Soil Quality Assessment

Assessment Site: "Yarran Hut"
Mitchell Highway, Nyngan NSW

Client: BayWa r.e. Projects Australia Pty Ltd

Address: 45 Denison Street, Bondi Junction NSW 2022

(Our Reference: 32626 ER-00)

Disclaimer

This report has been prepared solely for BayWa r.e. Projects Australia Pty Ltd in accordance with the scope provided by the client and for the purpose(s) as outlined throughout this report.

Barnson Pty Ltd accepts no liability or responsibility for or in respect of any use or reliance upon this report and its supporting material by anyone other than the client.

Project Name:	Soil Quality Assessment
Client:	BayWa r.e. Projects Australia Pty Ltd
Project No.	32626
Report Reference	32626 ER-00
Date:	22/04/2020
Revision:	Final

Prepared by:	
Nardus Potgieter M.Sc.(Chem) Environmental Scientist	

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 Background

Barnson Pty Ltd has been engaged by BayWa r.e. Projects Australia Pty Ltd to undertake a Geotechnical Investigation and Soil Quality Assessment in support of a Development Application for a proposed solar power generation facility, to be located at a undeveloped piece of agricultural land, north west of the town of Nyngan, NSW. Figure 1.1 presents a map of the area with the subject site indicated relative to nearby towns and main roads.

Site work for the Geotechnical Investigation and Soil Quality Assessment was undertaken on 26 March 2020 and involved the excavation of six auger holes across the 92 hectare site earmarked for the development. Samples of soil collected from the 6 auger holes were submitted to an accredited laboratory for chemical analysis. The results of this analysis will serve as input to the Soil Quality Assessment.

The purpose of the Geotechnical Assessment is to investigate the geological composition and geotechnical properties of the underlaying soils. The findings of this assessment are recorded in a separate Geotechnical Investigation Report (Barnson 2020).

1.2 Objectives

The main objective of the Soil Quality Assessment is to determine the potential for soil erosion and dryland salinity at the subject site. In addition, the report will document the results from the chemical analysis of the site soil samples and interpret the results in relation to the quality and agricultural potential of the soils.

barnson
DESIGN.PLAN.MANAGE

Figure 1.1 – Location of the subject site.

2.0 BACKGROUND INFORMATION

2.1 Site Description

Figure 1.1 shows that the subject site is a 92 hectare portion of agricultural land, located approximately 16 km north west of the regional town of Nyngan, NSW. The site is currently used for grazing and vegetation over the surface of the site is sparse. Figure 2.1 show the surface of the site. Remnant furrows confirm past use of the site for dryland cropping.

Figure 2.1 – Surface of the subject site.

2.2 Soil Profile

The subject site lies on the border of two geological regions, namely the Great Artesian Basin and the Lachlan Fold Belt. The Great Artesian Basin spans 22% of Australia (1.7 million square kilometres), covering a large area of Queensland and also including parts of NSW, South Australia and the Northern Territory. The Lachlan Fold Belt is located across NSW and Victoria and is characterised by deformed, Palaeozoic deep and shallow marine sedimentary rocks, cherts and mafic volcanic rocks. Soil at the subject site is mapped as the Summervale soil landscape. The Summervale landscape is part of the colluvial slopes and plains and flow lines associated with the Girilambone Beds to the northwest of Nyngan (DECC 2006).

Information from the NSW Soil and Land information system (OEH 2016) indicates the soil type where the subject site is located as Brown Chromosoil and describes it as fragile and medium textured with low organic matter content.

Figure 2.2 presents mapped soil type data from the NSW Soil and Land information system, indicating the location of the subject site and the extent of the Chromosoil soil type.

