Appendix 5:

Rehabilitation Monitoring Report

Mount Thorley Warkworth Rehabilitation Monitoring Report 2019

Prepared for Yancoal by Cumberland Plain Seeds

Document control		Cumberland Plain Seeds
Project Client	Yancoal Australia	Ecological restoration and consulting services
Document description	Report of findings of native vegetation monitoring conducted at Mount Thorley Warkworth and reference sites as part of the annual rehabilitation monitoring program	PO Box 201 Glenbrook 2773 NSW Email: tim@cpseeds.com.au
Project Manager	Tim Berryman	For further information or permissions relating to this report please contact John Moen via: email: john@cpseeds.com.au Phone: 0447316933
Authors	Brenden Field and John Moen	
Internal review	Tim Berryman, Neridah Davies	
Mapping	Supplied by Cambium Group	
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Cover photograph: John Moen - Native vegetation establishing at Mount Thorley Operation rehabilitation site.

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1 Introduction

Cumberland Plain Seeds (CPS) was engaged by Yancoal Australia Limited (Yancoal) to conduct monitoring of native vegetation on rehabilitated land at the Mount Thorley Warkworth Mine (MTW). The MTW mine is located in the Hunter Valley of NSW, approximately 10km South West of Singleton. CPS conducted the third round of vegetation monitoring in the MTW monitoring program. The first two rounds were undertaken by Niche Environment and Heritage Pty Ltd (Niche) in 2016 and 2017 for Coal and Allied as part of the combined MTW and Hunter Valley Operations rehabilitation monitoring program.

Due to an overlap with a project run through the Australian Coal Industry Research Program (ACARP Project C27038) the reference sites and selected rehabilitated sites were surveyed by Umwelt Australia. Further details of this project are included in the Appendices.

Umwelt personnel were:

- Travis Peake - Project Director
- Trish Robinson - Senior Ecologist
- Belinda Howe - Ecologist

Monitoring was repeated for sites surveyed in the 2016 and 2017 program and also includes several new sites. A total of 12 reference sites and 42 rehabilitation sites were surveyed and the results are presented in the following report.

The aim of the monitoring program is to record data which can be reported against a series of criteria specified in the Mining Operations Plan (MOP). Some extra measurements, not required by the MOP, were recorded to assist in management decisions.

The following tasks were completed at each of the monitoring sites:

- Establish permanent monitoring transects in new sites, sampled for the first time in 2019
- Complete Landscape Function Analysis (LFA) at all sites
- Floristic and vegetation quality monitoring based on Biobanking Assessment Methodology (BBAM).
- Visual monitoring at all monitoring sites.
- Photographic monitoring for all sites.
- Soil sampling for agricultural analysis at all sites.
- Soil sampling for microbial analysis at selected sites.
- Canopy development, stem density and overstorey regeneration assessments for all sites.

Following field data collection the rehabilitation site results were compared with those from reference sites or the relevant MOP criterion. The rehabilitation sites varied considerably in condition and some discussion of the significance of the monitoring results for each site has been included, along with implications for further management action.

2 Monitoring sites

2.1 Rehabilitation sites

Monitoring was conducted at 18 sites previously surveyed in the 2016 and 2017 monitoring rounds, except for MTWNPN201402, which was not sampled because the monitoring transect had been disturbed. Transects were established on an additional 24 sites. New transect locations were selected as randomly as possible. Transects were located away from the edges of the rehab site (minimum 20m) to avoid edge effects as far as possible. The transects were set up running downslope, as this is required by the LFA methodology, and this transect is also used for the BioBanking transect and quadrat. Site names and transect locations are provided in Appendix 8.3.

The MTW rehabilitation sites are spread across several areas within the mine and individual sites have been grouped together in this report accordingly. The rehabilitation areas are:

Rehabilitation area	Site name prefix
North Pit North	MTWNPN
CD Dump	MTWCDD
Tailings Dam 1	MTWTD1
South Pit North	MTWSPN
South Pit South	MTWSPS
Woodlands	MTWWDL
Mount Thorley Operations	MTWMTO

Table 1

For clarity the "MTW" has been removed from the site name prefix in graphs and tables below.

