                                                                                                                                                           | MD medium dense |  |  |
| ED excavation, bulldozer blade           |                                                   | VSt very stiff                                                                                                                                                                     | D dense         |  |  |
| EG excavation, grader                    |                                                   | H hard                                                                                                                                                                             | VD very dense   |  |  |
| G gully                                  |                                                   | The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726-1993, Geotechnical Site Investigations |                 |  |  |
| C undisturbed core sample 50 mm diameter |                                                   |                                                                                                                                                                                    |                 |  |  |
| O other                                  |                                                   |                                                                                                                                                                                    |                 |  |  |
|                                          | <u>Moisture condition</u>                         |                                                                                                                                                                                    |                 |  |  |
|                                          | D dry                                             |                                                                                                                                                                                    |                 |  |  |
|                                          | MM moderately moist                               |                                                                                                                                                                                    |                 |  |  |
|                                          | M moist                                           |                                                                                                                                                                                    |                 |  |  |
|                                          | W wet                                             |                                                                                                                                                                                    |                 |  |  |

Comments: This log must be read with the accompanying report by SEEC

## Engineering Log, Excavations

| <b>SEEC</b>                                                                               |                    |                                                   |              |                                                                                                                                                                                          |                    | <b>Job N<sup>o</sup>: 11000219</b>                                                      |         |  |
|-------------------------------------------------------------------------------------------|--------------------|---------------------------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------------------------------------------------------------------------------------|---------|--|
| Client: R.W. Corkery & Co. Pty Limited<br>Project: Nyngan Scandium Project, Nr. Miandetta |                    |                                                   |              |                                                                                                                                                                                          |                    | Date excavated: 27 <sup>th</sup> July 2011<br>Logged by: TSH<br>Datum:<br>Slope (%): <5 |         |  |
| Location: -31.617866, 147.006851                                                          |                    |                                                   |              |                                                                                                                                                                                          |                    | <b>Test Pit N<sup>o</sup> F7</b>                                                        |         |  |
| Method                                                                                    | Sampling / testing | Depth (m)                                         | Layer Change | Material description                                                                                                                                                                     | Moisture condition | Consistency / strength                                                                  | Remarks |  |
| EB                                                                                        | F7B                |                                                   |              | Orange silty sand                                                                                                                                                                        | D                  | St                                                                                      |         |  |
|                                                                                           |                    |                                                   |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | 1.0                                               |              | Light orange gravelly sandy clay                                                                                                                                                         | MM                 | VSt                                                                                     |         |  |
|                                                                                           |                    | 2.0                                               |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | 3.0                                               |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | 4.0                                               |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    |                                                   |              |                                                                                                                                                                                          |                    | <b>Test Pit N<sup>o</sup></b>                                                           |         |  |
| Method                                                                                    | Sampling / testing | Depth (m)                                         | Layer Change | Material description                                                                                                                                                                     | Moisture condition | Consistency / strength                                                                  | Remarks |  |
|                                                                                           |                    | 1.0                                               |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | 2.0                                               |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | 3.0                                               |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | 4.0                                               |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
| <b>Key</b>                                                                                |                    |                                                   |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
| <b>Method</b>                                                                             |                    | <b>Sampling/testing</b>                           |              | <b>Consistency / strength</b>                                                                                                                                                            |                    |                                                                                         |         |  |
| N natural exposure                                                                        |                    | HP hand penetrometer test (kPa)                   |              | VS very soft Fb friable                                                                                                                                                                  |                    |                                                                                         |         |  |
| A hand auger                                                                              |                    | DCP dynamic cone penetrometer test (blows/150 mm) |              | S soft VL very loose                                                                                                                                                                     |                    |                                                                                         |         |  |
| ES excavation, shovel                                                                     |                    | O other                                           |              | F firm L loose                                                                                                                                                                           |                    |                                                                                         |         |  |
| EB excavation, backhoe                                                                    |                    |                                                   |              | St stiff MD medium dense                                                                                                                                                                 |                    |                                                                                         |         |  |
| ED excavation, bulldozer blade                                                            |                    |                                                   |              | VSt very stiff D dense                                                                                                                                                                   |                    |                                                                                         |         |  |
| EG excavation, grader                                                                     |                    |                                                   |              | H hard VD very dense                                                                                                                                                                     |                    |                                                                                         |         |  |
| G gully                                                                                   |                    |                                                   |              | The classification symbols and soil descriptions are based on<br>the Unified Soil Classification System (Corps of Engineers, 1953)<br>and AS 1726-1993, Geotechnical Site Investigations |                    |                                                                                         |         |  |
| C undisturbed core sample 50 mm diameter                                                  |                    |                                                   |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
| O other                                                                                   |                    |                                                   |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | <b>Moisture condition</b>                         |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | D dry                                             |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | MM moderately moist                               |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | M moist                                           |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
|                                                                                           |                    | W wet                                             |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |
| <b>Comments:</b> This log must be read with the accompanying report by SEEC               |                    |                                                   |              |                                                                                                                                                                                          |                    |                                                                                         |         |  |