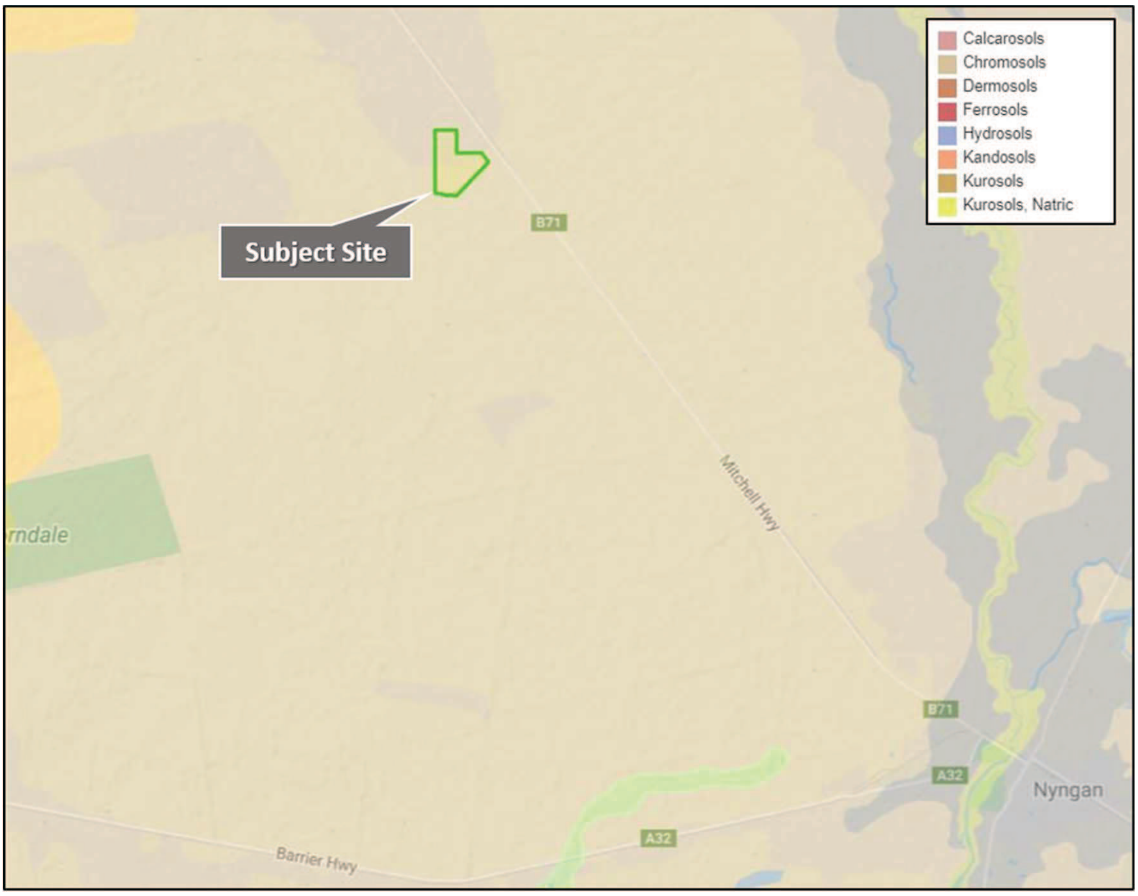

Figure 2.2 – Soil type at the subject site.
Source: NSW Office of Environment & Heritage – Soil and land information (OEH 2016)

A soil profile report from the NSW Soil and Land information system (OEH 2016) indicates the texture of surface soils (surface to 0.5m) in the area as silty loam to sandy clay-loam, while sub soil (>0.5m) is described as medium to heavy clay. This profile is confirmed by the logs presented in the Geotechnical Investigation Report (Barnson 2020), which indicate brown sandy silt at surface underlain by clay. Figure 2.4 shows the sequence of material extracted from one of the auger holes drilled at the subject site. The heaps of soil go from surface (0m) on the left to approximately 2m below surface on the right.

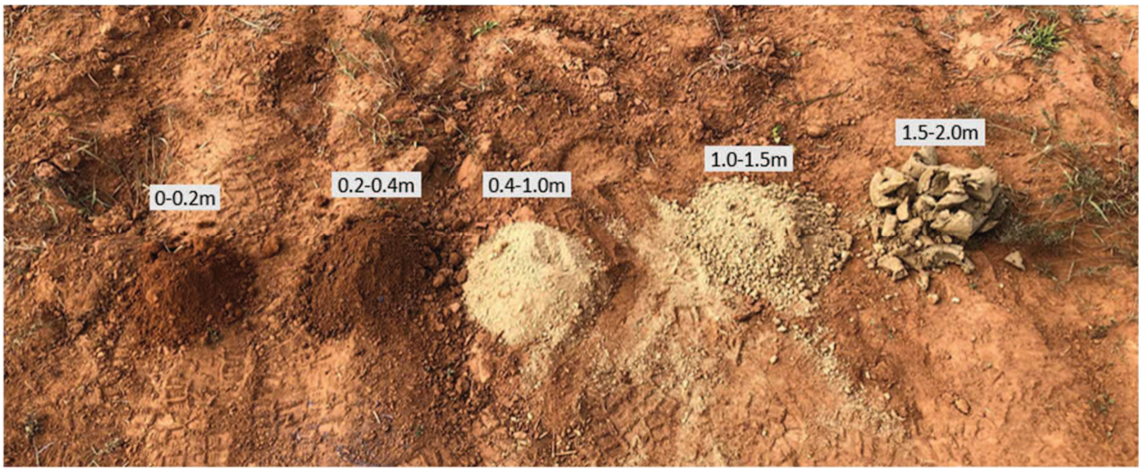

Figure 2.3 – Soil profile.

In spite of recent rain in the area, the surface and subsurface soils are largely dry with only slight moisture present at depth (>1.5m).

2.3 Soil Sampling

Based on the published information available for the area, the surface soil and subsoil profiles are expected to be homologous over the subject site. The locations where the geotechnical test bores and soil samples were collected, was therefore selected simply to cover as much of the subject site as possible as different areas are not expected to exhibit different soil characteristics. Figure 2.4 present a map indicating the approximate locations where samples were collected.

The soil samples used in the soil quality assessment were collected from the 6 locations identified for the geotechnical test bores (see Figure 2.4). Table 2.1 present a list of the samples collected from each location.

Table 2.1 – Surface soil and sub-soil samples collected from the subject site.

Soil Layer	Location and Assigned Sample Number					
	1	2	3	4	5	6
Surface soil (0-200mm)	BAN-01-1	BAN-02-1	BAN-03-1	BAN-04-1	BAN-05-1	BAN-06-1
Surface soil (200-400mm)	BAN-01-2	BAN-02-2	BAN-03-2	BAN-04-2	BAN-05-2	BAN-06-2
Sub-soil (>400mm)	BAN-01-3	BAN-02-3	BAN-03-3	BAN-04-3	BAN-05-3	BAN-06-3

As indicated earlier, the surface soil layer is approximately 400mm thick across the site. Two samples of surface soil were collected at each site from the layer 0 to 200mm and 200mm to 400mm, respectively. Sub surface soil samples were collected to represent the clay material from below 400mm deep. The samples of soil were submitted to the Australian Laboratory Services (ALS) laboratory for chemical analysis. ALS combined the two surface soil samples collected at each location to create six representative composite samples of surface soil for analysis.