2.2 Reference (Analogue) sites

The MOP specifies that the target ecological community for rehabilitation sites at MTW to be Central Hunter Grey-Box Ironbark Woodland (Endangered Ecological Community). Reference sites were established in 2016 in two Biometric Vegetation Types (BVTs) which were chosen based on vegetation types cleared from the MTW site. These communities are:

- Central Hunter Grey Box - Ironbark Woodland
- Central Hunter Ironbark - Spotted Gum – Grey Box Forest

Niche 2018 lists these as Biometric Vegetation Types HU701 and HU632 respectively but the MOP lists Central Hunter Grey Box - Ironbark Woodland as HU817 and Central Hunter Ironbark - Spotted Gum – Grey Box Forest would appear to fit more closely to HU818. The OEH benchmark values for HU817 and HU818 are used for comparison with reference site benchmarks in this report.

The reference sites are located on four separate blocks of land through the central Hunter Valley, two managed by Yancoal, one managed by Wambo Coal Mine and one at Belford National Park, west of Branxton. Site names and transect locations are provided in the Appendix 8.2.

2.3 Reference site Benchmark and OEH Benchmark Values

Benchmark values were calculated from the reference site Biobanking data. The calculated benchmark values were also compared to the OEH published benchmarks to assess the relative quality of the reference site-derived benchmarks. These benchmarks are derived from surveys of high quality undisturbed (or nearly undisturbed) native vegetation communities. Although AECOM (2016) considered it inappropriate to refer to undisturbed vegetation when setting reference values for rehabilitation the Society for Ecological Restoration refer specifically to the use of combined data when setting reference values "*These sources may include multiple extant reference sites, field indicators, historical records (including human use) and predictive data*". (McDonald et. al. 2016).

Table 2 Biobanking reference site and benchmark values

	Reference site average values								Benchmark values			
	Central Hunter Ironbark-Spotted Gum - Grey Box Forest 2019		Central Hunter Grey Box Ironbark Woodland 2019		Combined values for reference sites 2019		Combined values for reference sites Niche 2018		Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter - HU817		Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter - HU818	
BioBanking measure	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	upper	Lower	upper
Native plant species		44		44		44		27		41		41
Native overstorey cover	13.7	32.8	6.3	25	9.2	30.8	13.3	22.8	15	40	15	40
Native mid storey cover	0.3	10.9	1.8	6.6	0.6	7.9	0	10	5	20	5	20
Native ground cover grasses	16	23	6	32	8.6	23.8	18	33	30	50	30	50
Native ground cover shrubs	0	2	0	1	0	2	1	11	5	10	5	10
Native ground cover other	6	24	5	19	6	19.8	3	26	20	40	20	40
Exotic plant cover	<1			<1		<1	0	0	0	0	0	0
Number of trees with hollows	0	0	0	0	0	0	>1			3		3
Length of Fallen Logs		10		17		11	>21			5		5

The data for reference sites (2017 and 2019) and OEH benchmarks are comparable for most scores. The reference site ranges have been expanded in some categories although for most measures the reference sites do not meet the OEH benchmarks. This is not surprising because the reference sites are located in vegetation recovering from past disturbance. The notable exceptions are that the reference site average for species richness and fallen log length exceed that of the benchmarks.

3 Methods

3.1 Monitoring dates and team members

Monitoring Field work was undertaken between 3rd March and 5th May 2019. Field data was collected by Neridah Davies, Brenden Field and John Moen. Reference sites and selected rehabilitation sites were surveyed by Trish Robinson and Belinda Howe of Umwelt Australia.

3.2 Monitoring methodology design

The MTW rehabilitation program follows the AECOM 2012 *Monitoring Methodology – Post-mined Lands MTW and HVO North Mine Sites*. In brief the methodology derived by AECOM uses Landscape Function Analysis (LFA) and the BioBanking Assessment Method (BBAM), soil analysis and visual monitoring. LFA is used to measure the soil stability of a site and the levels of water infiltration and nutrient cycling. The BBAM is used to assess the biodiversity values of a given patch of vegetation.

Niche followed this methodology in 2016 and 2017 with some amendments including:

- Replacing the 1x1 m pasture/groundcover monitoring with a BioBanking plot (20x50m including a nested 20x20m plot).
- Addition of stem density counts to assist in vegetation management decisions (not a MOP criterion).
- Addition of tree tagging: canopy trees with a trunk diameter at breast height (DBH) of more than 5cm were tagged, numbered and DBH recorded.

