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Ripley Daleys Road JV: Ripley

Soil Assessment Report: Factors Affecting Soil Use, Planting Media & Subsoil Management for Landscaping

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Contents

Attachments:

- Soil Map - Ripley Daleys Road JV
- Soil Morphological Descriptions
- Full Testing Proformas, Planting Media (Full , Subsuite) , Organic Soil Conditioner
- Audit Sample requirements (Subsuite) And Organic Soil Conditioner Requirements
- PDF Attached File – Soil Laboratory Analytical Data

Tables and Figures

Summary

This report presents the results of a soil survey along part of the Ripley Road Corridor between Cunningham Highway, Daleys Road and Binnies Road. Daleys Rd JV is developing an area within this location as residential subdivision called Ripley - Daleys Road JV. Location and soils investigated is Soils within Lots 3, 5 and 6 of RP180932

As part of the development, P& D Holdings and Backup Australia Pty Ltd commissioned Environmental Soil Solutions Australia Pty Ltd to undertake a Soil Assessment for Stage 1.

Information is required by the client on the range of soils, their distribution and characteristics to assist engineering and environmental staff with planning and implementing landscaping and revegetation works and ensuring erosion control occurs both during and after construction.

A survey of the top 1 m of soil was undertaken to map the soil distribution within Stage 1, 160 Daleys Road in the section. A very high-intensity mapping scale of around 1: 5,000 was used. Each identified soil was given a name that is unique to this assessment and is shown in *italics*. Soil profile features are described for any surface layers, subsurface layers and subsoil. Surface layers are equivalent to "topsoil". This Definition is as defined by Transport and Main Roads. Subsurface layers and subsoil, as used in this report, represent part of the Transport and Main Roads definition of "subsoil".

A combination of field evidence and analytical results has been used to classify the soils using the Australian Soil Classification and soil groups described in the Transport and Main Roads Road Drainage Design Manual (RDDM).

Inherent soil erodibility ratings defined in the Road Drainage Design Manual have been assigned to each soil using site and soil profile conditions observed during field inspection, soil texture and four dispersion indicators:

- Exchangeable Sodium Percentage;
- Exchangeable Calcium : Exchangeable Magnesium Ratio;
- Emerson Dispersion Test; and
- Soil Dispersion Indicator field test.

Other soil laboratory data have been used to ascertain soil chemical properties that affect plant growth during landscaping and revegetation.

The soil survey element of the study information collected was used to determine:

- soil erodibility and permeability;
- recommended clearing and grubbing operations;
- recommendations for erosion and sediment control works;
- Soil Erosion Potential for exposed subsoils and
- Suitability of soil layers for landscaping and revegetation.

In addition, the laboratory soil testing element combined with the soil survey element has been used to provide soil amelioration recommendations for the "topsoil as defined by Transport and Main Roads as well as Subsurface layers and subsoil where exposed or used as landscape areas.

Recommendations are given in Tables 6 & 6a while Top Soil (Planting Media) management is given in Table 9.

1. Introduction

1.1 Background

This report presents the results of a soil survey and Soil Assessment Report along part of the proposed development in Stage 1 of the Ripley Daleys Road JV (RUC).

Daleys Road JV via Land Partners asked Environmental Soil Solutions Australia Pty Ltd to:

1. Investigate the Soils in 1st stages of release for site located off Daleys Road especially;
2. Open Space Areas & Park and
3. Riparian creek zones

As part of the design development the client requires this soil assessment and Soil Assessment Report & recommendations for the areas nominated.

Information therefore is required on:

1. the range of soils,
2. the soil distribution and characteristics

to assist engineering and environmental and landscape architect teams with planning and implementing landscaping and revegetation works and with erosion control both during and after construction.

Therefore, a soil survey within this section to assist in deciding the limitations of the existing soils is requested. Further to indicate what amelioration of the soils is required as well as indicating what further soil studies, sampling and testing may be required for the development.

A very high-intensity (1:10,000) soil survey is recommended for site planning in the Australian Soil and Land Survey Handbook: Guidelines for Conducting Surveys (Reid 1992). With increasing intensity there will be greater accuracy in boundary location between different mapped soil units and greater reliability on describing the actual soil properties within each mapping unit.

1.2 Purpose of the soil survey, soil assessment and management

Specific aims of the soil survey were to:

- identify and describe the range of soils within the defined development Area and Cunningham Highway;
- classify these soils according to the Australian Soil Classification (Isbell 2002) and the Road Drainage Design Manual (Transport and Main Roads 2002);
- map the distribution of individual soils at a scale of 1:5,000;
- analyse representative soil samples for a range of attributes that affect construction , landscape and rehabilitation;
- use the field descriptions of site characteristics and soil profile morphology in conjunction with laboratory analytical data to objectively assess soil erodibility and drainage; and
- Provide advice on suitability for use as planting media (topsoil) for revegetation and supply recommendations for soil amelioration and management, where necessary.

2. Study methodology

The soil survey and Soil Site assessments (Soil Assessment Report or SAR) was undertaken in four stages. These stages are discussed below:

2.1 Field work

Field inspection was designed to cover the area at required intensity. This approach has been chosen to include the required development area and as much as possible all areas where site soil is exposed especially the subsoils such as detention basins.

Sites were chosen using a free survey technique so that each landscape unit was adequately represented. This means that the most appropriate location for ground observations was chosen whilst in the field stage and on the basis of local landscape features. Observation sites were chosen to represent crest, upper slopes, mid-slopes and lower slopes of the hard rock geological units and to cover all alluvial landform components. As far as practicable, sites were also spaced within the study areas. However, access was restricted in some cases due to heavy wooded country & washouts from recent rain.

At 8 observation sites detailed soil profile descriptions were undertaken to a depth of at least 1 m or to bedrock, whichever came first. Soil profiles were mainly exposed with a hand held auger drilling a 75 mm diameter bore hole though some existing cuttings were used as well. Other observation points were check sites where only sufficient information was collected to reliably determine the soil type.

Landscape position, land surface features, substrate material and indicative vegetation were also recorded at each site to assist in soil classification and mapping.

All site descriptions used standard terminology of the Australian Soil and Land Survey Field Handbook (McDonald et al 1990). Site location was recorded with a hand-held GPS receiver which has an accuracy of ± 5-10 m. The site locations are depicted on the attached soil map of the area.

Adequate soil survey accuracy and reliability was achieved during this current survey with the sites recommended in the proposal. In addition, the proportion of detailed soil profile descriptions exceeds the recommended 10-30% of all observations (Reid 1988).

2.2 Soil sampling for laboratory analysis

In total, 14 representative soil samples were submitted for detailed laboratory analysis. These samples were selected from the 8 profiles described as part of the detailed site inspections. Additional deeper sample at site DR3 has been included as an opportunity to obtain was available due to the deeply incised washouts in that area.

The samples collected at each site were mainly taken from the surface layer, subsurface layer or from part of the subsoil layer which, based on field evidence, is likely to represent the greatest constraint to stability, landscaping, and site sustainability. However, 1- 2 samples were taken from weathered bedrock and from deep subsoil merging into weathered rock.

Of the 14 samples, all 14 were analysed using a sub-suite of analyses recommended in Standard Specification MRS11.16B – Vegetation Ground Works (Transport and Main Roads 2008). The MRS11.16B sub-suite includes:

- Soil pH;
- Electrical Conductivity (EC), as a measure of salinity;
- Exchangeable Cations (Calcium, Magnesium, Sodium, Potassium and Aluminium);
- Cation Exchange Capacity (CEC);
- ESP (Exchangeable sodium as a % of CEC); and
- Exchangeable Calcium: Exchangeable Magnesium ratio.

In addition, 5 of these 14 samples near the ground surface (generally A horizon) were also tested for:

- Macronutrient fertility – Nitrogen (N), Phosphorus (P) and Potassium (K);
- Organic Matter (derived from a laboratory measurement of Organic Carbon);
- Trace Elements – Copper (Cu), Zinc (Zn), Manganese (Mn) and Iron Fe);
- Sulfate; and
- Boron (B).

Texture was recorded for each sample during the site soil profile inspections.

Analytical methods for pH, EC, exchangeable cations, CEC, macronutrients and trace elements and Organic Carbon were performed according to the relevant Australian laboratory handbook (Rayment and Higginson 1992). These methods are the same as the updated version by Rayment & Lyons (2010) currently just released.

2.3 Soil mapping and classification

Site and soil profile data collected during field inspection were used to identify the range of soil "types" present within the area. Each soil "type" (referred to simply as a soil in this report) has a suite of features that distinguish it from other soils and the variation in these features is less within each soil than between soils.

Each identified soil was given a name that is unique to this assessment. The distribution of these soils was then mapped at a (very high-intensity survey) scale of 1:5,000 using available contour data.

At 1:10,000 scale mapping, individual soils cannot necessarily be mapped on their own as pure units. Rather, the delineated mapping units represent soil associations in which there is a dominant soil covering most of the unit and small inclusions of other soils. For this area, it is estimated that the dominant soil represents at least 70% of the mapping units.

Mapping scale also affects the positional accuracy of boundaries between mapping units. At 1:5,000 scale, the accuracy of mapping unit boundaries is a minimum ± 10-30 m. While information collected is at 1:5,000 scale the map of soils is supplied at 1:10,000 scale as it is no different for practical purposes for the project soils management.

Each identified soil was classified according to:

- Transport and Main Roads soil groups described in the Road Drainage Design Manual (Transport and Main Roads 2002); and
- The Australian Soil Classification: Revised Edition (Isbell 2002).

2.4 Suitability assessment and reporting

Each soil mapping unit was assessed for:

1. erosion potential,
2. permeability,
3. recommended depth to remove organic matter and
4. depth of suitable landscaping material for stripping and stockpiling.

The comprehensive Soil Assessment Report produced provides for the soils mapped:

- descriptions and classification of the soils present;
- maps the soil distribution;
- assesses the soil erodibility, drainage condition and the suitability of soil layers for landscape and vegetation works;
- recommends clearing and grubbing operations and strategies for land management during construction and revegetation;
- provides soil chemical interpretations of soils;
- provides soil amelioration recommendations for soils/soil layers

3. Assessment of site soils

3.1 Soil terminology

All soil descriptions in this report use standard terminology of the Australian Soil and Land Survey Field Handbook (McDonald et al 1990). Descriptions of field pH measurements (such as medium acid) are from Interpreting Soil Analyses – for Agricultural Land Use in Queensland (Baker and Eldershaw 1993).