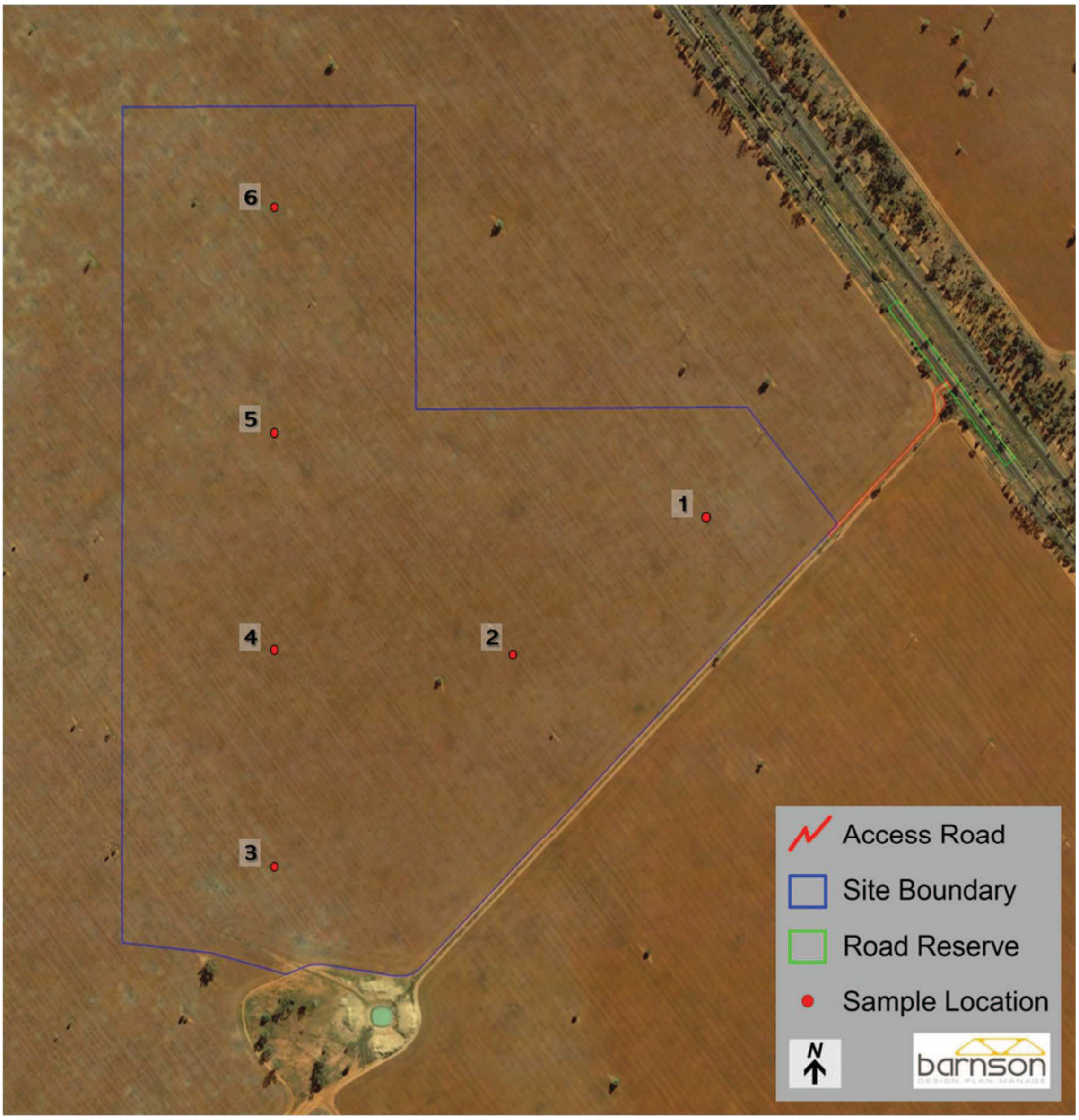

Figure 2.4 – Geotechnical sample collection sites.

3.0 SOIL AND LAND CHARACTERISTICS

3.1 Introduction

This section aims to identify potential agricultural viability as well as the risks of degradation associated with the subject site, according to characteristics of the site and the soils (texture, structure, erosion, salinity, dispersivity, acidity, fertility etc). From this information a scientific assessment is made of the potential issues and the future agricultural potential of the site.

3.2 Erosion Potential

Soil erosion is a complex issue with many related factors. Climate, slope, soils, vegetation cover and land management are all factors that influence soil erosion and the interaction between these factors is what determines erosion risk.

Numerical models are used to integrate the different influencing factors and predict soil erosion rates under different resource and land-use conditions. Several models and methods are available but the most widely used in soil science and soil conservation planning are empirical erosion prediction models such as the Revised Universal Soil Loss Equation (RUSLE). The RUSTLE model was adopted in this study for the assessment of soil erosion risk.

The RUSTLE model considers six parameters including:

- soil erodibility;
- rainfall-runoff erosivity;
- slope length factor;
- slope steepness;
- land cover and management; and
- conservation practices.

Two of the parameters in the RUSTLE model relate to the slope of the land. In the case of the subject site, the slope is very low as the area is practically flat. Figure 3.1 present the topography of the site and its surrounding area.