  Note: for the purposes of stem density counts and canopy development assessment Niche counted the following species:

  - *Acacia implexa*
  - *Acacia salicina*
  - *Allocasuarina leuhmannii*
  - *Corymbia maculata*
  - All endemic *Eucalyptus* species

CPS continued the amended methodology used by Niche. Sampling techniques are described in further detail below.

3.2.1 Landscape Function Analysis (LFA)

LFA is a monitoring procedure developed by the CSIRO as a method for assessing rangelands and later extended for use on mine sites (Tongway and Hindley, 1997, revised 2004). It is designed to measure the soil surface properties of a slope within a landscape and thereby assess how well that landscape is working in a biophysical sense and whether a recovering landscape, such as a rehabilitated mine site, is improving or declining in function. In essence, a functioning landscape should trap and retain resources such as water, soil, seed and organic matter. A dysfunctional landscape will tend to lose these resources over time.

LFA provides a series of scores or indices which must be compared to each other over time and to values obtained from surveying reference sites. The LFA scores should not be used in isolation but as a complement to biodiversity assessment. The scores derived from an LFA survey are landscape organisation, soil stability, soil infiltration and nutrient cycling. Landscape organisation is derived by measuring *patches,* which trap resources within a landscape and *interpatches,* which lose resources. The landscape organisation index (LOI) is a measure of the proportion of patch size to the total transect length. The other three indices are derived by assessing eleven indicators in a soil surface assessment (SSA).

These indicators are listed in the following table (after Tongway and Hindley 2004):

Table 3 LFA Soil surface indicators and related processes

Soil surface indicator	Process
Soil cover	Rain splash erosion, crust formation
Basal cover of perennial plants	Below ground biological activity (root volume)
Litter cover, origin and degree of composition	Decomposition and nutrient cycling of surface organic matter
Soil biological crust cover (Cryptogams forming a protective crust)	Surface stability, resistance to erosion and nutrient availability
Crust brokenness	Wind ablation or water erosion
Erosion type and severity	Nature and severity of current soil erosion features
Deposited materials	Upslope soil stability (any deposited material has been eroded from upslope)
Surface roughness	Water infiltration, flow disruption, seed capture
Surface resistance to disturbance	Susceptibility to mechanical disturbance
Slake test	Soil stability/dispersiveness when wet
Soil texture	Infiltration rate and water storage potential

The values recorded for patch organisation and soil surface assessment are entered into a spreadsheet which calculates the four indices. The results from these assessments are presented as graphs in the results section.

Although the value of LFA as a tool for assessing mine site stability is questioned by some (Erskine et. Al. 2015), the criticisms are addressed by the number of transects used at MTW and the comparison of LFA data over time. The rehabilitation sites at MTW are usually relatively small (often less than 10 Ha) and quite uniform in slope, soil type and vegetation condition. It may be useful to include additional monitoring transects on sites larger than 10 Ha or where there are obvious changes in soil type or vegetation cover. This would improve the overall quality of the LFA data and allow for better identification of problems with landscape function.

3.2.1.1 LFA transect

The LFA transect is set up running perpendicularly down slope. At MTW 50m transects were used. The transect was broken up into patch zones and interpatch zones by observing patterns of vegetation and other obstructions and potential water flow paths. Once patches had been identified five soil surface assessments were conducted for each patch and interpatch type. In some cases it was not possible to conduct five replicates due to small or infrequent patch types. More details on LFA sampling techniques are available in the LFA Field Procedures (Tongway and Hindley, 2004).

3.2.1.2 Rill surveys

Where rills were observed at less than 30m spacings across the slope a rill survey was conducted as defined in the LFA methodology (Tongway and Hindley 2004). Rills were observed and surveyed at WDL201801 and NPN201602.

3.2.2 Biobanking and site value scores

The NSW BioBanking scheme was set up as a way of trading biodiversity credits in order to offset impacts on biodiversity from developments such as mining. The BioBanking Assessment Methodology is used to generate a site value score which can then be converted into an offset credit. The methodology measures several vegetation attributes: species richness and native plant cover in the canopy (over-storey), mid-storey and ground layer, the number of hollow-bearing trees, length of fallen timber and the quality of regeneration in the overstorey.