The report describes the numerous soil layers that may occur through a soil profile as being either:

- **surface layers** which extend down from the ground surface and are generally darkened (compared to any underlying layers) due to the accumulation of organic matter;
- **subsurface layers** which occur below, and are very similar to, the surface layer in texture and structure but are usually paler in colour (due to much less organic matter); or
- **subsoil**, which refers to any layer below the subsurface layer (or below the surface layer if there is no subsurface layer) which has much higher clay content, brighter colours or markedly different structure.

The term "topsoil" is generally avoided in soil survey reports because its common usage covers a wide range of soil material that may be sourced from any part of the soil profile, though usually not clay. The term has also been applied to any natural soil (and artificial planting) material that is used for top or final planting layer.

The term "topsoil", can be defined as the top layer of existing soil that supports vegetation. There is no indication of what distinguishes this layer from any underlying layers. The definition of "topsoil" is refined to being the upper part of the soil profile that is enriched with organic matter. "Subsoil" is defined to include both the subsurface layer and any layer below in which there is much higher clay content, brighter colours or markedly different structure.

Thus, natural surface layers in this report are equivalent to "topsoil" as defined whereas subsurface layers and subsoil, as used in this report, represent different parts of the defined "subsoil".

3.2 Soil description and distribution

Two soils Units and one (1) variant (Texture Contrast Soils) have been identified in the Development Area of Daleys Road.

Both soil units are briefly described in Table 1 whilst their distribution is shown at 1:10,000 scale in Figure 1.

The mapping units in Figure 1 represent soil associations which are named after the dominant soil in each unit. The dominant soil represents at least 70% of the mapping unit with small inclusions of other soils in the remaining area. The accuracy of the mapping unit boundaries is a minimum ± 20-50 m at this scale of mapping.

Soils

Soil distribution is related to landform shape.

Two "sandy TC soils" occupy the area. The term sandy refers to the sandy texture grade of their surface and subsurface layers whereas "TC" refers to the texture contrast nature of their profiles. In sandy TC soils the sandy surface or subsurface layer abruptly overlies a much heavier, usually clay, subsoil. The change into the subsoil occurs over less than 20 mm.

Shallow sandy sodosols dominate undulating low hills that have developed on the sedimentary rocks. Slopes are commonly between 8 and 12 % on the side slopes but may be as low as 3% along the flattened crests of the ridges.

The soil profiles have grey, loamy sand to sandy loam surface layer of variable thickness (50-200 mm) that grades into a bleached (white or almost) subsurface layer of similar texture. Between 150 and 300 mm depth, the subsurface layer abruptly overlies mottled, grey and yellow or occasionally brown subsoil of sandy light medium clay or sandy medium clay.

The surface has a firm to hard setting condition when dry. Structure is massive (few if any natural soil aggregates) in the surface and subsurface layers but the clay subsoil is weakly to moderately structured with very coarse (≥ 50 mm diameter) angular blocks.

A few cobbles, stones and boulders occur on the ground surface. Very few small pebbles may occur through the soil profiles which can overlie weathered rock below 500 mm depth.

Field pH varies from slightly acid to neutral in the surface layer and from medium acid to slightly acid in the subsurface layer. Field pH either remains medium acid or declines to strongly acid in the clay subsoil but can increase again to neutral in the weathered bedrock.

The *Deep sandy Sodosols* only occur at the bottom of the landscape and appear to have developed on unconsolidated sediments from local alluvial and colluvial movement and deposition from higher slopes. They occur on the lower slopes and foot slopes of valley flats associated with major drainage lines. Slopes are commonly between 2 and 6%.

The soil profiles have a thin (50-150 mm), grey, loamy sand to sandy loam surface layer that overlies a bleached subsurface layer of similar texture. The subsurface layer abruptly overlies mottled, grey and yellow or brown, sandy light medium clay to medium clay between 150 and 300 mm depth.

The surface has a firm to hard setting condition when dry and soil structure is massive in the surface and subsurface layers. The upper subsoil has moderate to strong structure with very coarse aggregate size but structure becomes weak to moderate below 650 mm depth.

A few small pebbles may occur through the clay subsoil which are at least 1,000 mm deep. Below this depth weathered bedrock or buried layers of sandy light clay and sandy clay loam texture are often encountered though in deeper profiles the clay subsoil can extend to at least 1,500 mm. Texture in this deeper subsoil can increase to heavy clay.

Field pH is slightly acid to neutral in the surface layer, medium to strongly acid in the subsurface layer but varies from strongly acid to neutral in the clay subsoil. A few manganese nodules through the clay subsoil.

At one location (surrounding inspection site 4), the *Shallow sandy Sodosols* have a very thick bleached subsurface layer that extends to 650 mm depth then abruptly overlies the clay subsoil. This *thick sandy variant* was only observed at this location which is at the head of a drainage line containing *Deep sandy Sodosols*. The area is approximately 50 m in diameter, has concave slopes and represents an isolated transition area between the lower slopes of the valley flats and the convex slopes of the undulating low hills.

Table 1. Brief description and classification of soils

Soil name	Landform	Brief profile description	RDDM soil group [1]	Australian Soil Classification [2]
Shallow sandy Sodosols- Modal Slopes 3-12%	Crests and convex side slopes – Modal Slopes 3-12%	The soil *Shallow sandy sodosols* profiles have grey, loamy sand to sandy loam surface layer of variable thickness (50-200 mm) that grades into a bleached subsurface layer of similar texture. Between 150 and 300 mm depth, the subsurface layer abruptly overlies mottled, grey and yellow or occasionally brown subsoil of sandy light medium clay or sandy medium clay.	Texture contrast soils (dispersive)	*Grey Kurosols & Grey Sodosols*
Deep sandy Sodosols- Modal Slopes 2-6%	Concave and planar lower slopes and footslopes – Modal Slopes 2-6%	*Deep sandy Sodosols* only occur at the bottom of the landscape and appear to have developed on unconsolidated sediments from local alluvial and colluvial movement and deposition from higher slopes. They occur on the lower slopes and foot slopes of valley flats associated with major drainage lines. Slopes are commonly between 2 and 6%.	Texture contrast soils (dispersive)	*Yellow and Brown Kurosols Yellow and Brown & (Sodosols)*

Notes:

1. Soil groups identified in the Transport and Main Roads Road Drainage Design Manual (Transport and Main Roads 2002).
2. Suborders from the Australian Soil Classification Revised Edition (Isbell 2002).

3.3 Soil classification

A combination of field evidence and analytical results has been used to classify the soils into suborders of the Australian Soil Classification: Revised Edition (Isbell 2002) and into soil groups described in the Road Drainage Design Manual (RDDM) of Transport and Main Roads (Transport and Main Roads 2002). Results of these classifications are displayed in Table 1.

Table 1 shows via field and analytical evidence and indicates that the *Shallow sandy Sodosols TC* soils and *Deep sandy Sodosols TC soils,)* and have dispersive clay subsoil and thus belong in the Transport and Main Roads soil group of "Texture contrast soils (dispersive)".

4. Potential risks and soil limitations to re-use in landscaping and revegetation

4.1 Physical limitations

Physical limitations of the site soils refer to soil related attributes that affect the capacity to re-use soil material for landscaping and revegetation.

Physical attributes such as dispersion, overall soil erodibility and soil permeability are soil related attributes that affect re-use for landscape and revegetation and also affect performance & sustainability of landscape stability. These attributes are discussed separately in concluding sections 6.3, 6.4 and 6.5 of this report.

4.2 Chemical limitations affecting plant growth

Soil samples were collected in field stage of process from 8 augured soil profiles described within the Daleys Road Stage 1 development. Samples representing the surface layer, subsurface layer, part of the subsoil and weathered rock were submitted for a range of chemical analyses.

Chemical properties that directly affect plant growth are summarised for each soil in Table 2. Table 2 also lists the number of samples within each soil layer that was submitted for analysis. These attributes are discussed separately in sections 4.3, 4.4 and 4.5 of this report.

Terms used in this report to describe pH (such as medium acid) are from Interpreting Soil Analyses – for Agricultural Land Use in Queensland (Baker and Eldershaw 1993). Salinity ratings are from the Salinity Management Handbook (DNR 1997).

Table 2. Soil chemical properties affecting plant growth Daleys Road JV

Soil name	Soil layer [1]	Samples	pH [2]	EC [2, 3] (dS/m)	CEC [2, 4] (meq%)	Extr P [2, 5, 6] (mg/kg)
Shallow sandy Sodosols- Modal Slopes	Surface: Subsurface:	4 6	5.3-5.4 6.1-7.5	0.02-0.03 0.16-0.81	<3-5 <9.9-14.3	5 Nd
Deep sandy Sodosols-	Surface: Subsurface:	1 2	4.9-5.7 4.5-7.0	0.02-0.03 0.03-0.29	<1.8-4 <1.8-9.9	2-5 Nd

Notes:

1. Samples designated as "Surface or subsurface" have been combined from either the surface and subsurface layers.
2. Where more than 1 sample was analysed for each soil layer a range of values is given.
3. EC represents Electrical Conductivity which is a measure of soil salinity.
4. CEC represents Cation Exchange Capacity and is a measure of the soil ability to retain positively charged nutrients (such as calcium, magnesium, potassium, ammonium) for use by plant roots, as well as sodium and aluminium; CEC is measured in milli equivalents per 100g soil (meq %).
5. Extr P represents the amount of phosphorus that is available for plant growth and is usually only measured in the soil surface layer.
6. Nd = Not determined

4.2a Soil pH

The level of pH strongly influences the ability of plants to establish and to take up nutrients from a soil and the ability of the vegetation to be sustainable. Soil pH for the sample sites for both horizons (topsoil) and the mostly B horizons (subsoil) are all rated as strongly acid (pH < 5.5) and are not ideal for plant growth other than for insitu adapted plants & grasses which are poorly performing at best. Some deeper subsoil B horizon in DR 1 & 5 are rated neutral to slightly alkaline. For sake of discussion concentration on the topsoil A horizon & shallow B horizon will be made.

