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3 June 2019

Tim Maclean
Chief Operating Officer
Australian Mines Limited
Level 6, 66 St Georges Terrace
Perth WA 6000

Dear Tim,

RE: Topsoil Assessment Brief for Lucky Break Rehabilitation Works

AARC Environmental Solutions Pty Ltd (AARC) have been commissioned by Australian Mines Ltd (AUZ) to prepare a topsoil assessment brief for the Lucky Break Project. Under the current rehabilitation requirements for the Project, AUZ is required to source a topsoil for use on site. Areas of potential topsoil recovery have previously been identified on lands adjacent to the Dingo Dam Mining Lease (ML), as part of a potential topsoil recovery and dam excavation agreement with Spyglass Beef Research Station, the owners of the underlying land parcel. The location of the topsoil assessment study area is shown in Figure 1.

AARC completed a topsoil sampling program in the areas of interest in February 2019 to determine the suitability of the topsoil for rehabilitation purposes. This information was used to classify topsoil resources according to topsoil quality characteristics and identify any areas that may or may not provide a suitable topsoil resource.

Methodology

A total of ten sites, including nine sampling points and one observation point, were surveyed during the topsoil study. The locations of soil survey sites are shown in Figure 2.

Topsoil samples collected from the nine sampling sites were analysed in a NATA accredited laboratory to determine the physical and chemical properties of soils in the study area.

The topsoil results have been analysed in reference to various guideline values generally recommended for the intensive production of crop and pasture plants as sourced from several ‘best practice’ soil sampling resources (Attachment 1). As these values are representative of optimal conditions to support the growth of cultivated or production plants they are presented as a general guide only. The intent of rehabilitation efforts on the Project site is to return the land to the pre-mining land use of low intensity grazing / native ecosystems. Locally occurring native pasture, tree and shrub species tend to exhibit different physical and chemical tolerances to those of intensive production plants.

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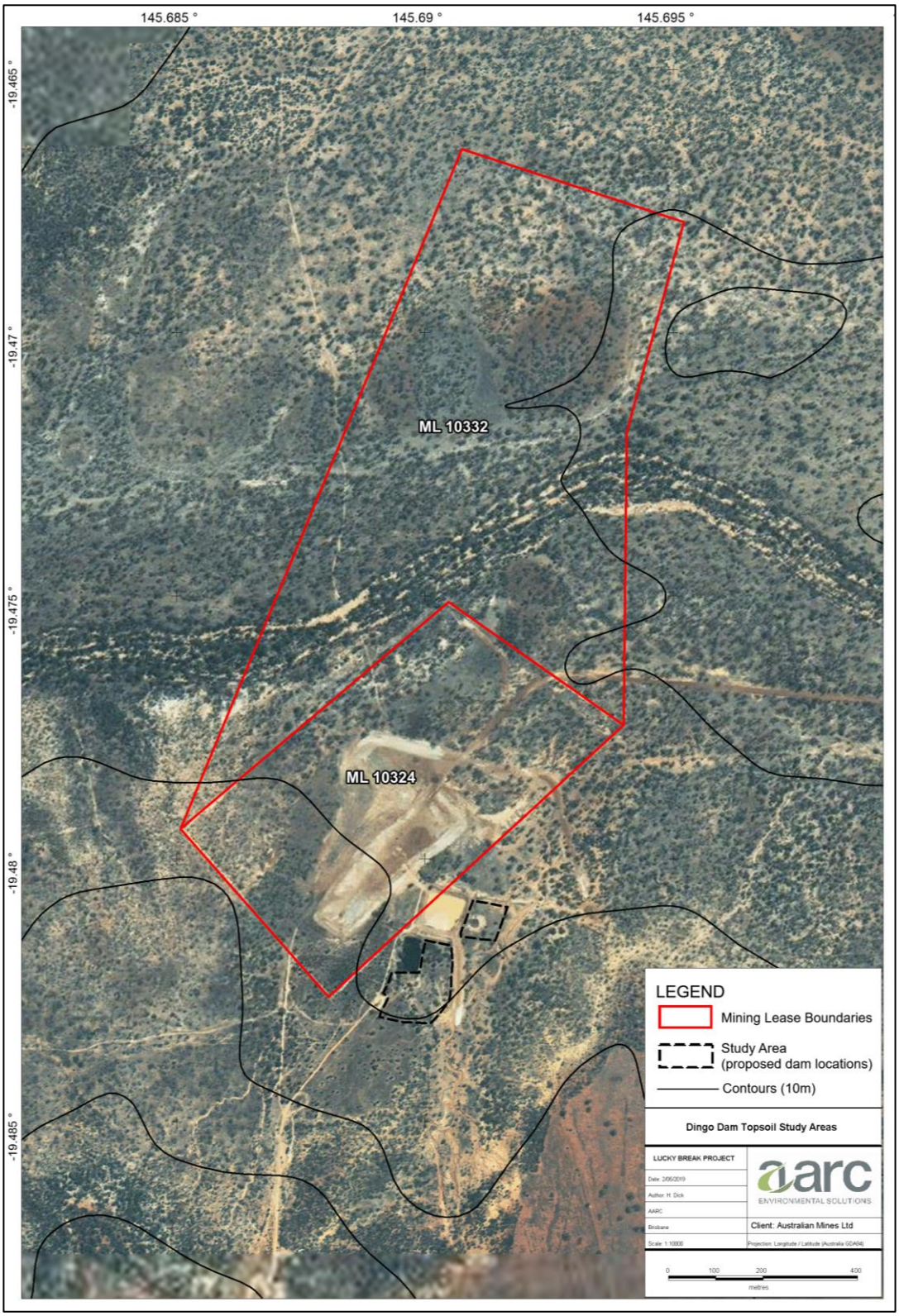