The values recorded for each of the site attributes are combined to calculate a site value score. This approach was suggested in AECOM (2021) but Niche considered it more useful to present each of the site attributes directly. CPS has continued this approach so as to more easily compare results with the MOP performance criteria.

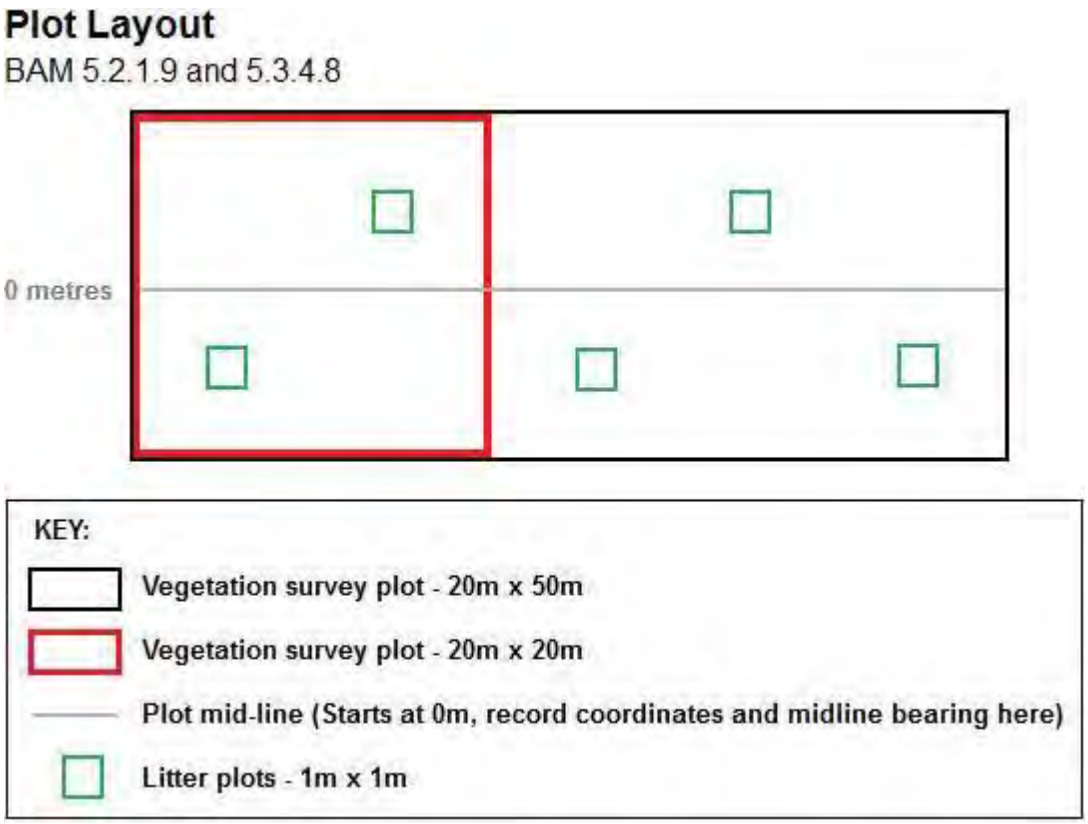


Figure 1 Biobanking survey transect and plot layout, OEH 2018. Note: 1x1m litter plots were not sampled

Table 4 Biobanking Attributes

Attribute	Abbreviation	Sampling method
Native plant species richness	NPS	Record number of species in each vegetation layer within a 20 x 20 m quadrat nested within the 50 x 20m quadrat.
Native overstorey % cover	NOS	Record % cover at 5m intervals along the 50m transect, then derive average for transect
Native mid-storey % cover	NMS	Record % cover at 5m intervals along the 50m transect, then derive average for transect
Native ground layer % cover (grasses)	NGCG	Record presence or absence at 1m intervals on along the 50m transect, then multiply total hits by 2 to calculate % cover
Native ground layer % cover (shrubs)	NGCS	Record presence or absence at 1m intervals on along the 50m transect, then multiply total hits by 2 to calculate % cover