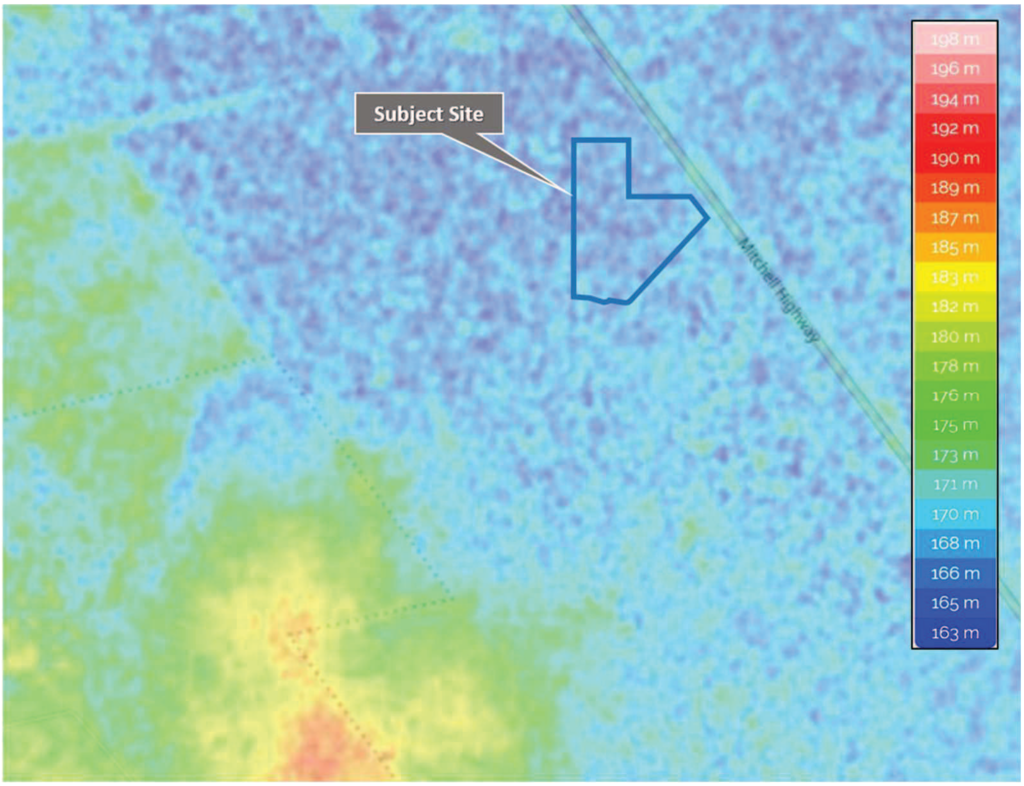

Figure 3.1 – Subject site topography.

The coloured areas on the map represent different elevation above mean sea level. At the site there is no clear increase or decrease in elevation noted in any direction, with small areas showing differences in elevation of between 1m and 4m. This small difference in elevation is at the very limit of the remote measurement technique that is used to compile the elevation map and therefore indicates land with a slope of less than 1° in any direction. A slope of more than 1.2° is required to have overland stormwater runoff enough to create conditions of significant surface soil erosion.

The soil erodibility is the susceptibility of soil particles to detachment and transport by rainfall and runoff. This factor is characteristic of a particular soil texture and is determined by assuming an arbitrarily selected slope length of 22.13 m and slope steepness of 1.2°. The average soil loss for a clay loam soil under cultivated, continuous fallow, conditions and with low organic matter content is estimated at 0.74 tonnes/hectare.

The NSW Soil and Land information system (OEH 2016) publishes soil erosion rates for the Nyngan area. The estimated soil erosion rates are determined using the RUSTLE model and values are presented for erosion of bare soil as well as soil with a vegetation cover. Figure 3.2 and Figure 3.3 show the mapped soil erosion rates for the two conditions. At the subject site (indicated in both Figures) the erosion rate for bare soil is estimated at 20 to 50 tons/hectare per year, while the rate for covered soil is 0.2 to 0.5 tons/hectare per year.

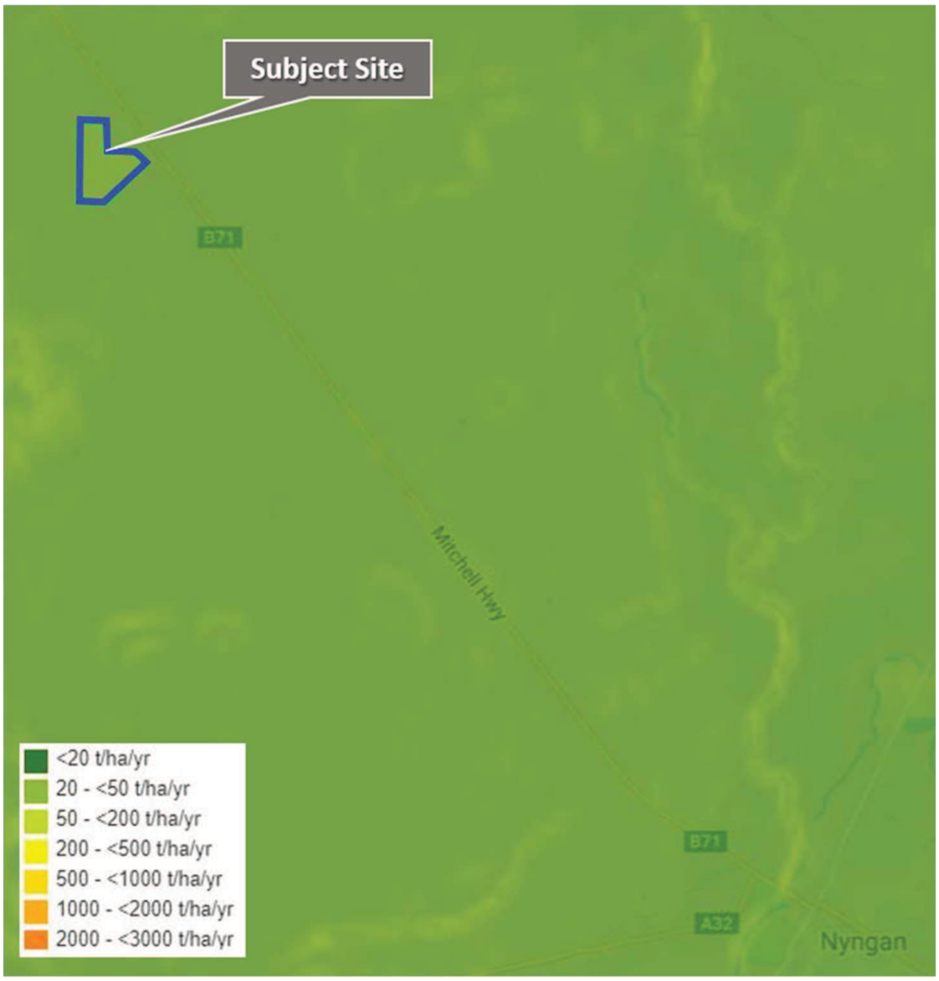

Figure 3.2 – Bare soil erosion rate.
Source: NSW Office of Environment & Heritage – Soil and land information (OEH 2016)