Figure 1 Topsoil Study Area

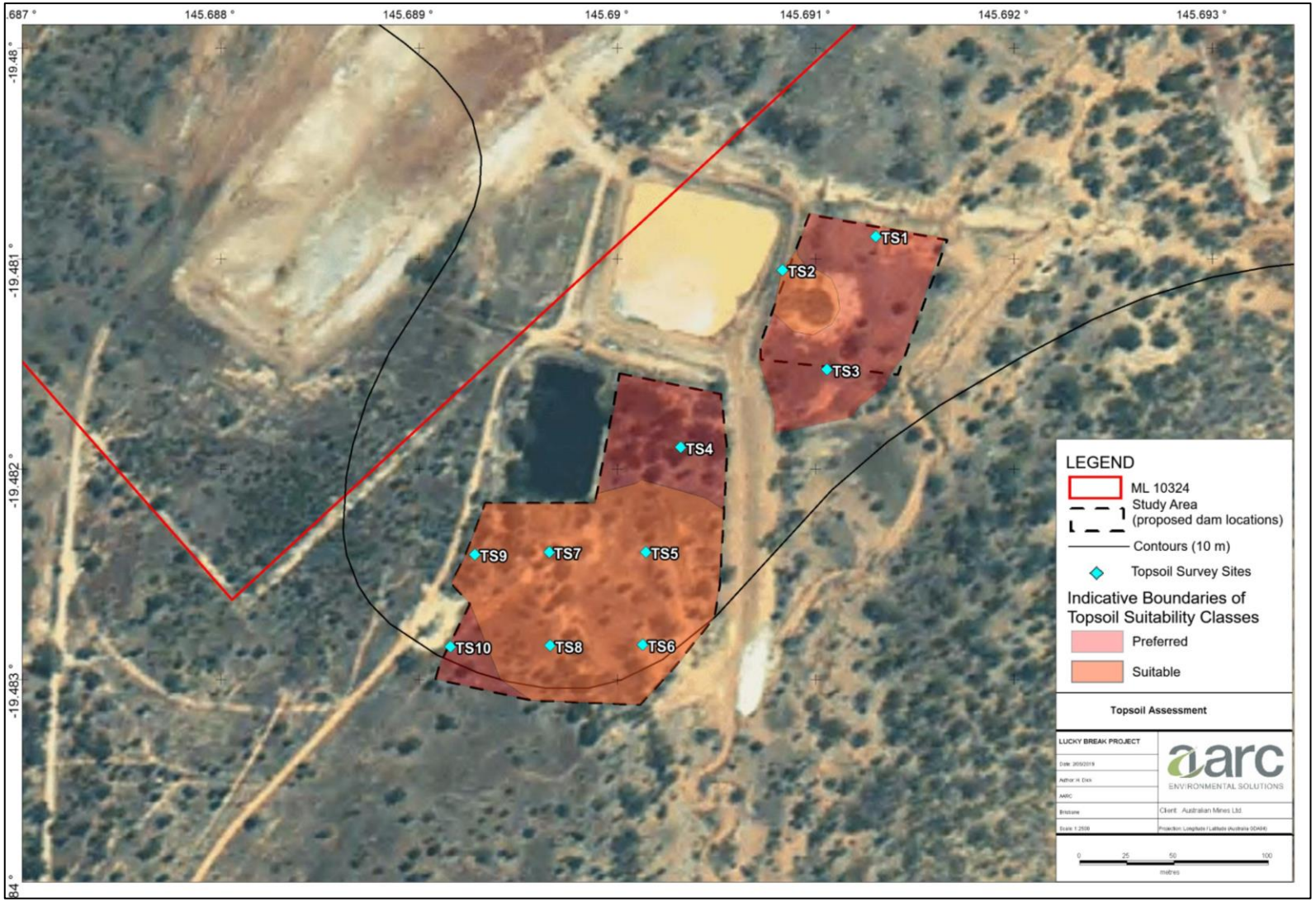

Figure 2 Topsoil Sampling Site Locations

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Results

The physical and chemical properties of the topsoil in the study area are described in the sections below. The soil quality results are displayed in Attachment 1.

Physical Parameters

Physical soil parameters are those items which are not based on chemical data, including soil moisture, colour, texture, and Emerson Class (observed soil dispersion). As outlined below, samples showed little variability in physical characteristics.

- Soil colours were within similar ranges between all sites, ranging from dark brown (7.5YR3/3) to very dark brown (7.5YR2.5/3).
- Soil texture ranged from loamy sands in south western sites, to sandy clay/sandy clay loams in the north east.
- Six sites presented an Emerson Class of 3 (dispersive if physically disturbed), though three sites (TS2, TS3 and TS4) produced values of 2 (moderate dispersive reaction when placed in water).

General Soil Characteristics

General soil characteristics include pH, electrical conductivity (EC), chloride content, and organic matter %. These characteristics have a large impact on the soil's ability to support plant life. pH values should generally measure between 5.5 and 7.5, as the availability of nutrients decreases outside of these limits. Within the survey area, all sites were within the acceptable pH bounds.

High EC and chloride can impact plant osmotic capacity, with increased salinity in the soil negatively impacting plant health. While none of the survey sites demonstrated elevated EC, the chloride concentration at TS2 was slightly elevated in comparison to the guideline value (<600 mg/kg). This exceedance appears to be localised to the soils of the existing dam wall and may be the result of agricultural activities, which may remain in place depending on the final dam design.