Native ground layer % cover (other species)	NGCO	Record presence or absence at 1m intervals on along the 50m transect, then multiply total hits by 2 to calculate % cover
Exotic plant % cover	EPC	Record presence or absence at 1m intervals on along the 50m transect, then multiply total hits by 2 to calculate % cover
Overstorey regeneration	OR	Total number of tree species in the overstorey is divide by the number of species with a diameter at breast height (DBH) of >5cm. Maximum value for this score is 1. E.g. 2 species >5cm DBH / 5 species total = 0.4
Total length of fallen logs (m)	FL	Within the 20 x 50m quadrat any fallen timber >10cm diameter and >0.5m long was measured and the total length of all logs recorded.
Number of trees with hollows	NTH	Count the number of trees with hollows within the 20 x 50m quadrat.

Note: Native species growth form classes follows the list associated with the OEH Biodiversity Assessment Calculator (Office of Environment and Heritage, 2019). This list is included in Appendix 8.8.

3.2.3 Canopy Development and over-storey regeneration

The BioBanking methodology is not ideally suited to the mine rehabilitation context because it is designed to compare natural vegetation which are either mature or in an advanced state of recovery from past disturbance. To assist in better understanding the early stages of the mine site revegetation process and identify success or potential problems early two measurements were added to the monitoring program by Niche:

1. Stem density count for canopy species. Any individual of a canopy species was counted in a 2m to the left and 2m to the right of the central transect. The values were used to calculate a stem density per hectare. Where juvenile plants could not be identified to species level they were identified to genus.
2. Canopy development data were also collected from the 20 x 20m quadrat:
    a. Average trunk diameter, measured for tree species with a DBH >5cm. These trees were tagged with metal tree tags for future identification.
    b. Percentage of the canopy layer flowering or fruiting
    c. General condition of the tree population

Many of the sites surveyed in 2019 are in the early stages of revegetation and tree and shrub species were often too small to be recorded in the mid or over storey layers. In these cases some information about potential canopy establishment can be inferred from the stem density counts.

3.2.4 Visual Monitoring

3.2.4.1 Species composition and vegetation health

Dominant or sub-dominant plant species were recorded for each site. This observation is important to quickly understand the succession stage of the vegetation and quickly identify potential weed problems. Where observed, notes were made on species fruiting or flowering and whether there was evidence of second-generation recruitment of native plants.

3.2.4.2 Habitat and fauna monitoring

Observations were made on habitat features such as dams, habitat ponds, availability of large rocks and woody debris and stag trees.

3.2.4.3 Disturbance

Evidence of factors which can affect the success or quality of the rehabilitation were recorded:

- Evidence of disturbance from vehicles such as tracks or excavation
- Mine rubbish
- Maintenance activities – herbicide application, slashing, fencing
- Exotic weeds
- Feral animals
- Fire
- Erosion

3.2.5 Photographic monitoring

Photographs were taken at the beginning and end of each monitoring transect. Three photographs were taken at the start point and three at the end point facing into the quadrat: 45° left, centred on the transect and 45° right.

3.2.6 Soil Analysis

3.2.6.1 Agricultural/Chemical analysis and microbial analysis

A composite soil sample was collected from each monitoring quadrat. Samples were composed of a minimum of nine sub-samples collected from within a 20m radius of the 15m point on the central transect. Sub-samples were mixed in a bucket, then bagged, labelled and stored at 5° C until sent to Environmental Analysis Laboratory (EAL).

For selected sites a second sample was taken in the same way, though stored at -15° C until sent to Sydney Environmental and Soil Laboratory (SESL) for microbial analysis.

3.2.7 Weather

Weather records for the periods were obtained from the Bureau of Meteorology for the Singleton Army Base weather station and are presented in the appendix. The field data collection period took place just after significant autumn rain and so there was generally good plant growth at many sites. However the prevailing weather conditions of 2017-2019 have been drier than average, warmer than average and with often very windy conditions.

3.3 Limitations

The field data collection was carried out at a single point in the year. This means that some plant species were at a point in their life cycle where they were not observable. This was almost

certainly the case for many annual species. Other species were not identifiable to species because correct identification often relies on observing flowers or fruit which were absent at the time of survey.