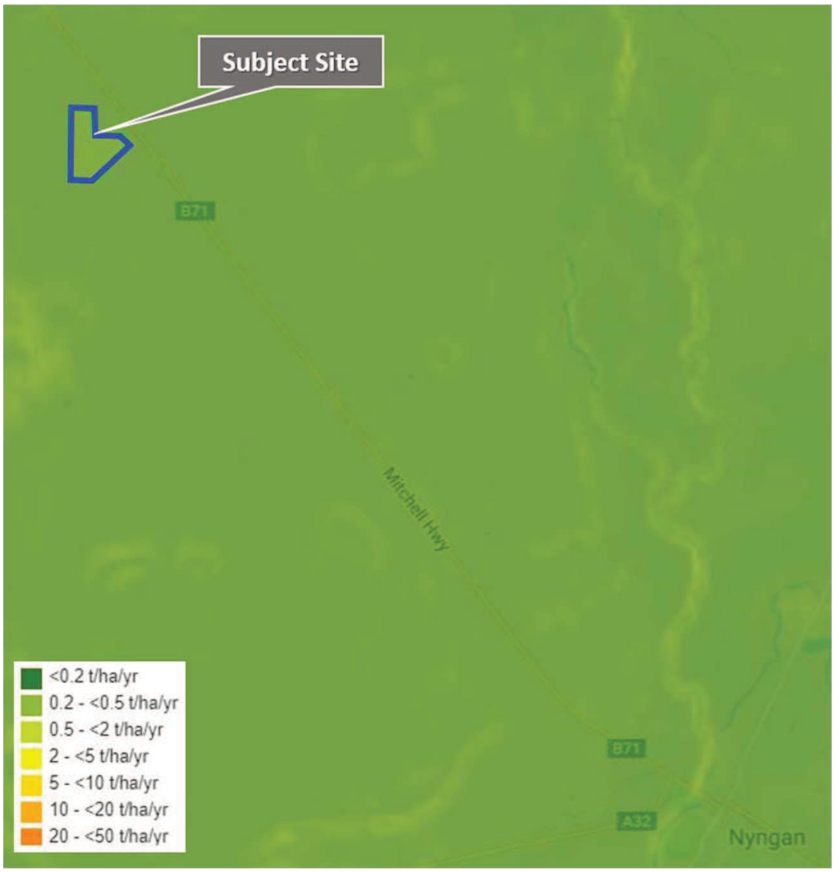

Figure 3.3 – Vegetation covered soil erosion rate.
Source: NSW Office of Environment & Heritage – Soil and land information (OEH 2016)

Considering the high erodibility of the sandy clay-loam surface soil type present at the site, the soil erosion rates estimated for the subject site are relatively low. This is likely attributable to the land being mostly flat, thereby avoiding high velocity rainwater runoff. Although there is some debate as to what can be considered a low soil erosion rate, a value of 6 tons/hectare per year is generally accepted as tolerable.

The values estimated for the subject site indicate that under bare soil conditions, soil erosion potential is unacceptable. However, with vegetation cover the rate of soil erosion can be reduced by a factor of 100 to well below tolerable rates.

3.3 Dryland Salinity

Dryland salinity (salinity on non-irrigated land) is defined as salinity at or near the soil surface causing reduced plant growth, reduced water quality and damage to infrastructure. Dryland salinity is usually the result of three broad processes, namely:

- groundwater recharge (or deep drainage);
- groundwater movement, and;
- groundwater discharge.

Often it results from replacing deep-rooted native vegetation with shallower-rooted crops and pastures, which take up less water. Unused rainwater leaks into the ground causing groundwater to rise and dissolve salts stored deep in the soil.

Soil salinity at the subject site was assessed by determining the amount of salt present in samples of the surface soil and sub-soil collected from the site. The concentration of salt in the soil is determined by measurement of the electrical conductivity (EC) of a saturated paste of soil in water. Table 3.1 present a summary of the measured values in both surface and sub-soil samples. A copy of the analytical results are attached as Appendix A.

Table 3.1 - Electrical conductivity measured in soil samples from the subject site.

	Electrical Conductivity of Saturated Extract (ECe) dS/m					
Soil Layer	1	2	3	4	5	6
Surface soil	0.38	0.48	0.33	0.41	0.32	0.5
Sub-soil	0.78	0.64	0.62	0.62	0.68	0.83

Soils are classified as saline when the measured ECe value is greater than 2 dS/m. The results for both surface and sub-soils at the subject site indicate that the soils are non-saline.

A property closely related to soil salinity is soil sodicity. Sodic soils have excess sodium attached to clay particles, while saline soils have excess sodium salts dissolved in water in the soil. Many soils can be sodic without being saline, however, most saline soils are sodic. The problems associated with sodic soils occur because these soils disperse when wetted. The free salts in saline soil help to preserve soil structure in a sodic soil, but if the site is dried out and the salts are washed away, a strongly sodic soil will result.

The exchangeable sodium percentage (ESP) measures the proportion of cation exchange sites occupied by sodium. Soils are considered sodic when the ESP is greater than 6%, and highly sodic when the ESP is greater than 15%. Results of the six surface soil samples and three sub-soil samples analysed for ESP indicate levels between 0.2 and 1.8% for surface soil and between 2 and 3.2% for sub-soil (see Appendix A). The soils at the subject site are therefore non-sodic.