Soil organic matter (OM) is important to the general health of a soil, with levels above 1.72% known to support the growth of production plants. Generally, organic matter levels were low across the study area when compared with the guideline value. However, low organic matter compositions are common in drier parts of Queensland, such as the Project region. The values of OM across the sample sites were close in range, with seven sites varying from 0.9 – 1.5%, whilst two sites held percentages of 2.2% and 2.5%.

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Exchangeable Cations

Concentrations and ratios of exchangeable cations can impact the nutrient capacity and dispersion of a soil body. Of particular importance to dispersion is the percentage of exchangeable sodium (ESP), and ratio of calcium to magnesium (Ca/Mg ratio). Ultimately, the cation exchange capacity (CEC) of the soil determines how much impact these parameters will have, as they operate based on a soil's clay content and ability to hold ions. Soils with a high cation exchange capacity are more likely to be affected by elevated ESP and low Ca/Mg ratios.

Survey sites TS1, TS8, TS9, and TS10 should not experience issues with dispersion. Although moderate CEC values were observed, ESP and Ca/Mg ratios were generally at an appropriate level. Sites that may experience issues with dispersion include TS2, TS3, TS4, TS6 and TS7. This is due to a combination of high exchangeable sodium, paired with low Ca/Mg ratios.

Extractable Phosphorous, Potassium, and Nitrogen

Extractable nitrogen, phosphorous and potassium (NPK) are considered the three most important macro-nutrients used by plants, and are key to increasing the carrying capacity of the soil.