As described in Niche 2018 the reference sites were located in remnants of Biometric Vegetation Types appropriate to the target vegetation of the MTW rehabilitation program. However, these sites are themselves in a state of recovery from past disturbances such as clearing, grazing and earthworks. As such the reference communities themselves lack some of the characteristics of old growth vegetation. For example, fallen timber and numbers of trees with hollows were much lower for reference sites than the OEH benchmark values for the target vegetation types. Canopy species stem counts were also very high when compared to stem densities in more mature vegetation (Kerle, 2005). This should be taken into consideration when comparing the rehabilitation monitoring results with reference site values and when making management decisions.

The BioBanking Assessment Methodology is designed for use in mature vegetation and as such is not ideally suited to monitoring vegetation in the early stages of establishment. In particular the methodology does not record individual species abundance or cover. This means that a particular site with high species richness may appear to be performing well in the early stages but species richness may decline over time if the abundance of a given species is too low. It would be useful to better understand the abundance of plant species on the mine sites so that potential problems could be identified before diversity declines.

3.4 Performance criteria

The Mining Operations Plan (MOP) 2019 provides performance criteria which are used to assess the success of rehabilitation efforts on the mine. Following the establishment of the final landform the revegetation is assessed at several stages: Growing Media Development, Ecosystem and Landuse Establishment and Ecosystem and Landuse Sustainability. Various criteria are to be measured in order for a given site to pass from one phase to the next. The performance criteria for each phase are given below, as specified in the MOP.

There are three target domain types for rehabilitated native vegetation at MTW: Grassland, Woodland – Endangered Ecological Community (EEC) and Woodland – Other. All rehabilitation sites were assessed against the MOP criteria for the Woodland – EEC domain. The Performance criteria for each rehabilitation stage are reproduced in the following tables.

3.5 Growth medium development

Table 5 Growth medium development performance criteria

Criterion	Performance measure	Measurement method
pH	>5.5 and <8.5	Soil analysis
Electrical Conductivity (EC)	<2dS/m	Soil analysis
Soil Phosphorous	Within analogue site values by year 5	Soil analysis
Organic Carbon %	Within analogue site values by year 5	Soil analysis
Cation Exchange Capacity (CEC)	Within analogue site values by year 2	Soil analysis
Exchangeable Sodium Percentage (ESP)	Within analogue site values by year 2	Soil analysis
Calcium : Magnesium ratio	Within analogue site values by year 2	Soil analysis

3.6 Ecosystem and Landuse Establishment – Woodland EEC

Table 6 Ecosystem and Landuse Establishment Performance criteria

Criterion	Performance measure	Measurement method
Tree species	1-4 species within a 20 x 20m quadrat	Flora survey
Shrub species	4-9 species within a 20 x 20m quadrat	Flora survey
Grass species	4-9 species within a 20 x 20m quadrat	Flora survey
Subshrub and understorey species other than grasses	10-20 species within a 20 x 20m quadrat	Flora survey
Native plant species richness	13-41 species within a 20 x 20m quadrat	Flora survey
Tree density	250-3,150 stems/Ha	Stem density survey
LFA Landscape Organisation	Trending towards or exceeding reference site values 0.84-1	LFA
LFA Stability Index	Trending towards or exceeding reference site values 53.9-81.8%	LFA
LFA Infiltration Index	Trending towards or exceeding reference site values 48.4-73.9%	LFA
LFA Nutrient Cycling index	Trending towards or exceeding reference site values 38.5-79.8%	LFA