3.4 Chemical Properties of Soil

3.4.1 Measured Parameters

Physical and chemical properties of the soil determined during the site inspection and from the collected soil samples include soil infiltration rate, phosphorous buffering index, soil pH and the ratio of calcium and magnesium concentration in the soil. These parameters all influence the capability of the soil to sustain crops.

Table 3.2 presents a summary of the parameters measured in selected samples of surface soil collected from the subject site. Only the surface soil was analysed as it is the soil horizon relevant to the agricultural use of the land. The sections that follow present discussions of the different parameters.

Table 3.2 – Measured chemical parameters for surface soil samples.

Parameter	Units	Sample Location					
		1	2	3	4	5	6
Soil pH	pH unit	7.1	7.8	5.7	5.6	5.8	6.6
Exchange acidity	meq/100g	-	-	0.4	<0.1	0.1	-
Exchangeable aluminium	meq/100g	-	-	0.3	<0.1	<0.1	-
Cation exchange capacity	meq/100g	11.6	14.8	7	8.3	8.6	12.3
Calcium/magnesium ratio	-	2.2	2.6	2.8	3.6	2.2	2.5
Phosphate sorption capacity	mg P/kg	1,130	-	924	-	-	726
Colwell extractable phosphorous	mg/kg	16	-	48	-	-	23
Phosphorous buffering index	-	70.9	-	59.6	-	-	45.5

3.4.2 Soil pH and Buffering

Parameters such as the exchange acidity and exchangeable aluminium is only measured by the laboratory if the soil pH is below 6. The pH of a soil is the measurement of the concentration of hydrogen ions in a mixture of soil and water. The greater the concentration of hydrogen ions in the soil water solution, the lower the pH. In return, the lower the pH value, the greater the acidity of the soil will be. Soil pH is an important soil property, because it affects the chemical, biological, and physical processes of the soil and controls the availability of the essential nutrients. In general a soil pH between 5.4 and 7.0 is acceptable for plant growth.

The concentration of hydrogen ions in the soil solution is directly proportional to, and in equilibrium with, the exchangeable acidity retained on the soil's cation exchange complex. This pool of exchangeable acidity refers to the amount of acid cations, aluminium and hydrogen, occupied on the cation exchange complex and represents the buffering capacity of the soil. In the case of the subject site, the extractable acidity and aluminium (see Table 3.2) is very low (<1) indicating low buffering capacity.

Aluminium toxicity can occur in soils that have large amounts of aluminium containing minerals, such as clays. In such soils, aluminium can dissolve into the soil solution as the soil pH drops below 5.4. In contrast, aluminium solubility decreases dramatically as the soil pH increases above 5.4. As a result, proper management of soil pH can prevent problems associated with aluminium toxicity.

Low pH soil is managed through the addition of lime. The optimal pH range for most plants is above 6.0. To avoid aluminium and manganese toxicity problems, a soil should be limed if the pH is less than 5.4. However, when the cation exchange complex of a soil is high but has a low base saturation, the soil becomes more resistant to pH changes. As a result, it will require larger additions of lime to neutralize the acidity.

3.4.3 Cation Exchange Capacity

Cation exchange capacity (CEC) is a measure of the soil's ability to hold positively charged ions. It is a very important soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilisers and other ameliorants (e.g. lime). The main ions associated with CEC in soils are the exchangeable cations calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}).

The CEC of soils varies according the clay %, the type of clay, soil pH and amount of organic matter. Pure sand has a very low CEC, less than 2 meq/100g. The most commonly occurring clays in Australian soils, have CECs ranging between 10 to 25meq/100g, while organic matter has a very high CEC ranging from 250 to 400 meq/100g. Because a higher CEC usually indicates more clay and organic matter is present in the soil, high CEC soils generally have greater water holding capacity than low CEC soils. Surface soil from the subject site have measured CECs ranging between 7 and 14.8 meq/100g (see Table 3.2), indicating a moderate capacity to hold exchangeable cations.

Considering the measured exchangeable ions reported for the surface soil, the optimum ranges of Ca, Mg and K for the measured soil CEC is as follows:

- %Ca – 50-70
- %Mg – 8-20
- %K – 3-5

Comparison of the measured values (refer Appendix A) indicate that while the Ca and Mg saturation is close to ideal, the potassium is concentrated above optimum levels.

3.4.4 Phosphorous

Measurements of phosphorous sorption and extractability was performed on three of the soil samples only, as the result is considered indicative of the parameter, which is interpreted as a range. The phosphate buffering index presented in Table 3.2 is calculated from the measured phosphate sorption capacity and Colwell extractable phosphorous measurements. The phosphate buffering index value is used to determine the rate at which phosphate fertiliser needs to be added to the soil to maximise crop yields.

The values calculated for the subject site are classified as very low and a phosphorous addition rate of 5 to 20 kg/hectare is indicated for optimum yield.

3.5 Infiltration and Water Holding

The water infiltration rate of the soil was determined using an in-field percolation test methodology. The method involves excavating a 150mm hole of uniform diameter into the surface soil, filling the hole with water and measuring the drop in water level over a set time period. The procedure is repeated several times to get a stable reading. Two sets of measurements were made at the subject site, one near sample location 1 and one near sample location 3 (refer Figure 2.4).

Based on the readings collected the field infiltration rate for the subject site ranges between 16 and 19mm/hour. According to the relation ship between water infiltration rate and soil structure (Geeves, et al. 1995), a rate of between 10 to 30mm/hour indicates a poor soil structure.