All sites (both surface and subsoils in the upper 0.9m and especially the exposed subsoils & if reused or exposed) would benefit from the addition of agricultural limestone / dolomite. This amendment is incorporated into the soil to reduce acidity and any available Aluminium (See Table 3 for Soil parameters) and achieve a soil pH closer to the ideal range of at least > pH 5.5 preferably pH 6.5 – 7.5.

Rates of limestone /dolomite incorporation into these soils recommended are based on MRS11.16B specification and associated guidelines and need to take into account the soil type & chemical conditions.

The following recommended soil pH amelioration rates have been extracted from *general guidelines:*

(a) **Apply agricultural lime with a NV of 95 generally at the following rates to increase soil pH by 0.5 units** -

- 2.5 t/ha for a clay soil;
- 1.7 t/ha for a silty clay loam;
- 1.3 t/ha for a sandy clay loam; and
- 1.0 t/ha for a sandy loam;

Soils with pH > 6.5 (of which no soil samples were found, all samples <pH 5.5) are not present except in the deeper subsoils at or close to C horizon. However where soils are pH

<5.5 and are sodic to strongly sodic (ESP > 6 for sands and sandy loam and ESP > 15 for sandy loams to clay loams to clays) will not require any agricultural gypsum but will require agricultural limestone or dolomite.

Comment: However most of these soils are pH 5.5 or less and low to very low calcium and magnesium in top sandy layers with lower Calcium and increasing subsoil magnesium and require and would benefit from applications of Agricultural Lime / Agricultural Dolomite.

For discussion of soil Aluminium concentration in strongly acidic soils (pH < 5.5) - refer to soil exchangeable cations section below.

For the very deep subsoils this does change. For instance DR1 1m and greater samples were neutral to alkaline. For excavations beyond1.0 m is anticipated then subsoil testing for Subsuite (see appendix for requirements) to determine where change occurs will be needed. See Appendix for Sub Suite Soil Testing criteria requirements.

Table 3. Organic Carbon/ Organic Matter, Slaking, Clouding & Emerson rating for Ripley Daleys Road JV surface soil samples

Sample No/ Depth Layer	Organic Matter%	ESP	Est. Emerson Class Number	Slaking	Clouding
SITE 1 – TS	2.8	4.6	5	None	None
SITE 2- TS	1.1	3.6	5	None	None
SITE 4- TS	0.7	3.3	5	None	None
SITE 5- TS	0.9	1.9	5	None	None
SITE 7- TS	2.1	1.8	5	None	None

TS = Topsoil

4.3 Soil Texture and Dispersion Characteristics

Soil texture gives an indication of the sand, silt and clay content of a soil. The dispersive (erosive) characteristic of a soil is related to the clay content. Refer to Table 2 for an explanation of the soil texture abbreviations. Each soil layer per site was assessed for texture see Table 4. The results are listed in Table 1 and show that the project soils generally Sandy loam (SL) surface (grassed top layer , pasture) to medium clays (MC) especially subsoils with a few subsoils reaching MHC (medium heavy clay) texture.

Evidence of soil dispersion is investigated in the field by carrying out slaking and clouding tests, See Table 3 for ratings. A soil that forms a cloud of soil particles and/or slakes (falls apart) when placed in a dish of distilled water is likely to have some dispersive characteristics. The test results for these characteristics are tabulated. However, as there is high aluminium in many very acid subsoils this test may cause it to be unreliable in the majority of the samples causing soils with these properties to rate on the slaking & clouding assessment as non dispersive.

Please note: no laboratory assessment of soil texture or particle size was part of the project brief (but texture was field assessed and has been provided by ESSA in Table 1a).

4.4 Soil Salts (EC)

For sites sampled, all sites have no significant concentration of soluble salts present in soil. However there are small salt accumulations in Site 8 deep subsoils soils with concentrations rated as low. Very low / low salt levels are rated as of no concern with respect to soluble salt content.

Soluble salts in soils from Sites rated as Medium (>0.45dS/m) and high (0.9dS/m) are not present in this study area, even in the deeper samples tested.

On that basis, on a general areas basis soil soluble salts are not a problem in areas studied.

Table 5 summarises (EC) – Total Salts of the soil properties from the selected representative soil samples from the series of samples both by ESSA and profile auguring.

Table 4. Soil Test Parameters, Daleys Rd Project – Ripley.

Sample No.	*Sample Depth*	*Soil pH*	*EC dS/m*	*ESP*	*Ca Meq/100g*	*Mg Meq/100g*	*Ca/Mg*	*Al %*
Concave and planar lower slopes and footslopes- *Deep sandy Sodosols*								
Site DR 1 TS	*0-100mm*	*5.4*	*0.05*	*4.6*	*1.42*	*1.22*	*1.2*	*8*
Site DR 1 SS	*600–1000mm*	*7.2*	*0.64*	*25.1*	*2.11*	*8.26*	*0.3*	*<1*
Site DR1 SS	*1100–1400mm*	*7.5*	*0.81*	*26.3*	*1.13*	*5.85*	*0.2*	*2*
Crests and convex side slopes- *Shallow sandy Sodosols-*								
Site DR2 TS	*0-150mm*	*4.9*	*0.03*	*3.6*	*1.14*	*1.48*	*0.8*	*13*
Site DR 2 SS	300-400mm	4.5	0.29	25.2	0.74	5.10	0.2	13
Concave and planar lower slopes and footslopes- *Deep sandy Sodosols*								
Site DR3 SS	400-600mm	5.3	0.05	11	0.35	3.53	0.1	10
Site DR 3 SS	1000 - 1200mm	6.1	0.16	22.3	0.20	7.88	<0.1	2
Crests and convex side slopes- *Shallow sandy Sodosols*								
Site DR4 TS	0-100mm	5.6	0.02	3.3	0.68	0.76	0.9	11
Site DR4 SS	100-600mm	5.4	0.03	10.3	0.16	1.00	0.2	16
Site DR4 SS	650–850m	6.5	0.19	24.1	0.07	5.41	<0.1	2
Crests and convex side slopes- *Shallow sandy Sodosols*								
Site DR 5 TS	0-150mm	5.7	0.03	1.9	0.98	0.64	1.2	9
Site DR 5 SS	300-600mm	7.0	0.05	7.8	3.05	4.25	0.7	2
Crests and convex side slopes- *Shallow sandy Sodosols*								
Site DR 6 SS	200-300mm	4.7	0.09	14.3	0.12	5.94	<0.1	21
Crests and convex side slopes- *Shallow sandy Sodosols*								
Site DR 7 SS	0-75mm	5.5	0.03	1.8	2.36	1.03	2.3	5

TS = Topsoil ; SS = Subsoil

Soil Groups:

Sites 1, 3	Deep sandy Sodosols	- dispersive
Sites 2, 4,5,6,7,8	*Shallow sandy Sodosols*	- dispersive

4.5 Soil Exchangeable Cations (Ca, Mg, ESP and Ca/Mg Ratio)

A soil's ability to supply nutrients to plants is determined by its cation retention properties measured as ECEC. Soil exchangeable cations assessed in this project were Ca, Mg, Na, K and Al.

While results show that the soils of the project site are highly leached texture contrast soils they are generally low in Exchangeable Cations and Cation Exchange Capacity with some containing moderate saturation of Aluminium in the subsoils and may contain 'variable charge' properties.

It is highly likely that these soils contain proportion of positive charge and nett positive charge especially. While this is significant soil property, as far as the reuse of the soils when used goes except in batters, will not be an issue when recommending reuse as planting media or subsoil fill in constructed landscape (grassed batters or planted areas). However for plant establishment in the soil due to current soil properties introduced revegetation will be very difficult to establish in unamended topsoils & subsoils. This applies to any exposed batters (cuts or fills using subsoil) as if left exposed & untreated will actively be erosive.

Soil data collected from the sites in this survey have very low to extremely low exchangeable Ca and while higher levels of Mg are present (especially in many subsoils) they vary from low to moderate to occasionally high Mg in the subsoil of the soil profiles sampled. In addition, the Exchangeable Magnesium (Mg) increases to high levels in lower subsoils, and are a significant issue for the overall soil dispersion assessment. The exchangeable cation soil content values are below 2meq/100g for Ca (very low, except for 1 sample in DR 1 >600mm & DR 5 300-600mm), but otherwise do not exceed 0.74meq/100g (the highest) & low of 0.07meq/100g of all subsoil samples tested.

Exchangeable Magnesium on the other hand is in equal proportions to Calcium OR exceeds it with concentrations in the range of around1 meq/100g for Mg generally for sandy topsoil with some subsoils up to >8 meq/100g (high to very high). Calcium to magnesium ratios for the series of samples rarely exceed 1 with (in fact 8 samples are <0.3 or <0.1) indicating that the low Calcium concentrations and low Ca to Mg ratios are providing low nutrient availability. These properties also indicate soil would have higher tendency to disperse (erode).

Calcium concentrations must be boosted while Mg levels, in both the topsoils and subsoils, will need to be maintained or boosted but not to exceed Calcium. In addition, the Ca to Mg ratios will need also to be improved. Examples of sites were this scenario applies are ALL Sites no exception even in some site 'A' horizon samples which contain some organic matter.

Incorporation of agricultural lime or dolomite will increase the dominance of the desirable Ca cation required for plant growth and also help negate the effects of high Mg compared to Calcium (low Ca/Mg ratios) and soil dispersion. However, as both calcium & magnesium levels are generally low for plant exploitation agricultural lime /dolomite should be considered as the preferred ameliorants (soil conditioner), especially in topsoil layer.

Soil exchangeable K is rated low in subsoil layers of site soils studied. The soils K levels will need to be increased for successful plant growth & to be sustainable. For the soils delineated in this survey assessment the K is low to very low and will need boosting (most levels <0.2meq/100g except DR6 SS at 0.37meq/100g.

Assessment of data for soil sodicity (also referred to as ESP) has been provided and ESP data is presented in Table 1. ESP is calculated by dividing the exchangeable Na by the effective cation exchange capacity expressed as %. The soils in the current study are rated generally non sodic in the surface but not subsoil using this measure. Soils with an ESP > 6 are rated sodic and > 15 strongly sodic,

Sodicity is a soil property associated with soil dispersion when ESP exceeds 6. The subsoils analysed indicated in general with the highly leached nature of the soils low sodicity (non sodic) and a tendency to be low dispersive. Non dispersive (low ESP) were found for most of the samples and is probably due to the stabilising influence of the organic matter present.