Nitrate (plant available nitrogen) and phosphorus concentrations at most sites fell below the guideline levels for supporting intensive grazing or production plants. Despite these comparatively low nitrogen and phosphorus concentrations, existing vegetation cover observed throughout the study area demonstrates that the local soils are capable of supporting both pasture and woody species.

Extractable Sulphur

All sites but one were deemed to contain extractable sulphur concentrations adequate to support plant growth. Sampling site TS2 returned a slightly elevated sulphur concentration of 12 mg/kg, which although outside the guideline range (5 – 10 mg/kg) for the growth of production plants it is not expected to inhibit rehabilitation efforts. These soils were found to support pasture species on the existing dam wall and depending on the final dam design, may remain in place.

Total Metals

High concentrations of total metals can cause plant toxicity, and present risks to grazing livestock, while low levels can cause nutrient deficiency. All sites analysed during this survey presented total metal concentrations below the guideline levels. This includes arsenic, boron, cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc.

Aluminium was recorded in the range of 1620 to 4880 mg/kg and is the only metal for which a guideline value is not defined. Aluminium is only available to plant roots where the soil pH

($CaCl_2$) is <4.5 – 4.7. At higher pH levels, aluminium is bound to the soil minerals. With pH levels recorded in the range of 5.5 to 7.5, aluminium toxicity is not a concern in the topsoils of the study area.

In summary, topsoils in the study area present some potentially dispersive properties as well as low nutrient and organic matter compositions when compared to guideline values for intensive pasture or crop production. Soil characteristics considered critical to supporting plant life such as pH, EC and chloride generally fell within recommended ranges throughout the study area. No indicators of potential metal toxicity were detected in any of the topsoils sampled.

Table 1 below provides a summary of the soil characteristics at each survey site. Topsoil suitability classifications have been derived on the basis of key soil quality conditions required to support low intensity grazing and native vegetation land uses on the Project site. Representative photographs from each soil suitability class are also provided in Table 1.

Table 1 Summary of Soil Quality Characteristics in the Study Area

Suitability	Sampling Site	Soil Characteristics	Photographic Profile
Preferred	TS1	Low OM and low nitrate	 Topsoil surface (TS1)
	TS3	Low Emerson Class (dispersion risk), good OM, good cation concentrations, high Na, good K and low nitrate	
	TS4	Low Emerson Class (dispersion risk), good OM, good cation concentrations, good K, good P and poor nitrate	 Landscape Context (TS4)

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Suitability	Sampling Site	Soil Characteristics	Photographic Profile
	TS10	Low OM, low Mg, low CEC, low P and low nitrate	 Topsoil profile (TS10)
Suitable	TS2	Low Emerson Class (dispersion risk), high chloride, low OM, poor cation concentrations, low P, adequate nitrate and high Sulphur	
	TS6	Low OM, poor cation concentrations (potential dispersion risk), good K, low P and low nitrate	 Topsoil surface (TS6)
	TS7	Low OM, poor cation concentrations (considerable dispersion risk), low P and low nitrate	 Topsoil profile (TS8)
	TS8	Low OM, low Ca, low Mg, low CEC, low P and low nitrate	
	TS9	Low OM, low Ca, low Mg, low CEC, low P and low nitrate	 Landscape context (TS8)

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Analysis of Topsoil Suitability

Overall, topsoils in the study area are considered suitable for the prescribed low intensity grazing / native vegetation rehabilitation purposes. The presence of both pasture and woody vegetation across the study area demonstrates that the physical and chemical properties of topsoil in the study area have the capacity to support plant growth.

Soils within the proposed dam excavation area have been identified as 'preferred' and 'suitable' for rehabilitation purposes as shown in Table 2 and Figure 2. Topsoil in the north-eastern portion of the study area is considered most suitable (preferred) for use in rehabilitation areas (Figure 2). In total, 1.09 hectares (ha) of land in and adjacent to the study area has been mapped as 'preferred' topsoil. Topsoil in the remaining portion of the study area (1.39 ha) is considered 'suitable' for rehabilitation purposes.