One of the main functions of soil is to store moisture and supply it to plants between rainfalls or irrigations. Evaporation from the soil surface, transpiration by plants and deep percolation combine to reduce soil moisture status between water applications. If the water content becomes too low, plants become stressed. The plant available moisture storage capacity of a soil provides a buffer which determines a plant's capacity to withstand drought.

The amount of water available to plants is determined by the capillary porosity and is calculated by the difference in moisture content between field capacity and wilting point. This is the total available water storage of the soil. As indicated earlier, water holding of soil varies with texture and organic matter content. On average a sandy clay loam has a available water storage of 1.3 to 1.5 mm/cm depth. For the subject site with a surface soil depth of 40cm this equates to 52 to 60mm of available water. Given the low organic content of the soil the lower end of this scale is most likely to apply.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The layer of surface soil at the subject site is approximately 400mm thick across the site and is classified as sandy clay loam with weak structure and low organic content. The surface soil is underlain by a layer of hard sandy to heavy clay of undetermined thickness.

Erodibility of the surface soils at the subject site is medium to low. The low slope of the land largely prevents water erosion of the surface soil, but bare soil may be subject to wind erosion. Vegetation dramatically decreases the risk of soil erosion to below 0.5 ton/hectare per year.

Both the surface soils and sub-soils (clay) at the subject site are non-saline and non-dispersive (sodic) in nature.

The surface soil at the subject site is of moderate fertility, with neutral to slightly acidic pH (5.5 to 7) optimum for the production of cereals, oilseeds, pulses and pasture grass. The soil has low acid buffering capacity and is unlikely to become acidic.

The soil has no specific limitations to fertility, aside from a limited water holding capacity, due to low organic content, and low phosphate buffering index indicating a possible high application of phosphorous fertiliser may be required to optimise crop yield.

A low water infiltration rate and the resistant sub-soil layer implies a high propensity for saturation (waterlogging) following high rainfall. Vegetation cover can further utilise excess water during high rainfall events to limit the risk of waterlogging.

- It is recommended that the growth of natural grass species present at the subject site be encouraged to stabilise the surface soils and prevent soil erosion.
- Fertilisers high in nitrogen have the potential to lead to the acidification of soil and should be used cautiously.
- Agricultural lime can be applied to improve the base buffering capacity of the soil and avoid the formation of low pH conditions.

5.0 REFERENCES

Barnson. 2020. *Geotechnical Investigation Report, Assessment Site: "Yarran Hut" Mitchell Highway, Nyngan NSW, 32626-GR01_A.* Dubbo, NSW: Barnson Pty Ltd.

DECC. 2006. *Nyngan Soil Landscape Map.* Canberra: Department of Environment and Climate Change.

Geeves, G, H Cresswell, B Murphy, and C Chartres. 1995. *Productivity and sustainability from managing soil structure in cropping soils of southern NSW and northern Victoria on lighter textured soil surfaces.* Sydney: CSIRO Division of Soils & NSW Dept. Land and Water Conservation.

OEH. 2016. *eSpade2.* December. Accessed April 2, 2020. https://www.environment.nsw.gov.au/eSpade2WebApp#.

Appendix A – Soil Analysis Results

Environmental Division
Mudgee
Work Order Reference
ME2000504

Telephone : 02 6372 6735

barnson
a Unit 4 / 108-110 Market Street
Mudgee NSW 2850
t 1300 BARNSON (1300 227 676)
e generalenquiry@barnson.com.au
w www.barnson.com.au

CHAIN OF CUSTODY AND ANALYTICAL REQUEST

Job Number	32626	Date	30 March 2020
Laboratory	ALS Environmental Mudgee	Report to	Nardus Potgieter npotgieter@barnson.com.au
Sample Temperature on Receipt 18			
	Signature:		

Sample ID	Description	Sample Date/Time	Lab Report ID	Analysis request 1	2	3	4	5	6
BAN-01-1 & BAN-01-2	Top Soil - Site 1	26/03/2020 8:00	32626-1A	X	X	X	X	X	X
BAN-01-3	Sub-soil - Site 1	26/03/2020 8:00	32626-1B			X	X		
BAN-02-1 & BAN-02-2	Top Soil - Site 2	26/03/2020 8:30	32626-2A	X	X	X	X		
BAN-02-3	Sub-soil - Site 2	26/03/2020 8:30	32626-2B			X			
BAN-03-1 & BAN-03-2	Top Soil - Site 3	26/03/2020 9:40	32626-3A	X	X	X	X	X	X
BAN-03-3	Sub-soil - Site 3	26/03/2020 9:40	32626-3B			X	X		
BAN-04-1 & BAN-04-2	Top Soil - Site 4	26/03/2020 11:26	32626-4A	X	X	X	X		
BAN-04-3	Sub-soil - Site 4	26/03/2020 11:26	32626-4B			X			
BAN-05-1 & BAN-05-2	Top Soil - Site 5	26/03/2020 11:51	32626-5A	X	X	X	X		
BAN-05-3	Sub-soil - Site 5	26/03/2020 11:51	32626-5B			X	X		
BAN-06-1 & BAN-06-2	Top Soil - Site 6	26/03/2020 13:40	32626-6A	X	X	X	X	X	X
BAN-06-3	Sub-soil - Site 6	26/03/2020 13:40	32626-6B			X			

1	Combine for analysis
2	Soil pH (1:5)
3	Electrical Conductivity of a saturated soil Extract (ECe)
4	Exchangeable Cations (Ca, Mg, Na, K) plus ECEC & ESP on Soils
5	Bicarbonate Extractable P (Colwell)
6	P Sorption Capacity

Relinquished by / Affiliation	Accepted by / Affiliation	Date
[signature] / Barnson	Brett Rowley / ALS Mudgee	30/03/2020
	15:29	