Soils which are Very strongly sodic are the clay sub soils while all soils have sodic subsoils with highest being 28 ESP for *Deep sandy Sodosols*. The *Shallow sandy Sodosols* have highest ESP similarly of 26 ESP. Range is generally in subsoils <1m 7.8 to 28.

For the Soils Summarised in Table 4a (soils from this study) the data indicates for the samples deeper than 100mm (subsoil) *Deep sandy Sodosols* deeper than 200mm (subsoil) & *Shallow sandy Sodosols* that soil properties do change from the properties existing in the upper (top) layer.

The data Table 4 shows that the soils can become strongly sodic and dispersive. For example Site 6 soils are very strongly sodic, dominated by magnesium and will be highly dispersive (ESP > 15) combined with Ca/Mg ratios of <0.1), again indicating high soil dispersion.

As the subsoils are sodic to strongly sodic as discussed and are magnesic (dominated by Magnesium cation) ***dispersion of the subsoils will actively occur if the soil is not treated due to the high contents, which have some destabilising erosive effect.***

However, it is also of note that the soils as a planting media or as subsoil for establishment plantings & maintenance of sustainable plantings will <u>not support vegetation establishment</u> other than for highly adapted plants which will establish slowly.

For rapid sustainable & desirable revegetation purposes the soils will need to be ameliorated as per recommendations section of this report.

Potassium (K) is *low to Very low.*

4.6 Soil Exchangeable Aluminium (Al)

A deleterious soil characteristic of some very acid soil horizons (**<u>as these are</u>**, with the least acid rated as medium to strongly acid) is the presence of high exchangeable Al. Higher proportions of Al, as found in subsoil layers of all Sites laboratory samples 8 of the 17 that is the vast majority of the sub soil layers examined across the site.

When the %Al of the CEC is >25% it may be toxic to most plants but will be when exceeding 40 especially, which 0 samples have. Any Aluminium concentration needs to be treated if exposed and or plantings or use of the subsoil for revegetation works is proposed. Simple agricultural lime / dolomite application as required in this area (to correct soil pH) will also correct the Al toxicity problem. Only DR 4 & DR 6 have some %Al of CEC but will be indicative of may soils on the site.

Application of the proposed agricultural lime /dolomite will address this problem by increasing the soil pH and thereby reduce any effects of plant toxic Al present in these soil planting materials. As well agricultural lime /dolomite will increase the desirable Calcium & Magnesium available for plant growth & clay property amelioration.

4.7 Emerson Class Number

The Emerson Class Number (ECN) is sometimes used as indicator of dispersion. ECN 1 and 2 denotes dispersive soils. ECNs of 5 are rated non dispersive.

The non dispersive Emerson estimates for soils from this RUC project are affected by the presence of high soluble aluminium. The presence of the free aluminium (which is in soil solution due to acid conditions) has a flocculating effect and negates the soils tendency to disperse in this assessment method. The property is of no use & therefore not determined.

Table 5. Soil Test Parameters, P, K, S Daleys Rd Project – Ripley.

Site	Depth	pH H20	EC dS/m	Chloride mg/kg	Al meq/100g	P mg/kg	S mg/kg	OM%	K meq/100g
Concave and planar lower slopes and footslopes- *Deep sandy Sodosols*									
Site DR 1 TS	*0-100mm*	*5.4*	*0.05*	16	*0.27*	5	8	2.8	0.18
Site DR 1 SS	*600–1000mm*	*7.2*	*0.64*	nd	*0.13*	nd	nd	nd	0.23
Site DR1 SS	*1100–1400mm*	*7.5*	*0.81*	nd	*0.13*	nd	nd	nd	0.16
Crests and convex side slopes- *Shallow sandy Sodosols*									
Site DR2 TS	*0-150mm*	*4.9*	*0.03*	15	0.44	3	4	1.1	0.20
Site DR 2 SS	300-400mm	4.5	0.29	nd	**1.28**	nd	nd	nd	0.28
Concave and planar lower slopes and footslopes- *Deep sandy Sodosols*									
Site DR3 SS	400-600mm	5.3	0.05	nd	0.50	nd	nd	nd	0.16
Site DR 3 SS	1000 – 1200mm	6.1	0.16	nd	0.25	nd	nd	nd	0.24
Crests and convex side slopes- *Shallow sandy Sodosols*									
Site DR4 TS	0-100mm	5.6	0.02	9	0.21	5	2	0.7	0.11
Site DR4 SS	100-600mm	5.4	0.03	nd	0.29	nd	nd	nd	0.10
Site DR4 SS	650–850m	6.5	0.19	nd	0.20	nd	nd	nd	0.13
Crests and convex side slopes- *Shallow sandy Sodosols*									
Site DR 5 TS	0-150mm	5.7	0.03	14	0.19	2	3	0.9	0.11
Site DR 5 SS	300-600mm	7.0	0.05	nd	0.14	nd	nd	nd	0.20
Crests and convex side slopes- *Shallow sandy Sodosols*									
Site DR 6 SS	200-300mm	4.7	0.09	nd	**2.11**	nd	nd	nd	0.37
Crests and convex side slopes- *Shallow sandy Sodosols*									
Site DR 7 SS	0-75mm	5.5	0.03	11	0.19	4	4	2.1	0.18

- High Aluminium not associated with pH < 5.5

4.8 Organic Carbon / Organic Matter

The Deep sandy Sodosols TC soils Organic Carbon / Organic Matter data was assessed on a top layer of soil Site 1 samples topsoil (TS layers) from this study. In addition *Shallow sandy Sodosols TC soils* Organic Carbon / Organic Matter data was assessed on a top layer of soil Sites 2, 4, 5 & 7 samples topsoil (TS layers) Organic Carbon concentrations found, as expected, a rapid decline in organic carbon with depth. Compared to the surface layer 0 -50 mm, the 50 – 200 mm depth decreases by more than 50%. It was considered unnecessary to continue testing beyond this depth due to low levels present and the rapid decline of organic carbon found with depth as is most common soil types.

Highest organic carbon contents of surface soil was 1.3% (Organic Matter 2.8 %) DR 1 while next highest was 1.0% (Organic Matter 2.1 %) DR 7 which is rated as unsatisfactory & low with the levels below 3% organic matter being rated as unsuitable for planting media use unless ameliorated. In all sites in the exposed subsoils subsoil layers the OM levels would be < 1% and as low as 0.5%. Stripping/mixing/stockpiling of these soils will result in low soil organic carbon contents when mixed.

However, the top layer (generally <100mm to 200mm) would benefit from incorporation of composted organics with a NDI > 0.5 into the top stripped layer of exposed soil. Use of this organic amendment will increase the soil water holding, soil drainage (leaching) increased nutrient retention and help stabilise the topsoil to resist erosion and promote healthy plant growth.

If controlled or slow release fertilisers are applied the composted organics will ensure nutrients are not leached from the root zone. A suggested rate of incorporation of conforming soil organic conditioner (see Appendix for requirements) is 20% by volume of compost to soil.

Please note Organic Matter is simply a derived property from Organic Carbon.

4.9 Soil Fertility Factors

Soil Nitrogen (N), Phosphorus (P) and Potassium (K) & Trace Elements (Copper (Cu), Zinc (Zn), Boron (B) etc) for topsoil layers have been assessed.

In summary the samples for N, P, and K are from low to Very low,

- N is low and will need to be applied as fertiliser
- Phosphorus is *low for all soil types* – Top soil will suit P sensitive native plants but additional P will be need to be added for the soil for general plantings and turf grass. If hydro mulch applied seed species or ecoblanket if applied, additional P will be need to be added
- *K is needed* for both groups must be added as fertiliser & increased further for healthy plants especially plants & turf grass

Trace Elements

Trace elements were assessed for these top soil layers soils and in summary the results are:

- Zinc (Zn) is *low to very low* and will need to be added as fertiliser
- Copper (Cu) is rated *low to very low* and will need addition as fertiliser

- Manganese (Mn) is rated moderate to *low*
- Iron (Fe) is rated *moderate*
- Boron (B) *is very low*

Any fertiliser amendment would need to contain trace elements, as additional fertiliser amounts, and also needs to contain Nitrogen (N), Phosphorus (P) (Not for P sensitive plants) and Potassium (K) added for most plants & turf grass to establish. Zinc, Boron &copper will need to be added as well.

4.10 Soil Laboratory Methods

For the areas from which the soil samples taken by ESSA at request of Client, laboratory subsamples were taken , described & mixed by ESSA and extracted to give an overall assessment of the soil conditions via a representative bulk sample at each location.

Methods used for the assessment followed *Australian Laboratory Handbook of Soil and Water Chemical Methods (1992) by Rayment & Higgenson.* The methods used are recognised Australia wide as consistent methods and procedures that are used for diagnostic and research purposes.

4.11 Acid Sulfate Soils (ASS)

Indicators of any ASS were not seen nor expected in this area. All sites were above 5mAHD and no indicators of pyritic acidity were present nor expected.

5. Recommendations

5.1 Soil Assessment

The characteristics of the soils of the site studied show that the site soils are in 2 management groups for most purposes have:

- Strongly acid pH levels,
- low salt levels,
- low to extremely low exchangeable calcium (Ca),
- low to very low calcium to magnesium ratios (Ca/Mg ratio),
- generally moderate to high magnesium & high when compared to calcium
- low to moderate aluminium levels (%Alsat)
- sodic to strongly sodic soils in subsoils

All the above will need to be addressed to reduce the risk of failure of any site revegetation works and dispersion effects of any disturbed subsoils used or left as cut batters or reused as fill batters or for advanced tree pit plantings.

For the acidic, low exchangeable cations (Ca/Mg) ratio, magnesic, sodic, soils it is recommended to add agricultural lime (preferred) /dolomite at suggested rates based on the pH section of the report and detailed in Table 6 & Table 6a.

If possible if site sandy topsoils are stripped for reuse then the preferred ameliorants are add agricultural dolomite (preferred) and composted organic matter as specified below in appendix as Soil Organic Conditioner requirements.

All ameliorants suggested will need to be incorporated by effective mixing with the soil to have maximum effect.

In addition, some soils especially the subsoil from existing surface textured as clays in this case will require incorporation of well composted organic matter with NDI (Nitrogen Draw Down) of > 0.5, as well as the agricultural dolomite to treat the acidic conditions and cation imbalances as described in the report.