Table 2 Topsoil Suitability Classes and Recommendations

Suitability	Description	Recommendations
Preferred	Sandy clay/sandy clay loams with some dispersion risk if disturbed	No restrictions noted. Suitable for stripping <30cm depth. Should be stripped to operator's discretion of soil horizons.
Suitable	Sandy-clay or sandy-loam with moderate risk of dispersion in water	Suitable for stripping ≥20cm depth depending on local soil horizons. Recommend for placement below preferred soil unit and on flat areas of rehabilitation where possible.

On the basis of Department of Environment and Science (DES) Financial Assurance decision, approximately 17,000 m^3 of topsoil is required for use in the placement of topsoil on the Waste Rock Dump (WRD), sediment dam, run of mine and stormwater management bunds.

Based on a proposed topsoil recovery depth of 30 centimetres (cm), approximately 7,200 m^3 of topsoil resource has been identified in the study area. Ideally, topsoil removal will consider localised changes in stripping depth to ensure maximum soil retention. A nominal stripping depth of 30 cm is proposed; however, the localised stripping depth should be at the discretion of the operator. The change from topsoil to sub-soil will usually correspond with a colour or textural change. Unless the proposed dam area can be expanded, additional topsoil will be required from a secondary source to meet the full rehabilitation requirements.

Recommendations for Topsoil use in Rehabilitation

The following strategies may be implemented during topsoil recovery, placement and rehabilitation works to improve soil quality:

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- Where possible, soils identified as 'suitable' should be applied as the base topsoil (to 20 cm) and covered with the 'preferred' soils (to 10 cm) as the topsoil surface layer.
- 'Preferred' soils should be applied preferentially in sloped or potentially erosion prone areas.
- Maximise opportunities for direct placement of topsoil from the dam area to rehabilitation areas and minimise the length of time that topsoil is stockpiled.
- Ripping and seeding of the topsoil will improve rainfall infiltration and enhance natural regeneration.
- Where rehabilitation success is poor, organic ameliorants such as mulch and/or gypsum may be required to increase the availability of nutrients and reduce the dispersion risk.

Other sub-soil and overburden material to be excavated from the proposed dam area may be used in preliminary rehabilitation works. For example, dam overburden material may be applied during any reprofiling or major structural earthworks (e.g. reshaping of bunds or placement of capping material, etc.), then if suitable, excavated sub-soil should be placed in position, followed by the topsoil.

Sub-soil materials are likely to be more dispersive than the topsoil and may have the potential to leach naturally occurring metals. A review of detailed surface geology mapping indicates that the study area is situated within the Late Tertiary – Quaternary Alluvium (TQa, Qr) geological unit, as opposed to the Argentine Metamorphics (sp) unit which underlies the adjacent Dingo Dam ML. The extent of mineralisation observed at Lucky Break is therefore unlikely to occur in the sub-soils of the study area.

In summary, while there may be some limitations to the volume of suitable topsoil available in the study area, the topsoil recovery and dam excavation option does present a practical and feasible option for sourcing topsoil.

Please do not hesitate to contact me if you have any queries.

Yours faithfully,

Hollie Dick
Environmental Scientist
AARC Environmental Solutions Pty Ltd
hdick@aarc.net.au