Appendix B - Chain of Custody

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ME2000504**	Page	: 1 of 6
Client	: **BARNSON**	Laboratory	: Environmental Division Mudgee
Contact	: Nardus Potgieter	Contact	: Mary Monds (ALS Mudgee Sampler)
Address	: Unit 4 108-110 Market Street MUDGEE NSW 2850	Address	: 1/29 Sydney Road Mudgee NSW Australia 2850
Telephone	: 1300227676	Telephone	: 02 6372 6735
Project	: 32626	Date Samples Received	: 30-Mar-2020 16:29
Order number	: ----	Date Analysis Commenced	: 01-Apr-2020
C-O-C number	: ----	Issue Date	: 09-Apr-2020 15:13
Sampler	: Client Sampler		
Site	: ----		
Quote number	: SY/546/19 Soil		
No. of samples received	: 24		
No. of samples analysed	: 12		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Dian Dao		Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

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

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

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

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

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

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

- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: COMPOSITE
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	COMP 1	COMP 2	COMP 3	COMP 4	COMP 5
Client sample ID				BAN-01-1 & BAN-01-2	BAN-02-1 & BAN-02-2	BAN-03-1 & BAN-03-2	BAN-04-1 & BAN-04-2	BAN-05-1 & BAN-05-2
Client sampling date / time				02-Apr-2020 09:00	02-Apr-2020 09:00	02-Apr-2020 09:00	02-Apr-2020 09:00	02-Apr-2020 09:00
				ME2000504-001	ME2000504-003	ME2000504-005	ME2000504-007	ME2000504-009
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.1	7.8	5.7	5.6	5.8
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	380	479	327	409	324
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	0.4	<0.1	0.1
Exchangeable Aluminium	----	0.1	meq/100g	----	----	0.3	<0.1	<0.1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	9.1	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	----	3.5	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	----	2.2	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	----	<0.2	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	----	14.8	----	----	----
Exchangeable Sodium Percent	----	0.2	%	----	<0.2	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	6.7	----	4.0	5.0	4.5
Exchangeable Magnesium	----	0.1	meq/100g	3.1	----	1.4	1.4	2.0
Exchangeable Potassium	----	0.1	meq/100g	1.6	----	1.6	1.9	2.0
Exchangeable Sodium	----	0.1	meq/100g	0.2	----	<0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	11.6	----	7.0	8.3	8.6
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	<0.1	<0.1	<0.1
Exchangeable Sodium Percent	----	0.1	%	1.8	----	1.0	0.6	1.0
Exchangeable Magnesium Percent	----	0.1	%	27.0	----	19.8	17.2	22.9
Exchangeable Potassium Percent	----	0.1	%	14.0	----	22.6	22.5	23.2
Exchangeable Calcium Percent	----	0.1	%	57.1	----	56.6	59.6	52.8
Calcium/Magnesium Ratio	----	0.1	-	2.2	----	2.8	3.6	2.2
Magnesium/Potassium Ratio	----	0.1	-	1.9	----	0.9	0.8	1.0
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	1130	----	924	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	16	----	48	----	----

Analytical Results

Sub-Matrix: **COMPOSITE** (Matrix: **SOIL**)			Client sample ID	**COMP 6 BAN-06-1 & BAN-06-2**	**----**	**----**	**----**	**----**
			Client sampling date / time	02-Apr-2020 09:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**ME2000504-011**	**--------**	**--------**	**--------**	**--------**
				Result	----	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**6.6**	----	----	----	----
EA032: Electrical Conductivity (saturated paste)								
ø **Electrical Conductivity (Saturated Paste)**	----	1	µS/cm	**500**	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**7.3**	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	**2.9**	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	**2.2**	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	**12.3**	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	**0.4**	----	----	----	----
Exchangeable Magnesium Percent	----	0.1	%	**23.4**	----	----	----	----
Exchangeable Potassium Percent	----	0.1	%	**17.5**	----	----	----	----
Exchangeable Calcium Percent	----	0.1	%	**58.6**	----	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	**2.5**	----	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	**1.3**	----	----	----	----
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	**726**	----	----	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	**23**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	BAN-01-3	BAN-02-3	BAN-03-3	BAN-04-3	BAN-05-3
			Client sampling date / time	26-Mar-2020 08:00	26-Mar-2020 08:30	26-Mar-2020 09:40	26-Mar-2020 11:26	26-Mar-2020 11:51
Compound	CAS Number	LOR	Unit	ME2000504-002	ME2000504-004	ME2000504-006	ME2000504-008	ME2000504-010
				Result	Result	Result	Result	Result
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	777	642	615	619	679
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	7.8	----	8.1
Exchangeable Magnesium	----	0.2	meq/100g	----	----	4.3	----	5.6
Exchangeable Potassium	----	0.2	meq/100g	----	----	2.3	----	2.4
Exchangeable Sodium	----	0.2	meq/100g	----	----	0.4	----	0.3
Cation Exchange Capacity	----	0.2	meq/100g	----	----	14.8	----	16.4
Exchangeable Sodium Percent	----	0.2	%	----	----	2.6	----	2.0
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	17.3	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	8.2	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	2.1	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.9	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	28.4	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	3.2	----	----	----	----
Exchangeable Magnesium Percent	----	0.1	%	28.6	----	----	----	----
Exchangeable Potassium Percent	----	0.1	%	7.4	----	----	----	----
Exchangeable Calcium Percent	----	0.1	%	60.7	----	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	2.1	----	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	3.8	----	----	----	----

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

			Client sample ID	**BAN-06-3**	----	----	----	----
			Client sampling date / time	26-Mar-2020 13:40	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**ME2000504-012**	--------	--------	--------	--------
				Result	----	----	----	----
EA032: Electrical Conductivity (saturated paste)								
ø **Electrical Conductivity (Saturated Paste)**	----	1	µS/cm	**828**	----	----	----	----