As per MRS11.16B (Interim) generally, all soil amelioration agents should be free of contaminants and specifically:

- agricultural lime and if dolomite substituted shall be agricultural dolomite consisting of ground limestone (calcium carbonate - $CaCO_3$) with a neutralizing value (NV) of 95 or above; or

- Agricultural dolomite shall be agricultural dolomite ($CaMgCO_3$) with NV of 90 - Preferred.

PRODUCTS NOT GENERALLY REQUIRED

- agricultural gypsum (calcium sulfate $CaSO_42H_2O$) shall be a natural agricultural grade material; Not Required

5.2 Recommended soil treatments – Ripley Daleys Road JV Development.

The Tables 6 & 6a below give recommended Amelioration & Management for Surface (Topsoil Layers) & Subsoil to be revegetated or planted & landscaped. Details of Table 6 & 6a content is given below

Table 6 – RUC Project – Ripley Daleys Road soil use and or amelioration recommendations for landscape treatments – Site Planting Media & Subsoil Management

Table 6a - RUC Project – Ripley Daleys Road soil use and or amelioration recommendations for landscape treatments – Imported Planting Media & Planting Recommendations

Table 6. Site Planting Media & Subsoil Management - Daleys Rd.

Site Requirement Description	Agricultural Lime/ Agricultural Dolomite*	Agricultural Gypsum	Fertiliser	Soil Organic Conditioner NDI >0.5
Stripped Site Soil (Top soil Layer) To conforming Planting Media	**Top soil Layer** -5-10kg/m3. Ag. Dolomite incorporate	NIL required	Per Plantings Use Appropriate Scotts Fertiliser products	Estimate require 20% minimum Conforming Organic soil conditioner
Site exposed soils – on the site subsoil areas for reveg. subsoil in exposed sloping surfaces for general cover & rehabilitation	1-**Subsoils** Estimate 10-15kg/m3, Ag. lime incorporate or (1.5-2 kg/m2/200mm depth incorporated). Ag. Lime Preferred	NIL required	Yes, CRF* appropriate to plantings. For Turfgrass add Scott's Lawn Builder @ 2.5kg/100m2 General Plantings Scotts Sierra Blen at 350kg/ha or 40-50g/m2	Recommend Apply Groundworks Ecoblanket** TM At manufacturers recommendation *NOTE :No Planting Media need for this option* *Or apply Hydromulch (Planting Media needed for this option)*
Site exposed soils – Earthworks in the subsoil areas to smooth out exposed sloping surfaces to be landscaped	1-**Subsoils** Estimate 10-15kg/m3, Ag. lime incorporate or (1.5-2 kg/m2/200mm depth incorporated). Ag. Lime Preferred 2-Add as surface (Top)Planting Media layer at minimum 50mm conforming MRS11.16B Planting Media or ameliorated site stripped soil conforming to MRS11.16B	NIL required	Yes, CRF* appropriate to plantings. For Turfgrass add Scott's Lawn Builder @ 2.5kg/100m2 General Plantings Scotts Sierra Blen at 350kg/ha or 40-50g/m2	For stripped Site topsoil to MRS11.16b add 20% minimum Conforming Organic soil conditioner
All subsoils used in batter / cut /fill areas (drainage swales) where in exposed areas in the project	**Subsoils** - Estimate 10-15 kg/m3, incorporate (1-2 kg/m2/200mm depth incorporated). Ag. Lime Preferred Leave Roughed surface add 50mm conforming MRS11.16B Planting Media	NIL required	Yes, CRF* appropriate to planting as appropriate suggest e g	None
All subsoils used in drains / in trenches for services etc where in exposed areas or as backfill & possible erosion in the project	**Subsoils** - Estimate 10-15 kg/m3, incorporate (1-2 kg/m2/200mm depth incorporated). Ag. Lime Preferred – **Compact Then** Leave Roughed surface add 50mm conforming MRS11.16B Planting Media if reqd	NIL required	Yes, CRF* appropriate to planting as appropriate suggest e g	None

Table 6a. Imported Planting Media & Recommendations - Daleys Rd.

Site Requirement Description	Agricultural Lime/ Agricultural Dolomite*	Agricultural Gypsum	Fertiliser	Soil Organic Conditioner NDI >0.5
If Imported Planting Media applied after subsoil amelioration	Add 50mm conforming MRS11.16B Imported Planting Media	NIL required	Yes, CRF* appropriate to planting	Per Full Suite MRS Specification in Appendix
Larger plantings Shrubs Trees	Mix backfill site soil with 15 kg/m3, Ag. Lime incorporate or Ag. Lime (1-2 kg/m/200mm depth incorporated). Coat excavated planting holes with 1mm thick blanket Ag. Lime	Nil	Yes , CRF appropriate to planting	Recommend Incorp @ 10% by Volume into backfill soil
Tree Pits	15 - kg/m3, Ag. Lime incorporate & mix into soil well Lime excavated tree pit with 1-2mm Ag. Lime to exposed surface (Coat excavated planting holes with 1-2mm thick blanket Ag. Dolomite	Nil	Yes, CRF appropriate to planting	Suggest 10% Soil conditioner well mixed with backfill soil
If Ecoblanket (compost) blanket applied after Earthworks & subsoil amelioration in cut batters as erosion control & reveg. Method. RECOMMENDED	Incorporate all ameliorants into Eco blanket after structure (such as batter) ameliorated as above	NIL required	Yes, CRF* appropriate to planting incorporated in application	Recommend Apply Groundworks Ecoblanket ™ At manufacturers recommendation. *No Planting Media need for this option*
All Layers	Suggest all watering containing wetting agent (Hydroflo II)			

5.3 Organic Fertiliser alternative for Tree Pits

As fertiliser alternative for tree pit planting as substitute for inorganic fertiliser is the following recycled organic products –

Tree Pits:

Apply per cubic metre volume of tree pit:

- 1 to 2 bags of "Multi –Pro" (Organic compost fertiliser & Soil Conditioner).AND
- 1 to 1.5 Kg of "Hydra TerraPlex " per cu metre mixed in with backfill soil around and next to root ball. Hydra- TerraPlex is an Organic based Long term Fertiliser with wetting agents and beneficial soil inoculants. It is a plant establisher, used in Street tree, fruit tree crops and Landcare plantings & where environmentally sensitive riparian soil treatment is required.

5.4 Limitations of Soil Data

Accuracy of soil properties assessed:

- the representative soil sampled is accurate and reliable at the scale of the project and the representative soil analyses information has been extrapolated to other soils examined from the field sampled sites and observations for these areas; and

Level of confidence of the Lab data being representative of the site:

- High level of confidence. Refer to *Further Soil Sampling and Testing* below for recommended actions.

Details of the variation of soil levels expected per soil type and location and depth.

- There are many layers / types of soils ,mostly hard & soft clays over decomposing parent materials

5.5 Further Soil Sampling and Testing

It is considered that further sampling and MRS11.16B modified sub suite testing of particular locations be undertaken where vegetative changes and or special landscape features or soil treatments (amelioration) proposed. O*ther than the above recommendations no other sampling / testing* is required at this stage unless changes to the landscaping or new features are added to the project areas.

Extra soil testing is especially recommended if landscape rehabilitation changes occur (Deeper excavations for example) to establish whether dispersive and soil pH conditions (and associated soil properties such as higher EC or soil aluminium) may occur. See report for the changes in soil properties expected.

It is recommended that MRS11.16B and consistent laboratory methods form part of the soil test monitoring and a Planting Media Management Plan (PMMP) be produced to ensure that valid and necessary soil comparison information is provided during the contract period to optimise the management of the soils used in this project.

Any imported planting media should conform to MRS11.16B (incorporates AS 4419, 2003 – but AS 4419 only NOT acceptable) full suite specification and the soil conditioner (stabilised compost) used as an ameliorant should conform to pH, EC Wettability and NDI specifications as Detailed in MRS11.16B. Note this should apply to the soil organic matter used as an additive to any manufactured soil imported into the project. Soil Testing Proformas for Laboratory Requirements is given in Appendix.

Laboratory Methods strongly recommended are Methods used for the assessment of soil properties by following the Australian Laboratory Handbook of Soil and Water Chemical Methods (1992) by Rayment & Higgenson. The methods used are recognized Australia wide as consistent methods and procedures that are used for diagnostic and research purposes.

It is recommended that MRS11.16B form part of the contract documents so as to ensure the necessary soil information is provided by the Contractor during construction to optimise the management of the soils used in this project.

5.6 Auditing of ameliorated soil / Rehabilitation

It is recommended that further sampling and MRS11.16B modified sub suite testing of particular ameliorated soil (after Ag Lime / Dolomite & organics incorporated) be undertaken to ensure appropriate soil treatments (amelioration) is applied.

Audit testing be part of the contractor requirements and auditing be done by qualified soil scientist (not geotechnical) and;

1) **auditing done on each area or**
2) **no less than 1 test per 500m3 to be treated.**

See Appendix to report for minimum testing requirement by contractor (Subsuite)

5.7 Soil Testing & Soil Organic Conditioner Requirements

As a minimum suite of testing the contractor to ensure:

- Soil Organic Conditioner complies with attached specification for 'Soil Organic Conditioner' in appendix
- For ameliorated stripped soil top layer or subsoils ameliorated with Soil Organic Conditioner & or Ag Lime that sub suite test is supplied.
- If topsoil applied must conform to MRS11.16B attached in Appendix
- Soil Analysis report must be provided with each audit analysis of :

    1) Ameliorated stripped soil
    2) Any imported topsoil (if used) &
    3) Soil Organic Conditioner.

See Appendix to report for minimum testing requirement by contractor.

5.8 Other Site Issues Swales, Services Trenches & Drains

The top of batters need to have grassed swale drains to ensure overland runoff onto the batter surfaces is minimised. An alternate may be an organic berm or soil berm installed at top of batter to achieve similar result.

For Drains that may need cleaning out use Turfing (on ameliorated sub soil) & for high flows consider Vetiver Grass hedges (across flow path) & planted every 20m lineal of flow path (detail can be provided if this option selected).

For Services trenches backfill must be ameliorated sub soil per Table 6a. In any case all soils under Swales Trenches & Drains must be ameliorated per Table 6a.