Attachment 1: Soil Chemistry Results

Site ID			TS1	TS2	TS3	TS4	TS6	TS7	TS8	TS9	TS10
Analyte	Unit	Recommended Grazing Land Values									
Physical Parameters											
Moisture Content	%	-	9.4	18.6	25	20.9	13.1	16.6	15.2	18.5	13
Colour (Munsell)	-	-	Very Dark Brown (7.5YR 2.5/3)	Very Dark Brown (7.5YR 2.5/2)	Very Dark Brown (7.5YR 2.5/2)	Dark Brown (7.5YR 3/3)	Very Dark Brown (7.5YR 2.5/3)	Very Dark Brown (7.5YR 2.5/2)	Very Dark Brown (7.5YR 2.5/2)	Dark Brown (7.5YR 3/3)	Very Dark Brown (7.5YR 2.5/3)
Texture	-	-	Clay Loam, Sandy	Sandy Clay	Clay Loam, Sandy	Sandy Clay	Sandy Clay	Sandy Loam	Loamy Sand	Loamy Sand	Loamy Sand
Emerson Class Number	-	>3[1]	3	2	2	2	3	3	3	3	3
General Soil Characteristics											
pH Value	pH Unit	5.5-7.5[1]	7.2	6.3	6.4	6.8	6	5.8	6.3	5.8	6.6
Electrical Conductivity	dS/m	<0.45[2]	0.039	0.373	0.022	0.039	0.006	0.02	0.007	0.01	0.008
Chloride	mg/kg	<600[3]	<10	600	10	<10	<10	10	<10	<10	<10
Organic Matter	%	>1.72[1]	1.3	1.1	2.8	2.2	0.9	1.5	1.4	1.1	1.1
Exchangeable Cations											
Exchangeable Calcium	meq/100g	2-30[1]	4.5	3.8	4.2	6.8	1.3	1.6	1.3	0.9	2
Exchangeable Magnesium	meq/100g	1-15[1]	2.9	5.1	3.3	7.2	1.4	1.8	0.6	0.4	0.8
Exchangeable Potassium	meq/100g	0.2-2.0[1]	1.7	0.4	0.7	0.9	0.3	0.4	0.4	0.2	0.6
Exchangeable Sodium	meq/100g	<0.1[1]	<0.1	0.5	0.2	<0.1	<0.1	0.3	<0.1	<0.1	<0.1
Cation Exchange Capacity	meq/100g	6-25[1]	9.2	9.8	8.3	15	3.4	4.4	2.3	2.3	3.4
Exchangeable Sodium Percent	%CEC	<6[2]	0.3	4.7	2.1	0.6	1.7	6.6	1	4.2	0.5
Calcium/Magnesium Ratio	-	>1[1]	1.6	0.7	1.3	0.9	0.9	0.9	2.2	2.2	2.5

Site ID			TS1	TS2	TS3	TS4	TS6	TS7	TS8	TS9	TS10
Analyte	Unit	Recommended Grazing Land Values									
Total Metals											
Aluminium	mg/kg	-	3700	4480	4450	4880	2380	2550	1720	1620	1960
Arsenic	mg/kg	<100[4]	<5	6	<5	<5	<5	<5	<5	<5	<5
Boron	mg/kg	<5000[4]	<50	<50	<50	<50	<50	<50	<50	<50	<50
Cadmium	mg/kg	<20[4]	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	mg/kg	<100[4]	42	37	50	46	35	17	18	15	18
Cobalt	mg/kg	<100[4]	9	11	8	8	5	4	2	<2	10
Copper	mg/kg	<7000[4]	10	10	11	13	6	5	<5	<5	5
Lead	mg/kg	<300[4]	10	13	10	11	6	8	8	7	10
Manganese	mg/kg	<3000[4]	284	360	448	313	161	93	79	39	504
Nickel	mg/kg	<400[4]	20	27	14	20	9	6	4	3	7
Zinc	mg/kg	<8000[4]	23	15	22	30	12	10	8	8	9
Extractable P, K (Colwell) and Nitrogen											
Bicarbonate Extractable K (Colwell)	mg/kg	>161[1]	876	<200	276	370	475	<200	<200	<200	<200
Bicarbonate Ext. P (Colwell)	mg/kg	>10[1]	28	<5	8	18	5	<5	<5	<5	<5
Nitrate as N	mg/kg	>8[1]	3.1	27.6	0.9	6.3	0.7	0.2	0.2	<0.1	0.5
Sulphur											
KCl-40 Extractable Sulphur	mg/kg	5-10[1]	<10	12	<10	<10	<10	<10	<10	<10	<10

Sources for guideline values (generally recommended for intensive grazing and crop production land uses):

1 – Hazelton P & Murphy B (2016) *Interpreting Soil Test Results – What do all the Numbers Mean?* (3rd Edition). CSIRO Publishing, Melbourne;

2 – Rayment GE & Lyons D (2011). Soil Chemical Methods – Australasia. Australian Soil and Land Survey Handbook Series, Table 3.1 (*EC limit dependant on soil texture*) CSIRO Publishing, Melbourne;

3 – Soil Testing and some soil test interpretations used by the Queensland DPI (1984), Table 1;

4 - National Environmental Protection (Assessment of Site Contamination) (2011), Schedule B1: Guideline on investigation levels for soil and groundwater. Table 1A (1), Category A.