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# Appendix B

## Laboratory Soil Test Results

(No. of pages including blank pages = 2)

SOIL CONSERVATION SERVICE  
Scone Research Service Centre

Report No: SCO11/247R1  
Client Reference: M Passfield  
SEEC  
PO Box 1098  
Bowral NSW 2576

| Lab No | Method                | P7B/2 Particle Size Analysis (%) |      |        |        |        |    | P8A/2 | P9B/2 | P7C/2 Particle Size Analysis - mech disp (%) |      |        |        |        |        | C6A/2 |
|--------|-----------------------|----------------------------------|------|--------|--------|--------|----|-------|-------|----------------------------------------------|------|--------|--------|--------|--------|-------|
|        |                       | clay                             | silt | f sand | c sand | gravel | D% |       |       | clay                                         | silt | f sand | c sand | gravel | OC (%) |       |
| 1      | F3B and F1B composite | 20                               | 14   | 48     | 17     | 1      | 25 |       | 3(1)  | 13                                           | 15   | 51     | 20     | 1      | 0.16   |       |
| 2      | F1A and F5A composite | 21                               | 9    | 55     | 15     | <1     | 25 |       | 2(1)  | 15                                           | 11   | 58     | 16     | <1     | 0.50   |       |
| 3      | F5C and F3C composite | 16                               | 12   | 24     | 9      | 39     | 44 |       | 3(1)  | 13                                           | 12   | 26     | 10     | 39     | 0.13   |       |
| 4      | F1D                   | 12                               | 11   | 50     | 25     | 2      | 33 |       | 2(1)  | 10                                           | 13   | 45     | 30     | 2      | 0.05   |       |

| Lab No | Method                | C5A/3 CEC & exchangeable cations (me/100g) |       |                         |      |     |     |     |     |      |    | C8A/2 |  |
|--------|-----------------------|--------------------------------------------|-------|-------------------------|------|-----|-----|-----|-----|------|----|-------|--|
|        |                       | C1A/4                                      | C2A/3 | C2B/3                   | CEC  | Na  | K   | Ca  | Mg  | Al   | P  |       |  |
| 1      | F3B and F1B composite | EC (dS/m)                                  | pH    | pH (CaCl <sub>2</sub> ) | 18.2 | 1.0 | 1.1 | 9.1 | 5.3 | <0.1 | 3  |       |  |
| 2      | F1A and F5A composite | 0.09                                       | 8.5   | 7.4                     | 15.1 | 0.7 | 1.0 | 9.6 | 2.4 | <0.1 | 10 |       |  |
| 3      | F5C and F3C composite | 0.13                                       | 7.9   | 7.3                     | 22.0 | 2.8 | 1.1 | 9.4 | 7.7 | <0.1 | 2  |       |  |

*SK Young*

END OF TEST REPORT