6. Conclusions

As detailed in the above report the soils studied in this report indicate poor soil conditions exist in the Ripley Daleys Road JV areas studied in the upper 0.9m of the profile. Some data for deeper sample layers are presented by ESSA and this soils data indicates similar soil conditions exist >0.9m with possibility of some areas saline and as recommended excavations below 0.9m from top of ground surface be checked.

In any event the soils insitu for revegetation present particular problems.

For establishment of vegetation and thereby stabilising the soils and preventing soil erosion & production of erosion and sediment control the soil properties for stripped topsoil and within any of the exposed subsoil layers need to be treated as recommended.

Suggested treatments & alternates are recommended and are contained in Tables 6 & 6a in the report. If subsoil treatment & 50mm Planting Media is applied (planting media tests per full suite specification in appendix A).

Imported Planting Media used must not be sand or clay (see Full Suite specification for details). For the conclusion Primary Soil Attributes are summarised & their importance discussed.

6.1 Dispersion

Table 3 presents four commonly used indicators of potential for clay dispersion. Dispersion of clay particles can damage soil structure by destroying large flocculated aggregates and filling the voids between these aggregates with much finer, dispersed material.

Then of course the soil porosity and hydraulic permeability of the soil declines and the erodibility increases as the small dispersed particles are easily moved in water.

The Exchangeable Sodium Percentage (ESP), Exchangeable Calcium: Exchangeable Magnesium (Ca: Mg) ratio, Soil Dispersion Indicator field test (SDI) and Emerson Dispersion Test (EDT) are used as independent estimates of soil dispersion.

The tendency for dispersion usually increases with increasing ESP and decreasing Ca: Mg ratio. Sodic soil layers (ESP ≥6) may disperse and strongly sodic soils (ESP≥15) usually do disperse (soil erodes). Soils with Ca:Mg ratios of 0.5 or less often exhibit dispersion even with low ESP.

ESP and Ca:Mg ratios are derived from chemical analyses and must be interpreted with care and in relation to soil type and strata. When the actual exchangeable cation levels are very low, any small change in one value can cause a disproportionate change in the percentage or ratio calculation and thus alter the dispersion rating.

Another complicating factor that must be considered for soils within the development area studied is the aluminium saturation. Soil layers with high aluminium saturation may not disperse despite many of the soil indicators suggesting that they should. This is due to the effects of aluminium in causing clay particles to flocculate (aggregate) together, thus resisting their tendency to disperse. This factor does not seem to be as dominant in the current study area.

However, the results for the dispersion indicators have been interpreted and modified where necessary to allow for soil texture (low CEC), any aluminium saturation and site and profile conditions observed during field inspection.

The overall interpretation is provided in Table 7 for all sampled soil layers.

Table 4 and others indicates that the surface layers of the *all* soils are mainly non sodic (ESP <6) though they have a Ca:Mg ratio of 1.0 or less. However, the subsurface layers are sodic to strongly sodic. The EDT tests indicate a tendency to disperse in subsoil samples and overall of the two layers only topsoils are considered unlikely to be dispersive.

All subsoil samples from the *TC soils* on the site have at least one indicator (mostly two) designating dispersion and a substantial proportion have three indicators. Most subsoil samples have low aluminium saturation suggesting dispersion may be likely and significant subsoil erosion was observed nearby.

Table 7. Dispersion indicators for each mapped soil type - Daleys Rd

Soil name (Site) [1]	Soil layer [1]	Samples [1]	Texture [2, 3]	ESP ≥ 6 [2, 4]	Ca:Mg ≤0.5 [2, 4]	ECN ≤2 [2, 5]	SDI [2, 6] Slaking, Clouding	Al sat'n ≥ 25% [2]	Dispersive [6]
Shallow sandy Sodosols-	Surface: Subsurface:	4 6	LS/SL LMC/SMC	<6 10->15	1.2 <0.3	Nil all	low, Nil moderate to high	No No	Unlikely Probably
Deep sandy Sodosols-	Surface: Subsurface:	1 2	LS/ SL SLMC/MHC	<6 >15	1.2 <0.8 to <0.1	Nil All	Nil, Nil low tohigh	No around 20	Unlikely Probably

Notes:

1. Samples designated as "Surface + subsurface" have been combined from both the surface and subsurface layers.
2. > = samples that exceed the threshold limit ;< samples that do not exceed the threshold limit >6; Sodic >15 Strong Sodic.
3. Texture codes are:

SL	Sandy loam	CL	Clay loam
SCL	Sandy clay loam	LMC	Light medium clay
MC	Medium clay		

4. Some surface and subsurface samples with high ESP or Ca:Mg ratio have a CEC of 2 or less and the results are subject to high computational error.
5. ECN is the Emerson Class Number assigned to each soil sample as a result of the laboratory-based Emerson Dispersion Test. Classes 1 and 2 are dispersive but Classes 5 and 6 are non dispersive.
6. SDI is the Soil Dispersion Indicator field test and any sample which exhibits "Slow" to "Fast" slaking or with "Slight to "High" clouding indicates some degree of soil instability.
7. Soil layers labelled as "probably" dispersive have more indexes suggesting dispersion than those that don't. Soils labelled as "possibly" dispersive have fewer indexes suggesting dispersion than those that don't. Soils labelled as "unlikely" to be dispersive are generally non sodic and have much fewer indexes suggesting dispersion than those that don't.

6.3 Erodibility

Five soil erodibility ratings have been defined in the Transport and Main Roads RDDM (Transport and Main Roads 2002). All soils identified within the corridor have been assigned to these erodibility ratings which are presented in Table 5.

All subsoil layers of the *TC* are likely to be dispersive and have inherent erodibility. This especially applies to the clay subsoil which is dispersive giving the entire subsoils a moderate to high erodibility rating.

6.4 Permeability

Soil permeability refers to the ability of the soil to transmit water through its profile in situ and is controlled by the transmission potential of the least permeable layer. Soil permeability is a function of texture, structure, capacity to crack open when dry and soil dispersion. The Australian Soil and Land Survey Field Handbook (McDonald et al 1990) defines four permeability classes:

- very slowly permeable;
- slowly permeable;
- moderately permeable; and
- highly permeable.

These soil permeability ratings have been assigned to each soil based on field evidence and soil analytical results. The ratings are listed in Table 8.

Table 8. Soil erodibility and permeability ratings- Daleys Rd

Soil name	Erodibility [1]	Permeability [2]	Indicative hydraulic conductivity [2]
Shallow sandy Sodosols-	Moderate	Moderate-slow	≈50 mm/day
Deep sandy Sodosols-	Moderate – high	Moderate-slow	≈50 mm/day

Notes:

1. From the Transport and Main Roads Road Drainage Design Manual (Transport and Main Roads 2002).
2. From the Australian Soil and Land Survey Field Handbook (McDonald et al 1990).

Overall, these profiles would have slow to very slow subsoil permeability with an indicative hydraulic conductivity varying from less than 5 up to 50 mm/day.

7. Site soil suitability for re-use in landscaping and revegetation

7.1 Suitable soils

Provided appropriate amelioration strategies (per Table 6) are implemented the surface layers of the *TC* are suitable for re-use in landscaping and revegetation as detailed below.

Table 9. Soil Group Stripping Depths for Planting Media, Ripley Daleys Road JV

Soil	Landform	Modal slopes	Stripping depth (mm)	Area (ha)
Shallow sandy Sodosols-	Crests and convex side slopes	Slopes 3-12%	**50-150**	3ha
Deep sandy Sodosols-	Concave and planar lower slopes and footslopes	Slopes 2-6%	50-100	32ha

7.2 Unsuitable soils

Because of their hilly terrain and thin cover of surface layer overlying clay subsoil that is probably dispersive, the *Shallow sandy Sodosols TC soils (dispersive) on crests* are unsuitable for any re-use in landscaping and revegetation as planting media. The whole soil profile however must be ameliorated per Table 6 & 6a before landscape treatments applied.

Disturbance of these soils should be limited to removal of organic matter from surface that is grubbing.

8. Site soil stripping

This report arranges soil profiles into surface layers, subsurface layers and subsoil to facilitate description of profile features (see section 3.1). However, MRS11.16 General Requirements Landscape and Revegetation Works use the terms "topsoil" and "subsoil" (Transport and Main Roads 2009). Natural surface layers are equivalent to "topsoil" as defined by Transport and Main Roads whereas subsurface layers and subsoil as used in this report are part of the Transport and Main Roads definition of "subsoil".

Where necessary, the term "topsoil" is used in sections of this report to provide direct correlation with Transport and Main Roads specifications but is applied strictly according to the Transport and Main Roads definition.

8.1 Removal of organic matter

During construction, "topsoil" is partly or fully stripped to remove as much organic matter as possible from the disturbed site areas.

8.2 Depth of suitable soil for re-use in landscaping and revegetation – Daleys Road

The limited chemical analyses performed on soil samples for this survey indicate the chemical barriers to using any of the surface and subsurface layers for revegetation can be overcome with acceptable amelioration strategies.

Therefore, the thickness of soil material suitable for stripping, stockpiling and subsequent revegetation has been determined by the depth to heavier clay subsoil in the three soil groups.

However, the maximum depth recommended for stripping has been decreased by 50 mm to leave some suitable material within the landscape so that the dispersive subsoil is not mixed with the desirable top layers to be ameliorated for use as planting media.

Table 9 presents the calculated depth of soil material in each soil that is suitable for stripping and re-use in landscaping and revegetation. It includes all suitable surface and subsurface layers. Only the surface layer is equivalent to "topsoil" as defined in MRS11.16 General Requirements Landscape and Revegetation Works (Transport and Main Roads 2009).

Thus, the maximum depth that is recommended for stripping is not restricted to "topsoil" alone (as defined by Transport and Main Roads 2005). It may also include any part of the Transport and Main Roads defined "subsoil" that is non dispersive, friable and readily breaks down to create a fine seed bed. Medium and heavy clays are usually not recommended as they tend to be difficult to work, have very slow permeability and have coarse structure which will not readily break down.

A proposed topsoil stripping schedule is provided in Table 9.

9. Risk management strategies

9.1 Clearing and grubbing operations

On sloping land where slopes exceed 2% (1:50), clearing and grubbing operations should not leave tyne lines or rills aligned down the slope. Working along contours is recommended.

Erosion control measures as outlined in section 10.2 should be implemented on all sloping land as soon as clearing and grubbing operations are completed.

9.2 Erosion control works and any sedimentation basins

Temporary runoff control structures should be installed in disturbed areas of sloping land where slope length exceeds 100 m. The runoff control structures should be placed across the slope at regular intervals (down the slope) within any disturbed area as soon as is practicable. The placement of these structures should divert runoff water along the contour and then spread it across the slope outside the disturbed area.

The *TC soils preset at the site* have moderate to high inherent erodibility but sometimes occur on quite steep slopes and a number of specific precautions should be implemented in addition to those described above and in section 7:

- Wherever possible, grubbing operations should leave at least 100 mm of undisturbed soil material (surface and/or subsurface layers) on top of the subsoil.
- The land surface should be levelled as soon as possible after any clearing and grubbing operations are finished. The levelling should create a slight convex shape that spreads runoff water away from the disturbed area rather than allowing it to concentrate.
- In particular, any holes should be filled with soil material from the surface and/or subsurface layers. If necessary, complying topsoil should be brought in from elsewhere to ensure no subsoil remains exposed. The levelled surface may have to be lightly compacted to ensure it is not easily moved by raindrop splash and running water.
- Sedimentation basins that expose the subsoil to runoff water should be compacted to ensure minimal water penetration into the soil material.

Works across the footslopes are usually built on top of the existing land surface, rather than excavating into it, and will thus minimise any erosion risk. However, the *TC* soils will be the dominant soil on bank slopes and any disturbance of these banks will involve a high erosion risk. If disturbance is necessary, these slopes should be restabilised as soon as possible as directed in summary in Tables 6 in this report.

9.3 Recommended Supervision of Soil Treatment

It is strongly recommended that Soil Scientist member of Australian Soil Science Society with at least 10years experience in Soil Chemistry should form part of the project documentation team to provide expert advice in following areas:

- Earthworks Fill Testing – include as recommended in Section 5.6 of report
- Cut batter treatment requirements (for dispersive soils erosion control)
- Bund detail at top of batters
- Any reuse or disturbance of site subsoils in cut and fill situations
- Sediment basin dispersive soil treatment
- Drainage swale construction details (for dispersive soils erosion control)
- All service trenching & backfill requirements
- General landscaping requirements

10. References

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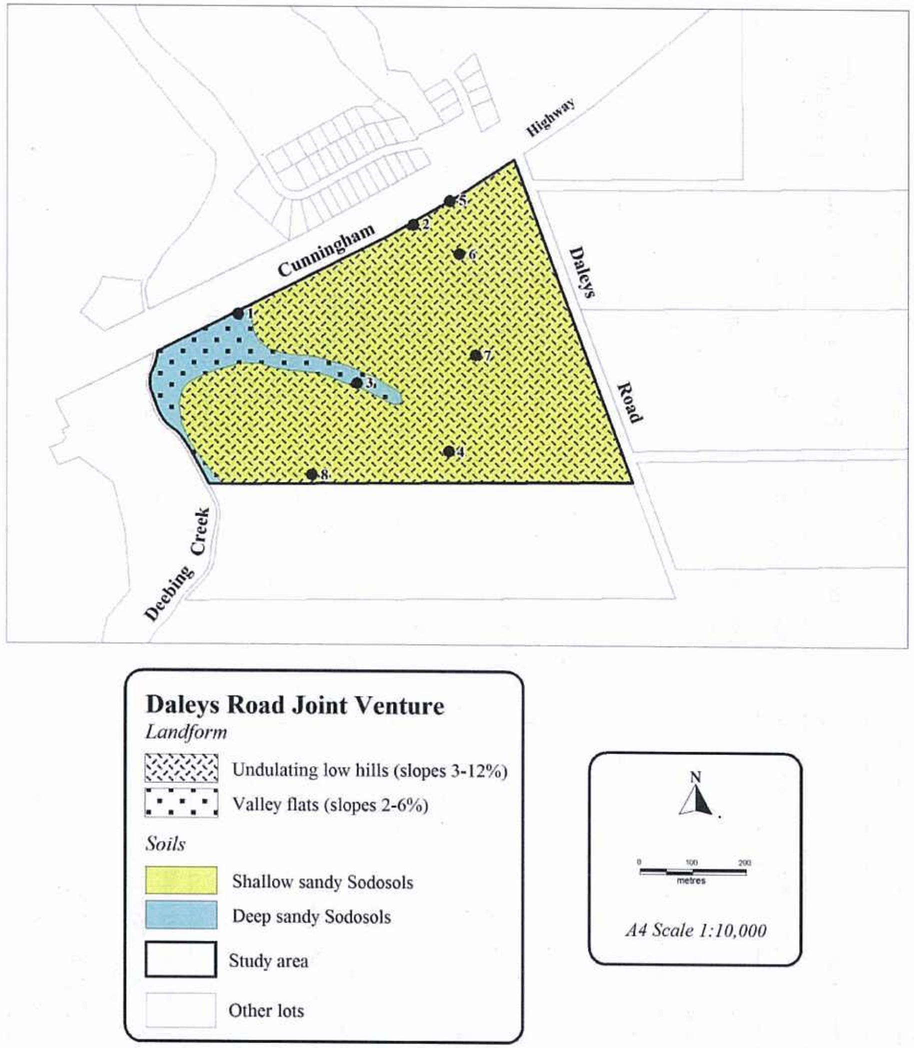

Figure 1. Soil Distribution Area 1 and Corridor Ripley Road Daleys Road JV

C – Full-Suite Analysis Schedule

Site Sample Identification	
Project Name:	Sample Location:
Job / Contract No:	Site / Stockpile No:
Date Tested:	Layer and Depth (from surface in mm):

Testing Laboratory Sample Identification	
Laboratory No:	Sample No:

Soil Test Parameter	**Test Method**	**Soil Test Parameter Requirements**	**Soil Test Results**
Refer AS 4419 – Soils for landscaping and garden use NOTE MODIFIED REQUIREMENTS			
Bulk density (BD)	Clause 5.2	> 0.7 kg/L	
Organic matter (OM) (relevant to the organic carbon concentration)	Clause 5.3	3 to 10%	
Wettability	Clause 5.4	> 5 mm/min.	
pH (H2O, 1:5) – a) General range b) Naturally occurring acid soils c) Naturally occurring alkaline soils	Clause 5.5	> 5.5 and < 7.5 > 5.5 and < 6.5 > 7.0 and < 8.5	
Electrical conductivity (EC)	Clause 5.6	< 1.2 dS/m	
Extractable phosphorous content (Extr. P) Very P sensitive plants Moderately P sensitive plants	Clause 5.8	< 5 mg/kg < 20 mg/kg	
Permeability	Clause 5.12	2 – 100 cm/hr	
Texture	Clause 5.13	Refer to Table AS 4419, Table I1 Soil texture Classification	
Large particles – planting media to – a) Turfed or grass seeded areas to be mown or slashed b) Batters to be mulched or hydraulic seeded and hydraulically mulched c) Broad acre areas to be seeded with native species	Clause 5.14	100% by weight to pass a 20 mm sieve 100% by weight to pass a 50 mm sieve 100% by weight to pass a 75 mm sieve	
Refer Appendix Table 1 – Method for Determination of Water Repellency of a Soil (Hydrophobicity)			
Water Repellence Rating (for sands to clay loams)	Appendix Table 1	Class 0 or 1	
Refer AS 1289.3.8.1 – Methods of testing soils for engineering purposes			
Dispersion – Emerson class number	Clause 3.8.1	Class 3 to 8	

Schedule continued over page.

C – Full-Suite Analysis Schedule – (continued)

Schedule continued from previous page.

Soil Test Parameter	Test Method	Soil Test Parameters Requirements	Soil Test Results
Refer ALHS (Australian Laboratory Handbook of Soil and Water Methods)			
Exchangeable calcium (Ca) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15B3	≥ 2 meq/100g ≥ 5 meq/100g	
Exchangeable magnesium (Mg) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15B3	> 0.6 meq/100g > 1.0 meq/100g	
Calcium magnesium ratio (Ca:Mg) Exchangeable form for sands and loamy sands and sandy loams to clay loams	Clause 15B3	2 – 10	
Exchangeable sodium percentage (ESP) (Na base saturation % = % Na of total cations) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15B3	< 6 < 15	
Exchangeable potassium (K) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15B3	> 0.2 meq/100g > 0.4 meq/100g	
Exchangeable aluminium percentage (Al base saturation % = % Al of total cations) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15G1	< 25 < 40	
Effective cation exchange capacity (ECEC) (ECEC = sum of exchangeable cations) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15J1	> 5 meq/100g > 10 meq/100g	

Sub-Suite Analysis Schedule

Site Sample Identification			
Project Name:		Sample Location:	
Job / Contract No:		Site / Stockpile No:	
Date Tested:		Layer and Depth (from surface in mm):	
Laboratory Sample Identification - Laboratory No:		Sample No:	
Soil Test Parameter	**Test Method**	**Soil Test Parameter Requirements**	**Soil Test Results**
Refer AS 4419 – Soils for landscaping and garden use NOTE MODIFIED REQUIREMENTS			
Organic matter (OM) (relevant to the organic carbon concentration)	Clause 5.3	3 to 10%	
pH (H2O, 1:5) – a) General range b) Naturally occurring acid soils c) Naturally occurring alkaline soils	Clause 5.5	> 5.5 and < 7.5 > 5.5 and < 6.5 > 7.0 and < 8.5	
Electrical conductivity (EC)	Clause 5.6	< 1.2 dS/m	
Refer Appendix Table 1 – Method for Determination of Water Repellency of a Soil (Hydrophobicity)			
Water Repellence Rating (for sands to clay loams)	Appendix Table 1	Class 0 or 1	
Refer AS 1289.3.8.1 – Methods of testing soils for engineering purposes			
Dispersion – Emerson class number	Clause 3.8.1	Class 3 to 8	
Refer ALHS (Australian Laboratory Handbook of Soil and Water Methods)			
Exchangeable calcium (Ca) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15B3	≥ 2 meq/100g ≥ 5 meq/100g	
Exchangeable magnesium (Mg) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15B3	> 0.6 meq/100g > 1.0 meq/100g	
Calcium magnesium ratio (Ca:Mg) Exchangeable form for sands and loamy sands and sandy loams to clay loams	Clause 15B3	2 – 10	
Exchangeable sodium percentage (ESP) (Na base saturation % = % Na of total cations) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15B3	< 6 < 15	
Exchangeable potassium (K) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15B3	> 0.2 meq/100g > 0.4 meq/100g	
Exchangeable aluminium percentage (Al base saturation % = % Al of total cations) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15G1	< 25 < 40	
Effective cation exchange capacity (ECEC) (ECEC = sum of exchangeable cations) a) Sands and loamy sands b) Sandy loams to clay loams	Clause 15J1	> 5 meq/100g > 10 meq/100g	

Soil Assessment Report

Site Sample Identification	
Project Name:	Sample Location (general):
Job / Contract No:	Site No's:
Date Tested:	Soil Layers (topsoil and / or subsoil):
Testing Laboratory Sample Identification	
Laboratory No:	Sample No's:

The Soil Assessment Report shall include –

- a completed test suite analysis schedule per sample;
- written assessment and interpretation of test results relevant to the intended use of planting media; including –
  - an erodibility and dispersion risk assessment; and
  - recommendations for the best use of a particular soil type, where applicable,
- clearly defined non-conforming soil properties;
- where amelioration is required, the type of ameliorant material together with rates and methods of incorporation; and
- where required, provide a Soil Assessment Report on the material to be used for the construction of drainage devices as outlined above.

Organic Soil Conditioner Requirements

Site Sample Identification	
Project Name:	Sample Location:
Job / Contract No:	Site / Stockpile / Windrow No:
Date Tested:	Depth (from surface in mm):
Testing Laboratory Sample Identification	
Laboratory No:	Sample No:

Organic Soil Conditioner Parameter	Test Method	Organic Soil Conditioner Test Parameter Requirements	Organic Soil Conditioner Test Results
Refer AS 4454 – Composts, soil conditioners and mulches			
National health standards	Clause 2.1.1	Complies with standards	
Visible extraneous material (% dry matter) – a) glass, metal, rigid plastics > 2 mm b) plastics-light, flexible or film > 5 mm c) stones and lumps of clay ≥ 5 mm	Appendix H	0.5% 0.05% ≤ 5%	
United States Environmental Protection Agency (USEPA)			
Soil Conditioner Quality USEPAA/625/R – 92/013 Control of pathogens	Thermophilic	Turning and temperature	
Refer AS 4419 – Soils for landscaping and garden use – NOTE MODIFIED REQUIREMENTS			
*pH (H2O, 1:5) – a) General range b) Naturally occurring acid soils c) Naturally occurring alkaline soils	Clause 5.5	> 5.5 and < 7.5 > 5.5 and < 6.5 > 7.0 and < 8.5	
NDI (Nitrogen Drawdown Index)	Clause 5.9	> 0.5	
*Wettability	Clause 5.4	> 5 mm/min.	
*EC (Electrical Conductivity)	Clause 5.6	< 2.5 dS/m	
Particle size of soil conditioner – a) to pass a 10 mm sieve b) to pass a 20 mm sieve c) not to pass a 20 mm sieve	Clause 5.14	90% by weight 8% by weight 2% by weight	
Refer Appendix Table 1 – Method for Determination of Water Repellency of a Soil (Hydrophobicity)			
Water Repellence Rating (for sands to clay loams)	Appendix Table 1	Class 0 or 1	
Refer ALHS (Australian Laboratory Handbook of Soil and Water Methods)			
Moisture content	2 B1 Rayment & Higginson	> 25% and < 35%	
Refer Draft Guidelines for the Assessment & Management of Contaminated Land in Qld – EPA			
Heavy metals and organic chemicals contaminants	Appendix 9 Table 9.1	Not to exceed EIL thresholds	

* Test requirements that have been modified from those in AS 4419.

Soil Descriptions Field Inspection Daleys Road Project (DR) – Ripley, Inspection Date 13 May 2011

SITE DR1: Foot slope near Deebing Creek south of Cunningham Highway (severe sheet rill and gully erosion).

WP (1)

0 – 50 cm	SCL; 7.5YR 4/2(M), 5/2(D); massive; T3; no gravel; no segs; Clear to -
50 – 120cm	SCL; 10YR 4/2(M), 6/2(D): sporadic bleach; massive; T3; no gravel; no segs; pH 5.5; Abrupt to -
120 – 700cm	SLMC; 2.5Y 5/2(M) and 10YR 5/6(M), massive; strong >100mm AB; T7; 2-10% 6-20mm SA and SR gravels; no segs; (charcoal); pH 6.5- 7.0
700 – 1100cm	SMC; 10YR 4/1(M); 6/6(M) and 6/2(M); massive – strong >100mm AB structure; gravel as above and weathered sandstone tabular slabs; no segs, charcoal; pH >7.0; Abrupt to-
1100 – 1400⁺cm	CLS/SLC [C/D]?; 10YR 4/1→6/1(M); massive; T3; no gravel; no segs

SAMPLES 0 - 0.1; 0.2 - 0.5; 0.6 – 1.0; 1.1 – 1.4: 1.4m+

pH	5.5	7.0	6.5	7.0	7.4
m	0.1	0.3	0.6	0.9	1.2 m

SITE DR 2: Upper slope on ridge; spotted gum; ironbark; wattles

WP (2)

0 – 120cm	SL; >5YR 5/4(M); massive; T2; no gravel; no segs; pH 6.5; Clear to -
120 – 200/300cm	LS; 7.5YR 6/4(M); 8/2(D); conspicuous bleach; massive; D2; no gravel; no segs; pH 5; Abrupt -
200 /300 – 500/600cm	MCS; 7.5 YR 5/6(M); 2-10% IF grey mottles; strong-medium 20-50mm AB; T5/6; no gravel; no segs; pH 5.5
600+	Weathered sandstone (hard)

SAMPLES 0 – 0.15; 0-0.25 – 0-0.35m

pH	4.9	5.0	4.5
	100	200	400

SITE DR 3: Mid-lower slope; spotted gum; ironbark; soap trees

WP (3)

0 – 120/150cm	SL; 10YR 5/3(M); massive; T1; no gravel; no segs; pH 6.5; Clear to-
120/150 – 230cm	SL; 10YR 6/3-7/3(M); conspicuous bleach; massive; T2; no gravel; no segs; pH 6; Abrupt to-
230 – 1000cm	SLMC→SMC; 10YR 5/6 and 10YR 7/1(M); weak-moderate 20-50mm AB; T 4/5; no gravel; 0-2% Mn2; pH6
1000 – 1500/1700cm	SMC; 10YR 5/6(M); 2-10% IDG mottles; massive-weak; 20-50mm AB structure; M4; 0-2% iron stained sandstone gravel; no segs; pH 5.5; Clear to-
1500 – 1700cm	HC; 10YR 6/6 and 7/2(M); weak 20-50mm AB; M4; 0-2% 2-6mm; SR sandstone gravel; no segs; pH 7.5
1700 – 2000cm	Hard sandstone

Depth m	0.1	0.2	0.6	0.8	1.0	1.7
pH	6.5	6.0	6.0	6.0	5.5	7.5

Samples 0- 150; 230-400; 400-600;1000-1200mm

SITE DR 4: Mid-upper slope at head of gully (slight swale relief); ironbark; gum topped box; soap tree; wattles

WP (4)

0 – 200cm	LS; massive; pH 6; Abrupt to -
200 – 650cm	LS; massive; conspicuous bleach; pH 6; Abrupt to-
650cm^{+}	Mottled yellow and grey; SMC; pH 6; as for previous site

SAMPLES: 650 – 750mm; 100 – 600mm; 0 – 100mm

SITE DR 5: Foot slope beside valley flat (proposed Detention basin); spotted gum; grey gum; bloodwood

WP (5)

0 – 100mm	LS; massive; D1; pH 5.0Abrupt to-
100 – 150mm	As above (LS; massive); but conspicuous bleach; pH 5.5 Abrupt to-
150 – 600mm	Mottled yellow-brown and grey SLMC; pH 6.5
600+mm	Weathered sandstone as per Site 1

SAMPLES: 650 – 750mm; 100 – 600mm; 0 – 100mm

SITE 6: Mid-upper slope, ironbark; gum topped box; wattles

WP (6)

0 – 50mm	A1; SL; massive; Clear to-
50 – 180mm	A2; SL; conspicuous bleach; massive; Abrupt to-
180 – 250mm^{+}	SMC; yellow 10YR 5/4 with 2-10% ;Dark Grey mottles

SITE 7: Crest of ridge line; grey gum; casuarinas; spotted gum

WP (7)

0 – 50mm	A1; SL; massive; Clear to-
50 – 150mm	A2; SL; conspicuous bleach; Abrupt to-
150 – 400mm^{+}	7.5YR 5/6(M) with 10-20% IDG (10YR 6/1M) mottles; SMC

SITE 8: No waypoint

0 – 100mm	A1; SL to
100 – 200mm	A2; SL; conspicuous bleach to
200 – 400mm^{+}	Mottled yellow-brown and grey SMC

YARA

Analysis Results (SOIL)

Customer	DALEYS RD JV RIPLEY	**Distributor**	ENVIRONMENTAL SOIL SOLUTIONS 5 DUNPHY ST SUNNYBANK HILLS QLD
Sample Ref	DR1 0-100	**Date Received**	16/05/2011
Sample No	B051905-001 / SAC2983		
Crop	DATA ONLY		

Analysis	Result
pH [H2O]*	5.4
pH [CaCl2]*	4.9
Organic Matter (%)	2.6
CEC (meq/100g)	3.24
EC (dS/m)	0.05
NO3-N* (ppm)	< 1.0
Phosphorus (Olsen)* (ppm)	5
Potassium* (meq/100g)	0.18
Calcium* (meq/100g)	1.42
Magnesium* (meq/100g)	1.22
Sulphur (ppm)	8
Boron* (ppm)	0.2
Copper (ppm)	0.2
Iron (ppm)	81
Manganese (ppm)	57.7
Zinc (ppm)	0.6
Sodium* (meq/100g)	0.2
Aluminium (meq/100g)	0.27
Chloride* (ppm)	16
Ca base saturation (%)	43.8
K base saturation (%)	5.6
Mg base saturation (%)	37.7
Na base saturation (%)	4.6
Al base saturation (%)	8.30
Ca:Mg Ratio	1.2
Aluminium (ppm)	24.0
Sodium (ppm)	35.0
Calcium (ppm)	284.0
Magnesium (ppm)	148.0
Potassium (ppm)	70.0

PHOSYN ANALYTICAL

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