3.7 Ecosystem and Landuse Sustainability – Woodland EEC

Table 7 Ecosystem and Landuse Sustainabiliy Performance Criteria

Criterion	Performance measure	Measurement method
Native over-storey	15-50% cover	BioBanking Assessment Methodology
Native mid-storey	5-60% cover	BioBanking Assessment Methodology
Native ground cover (grasses)	5-50 % cover	BioBanking Assessment Methodology
Native ground cover (shrubs)	5-10% cover	BioBanking Assessment Methodology
Native ground cover (other species)	5-40 % cover	BioBanking Assessment Methodology
Exotic Plant cover	5-33% or less than reference site range	BioBanking Assessment Methodology
Total groundcover	32-74%	BioBanking Assessment Methodology
Native understorey species richness / m^2 (across the site)	16-27 species in a 20m x 20m quadrat	Flora survey
Diversity of maturing trees	1-4 species in a 20m x 20m quadrat	Flora survey
Percentage of maturing trees and shrubs that are local endemic species	90-100%	Canopy development survey
Density of maturing trees (DBH>5cm)	50-725 stems/Ha	Canopy development survey
Average trunk diameter trending towards analogue sites	10.8-65cm	Canopy development survey
Percentage of tree population in a healthy condition, medium health and in advanced dieback	To be determined but comparable to analogue sites	Canopy development survey
Presence of reproductive structures	To be determined but comparable to analogue sites	Canopy development survey
Overstorey Species regeneration (OR)	0.5 to 1.0	Canopy development survey
Length of fallen logs	⩾ 3m in a 20m x 20m quadrat	BioBanking Assessment Methodology
Number of hollows/nesting sites	0.5 in a 20m x 20m quadrat	BioBanking Assessment Methodology

4 Results

4.1 Growth medium development

4.1.1 Soil Analysis

Complete soil analyses conducted by Southern Cross University's EAL laboratories are contained within the appendices, while values relevant to the MOP performance criteria are displayed in the following tables. Summary statistics between reference and rehabilitation site soil chemistry parameters are displayed in table 9. Attributes diverging most from reference sites values included: pH, Electrical Conductivity (EC), phosphorus and Exchangeable Sodium Percentage (ESP), with many site's phosphorus and EC values 10-fold that of reference site mean values. A trend of rehabilitation sites with higher pH values is exhibited, with all site pH values greater than those found for reference sites. The highest sites (CDD201501, MTO201703, MTO201803, NPN201702, TD1201501) were found to be between 2-3 pH units above the reference mean (5.68).

Table 9: Summary statistics for 2019 soil chemistry results.

MTW 2019 Sites	pH (units)	Electrical Conductivity (dS/m)	Phosphorous (Colwell - ppm)	Organic Carbon (% OM)	Cation Exchange Capacity (cmol+/kg)	Exchangble Sodium (%) (ESP)	Ca:Mg ratio
Mean	7.24	0.469	84.2	6.5	17.28	9.8	2.4
Max	8.62	1.863	422.8	18.6	29.86	39.4	11.1
Min	6.22	0.066	6.6	2.8	9.45	1.0	0.8
Reference Sites							
Mean	5.68	0.089	8.6	6.1	10.11	3.9	1.6
Max	6.20	0.152	15.1	8.7	17.43	7.6	3.2
Min	5.39	0.049	4.3	3.9	4.71	1.0	0.7

Reference sites

Reference site soil chemistry values are displayed in table 10. The pH values are consistent (mean 5.68) with only one site exceeding a pH of 6. High variability is evident between other parameters, even amongst site's results with a common soil texture. Of note is the high variability in phosphorus concentrations detected. Only parameters referred to by the MOP are displayed in the following tables to assist in interpretation of results.

Table 10: Reference site soil chemistry results (2019).

MTW (2019)	pH (units)	Electrical Conductivity (dS/m)	Phosphorous (Colwell- ppm)	Organic Carbon (% OM)	Cation Exchange Capacity (cmol+/kg)	Exchangble Sodium (%) (ESP)	Ca:Mg ratio
BEL01	5.39	0.082	6.2	8.7	8.94	5.0	0.7
BEL02	5.85	0.049	5.2	4.7	8.67	1.7	3.2
BEL03	5.59	0.089	4.9	7.5	10.08	5.2	1.1
WAMBOGB01	5.52	0.121	15.1	6.3	12.91	5.5	0.9
WAMBOGB02	5.98	0.152	13.0	5.3	16.13	4.2	1.2
WAMBOSPOT01	5.76	0.063	4.3	5.3	6.91	1.0	2.1
WAMBOSPOT02	6.20	0.083	10.2	7.5	17.43	1.8	2.3
WAMBOSPOT03	5.68	0.071	7.2	4.6	6.34	4.0	1.4
WARKGB01	5.66	0.087	8.2	7.9	12.27	2.8	2.3
WARKGB02	5.54	0.062	9.2	5.1	6.72	2.4	2.1
WARKGB03	5.57	0.065	4.9	3.9	4.71	5.5	1.3
WARKGB04	5.45	0.150	14.8	6.4	10.19	7.6	0.8
Mean	5.68	0.089	8.6	6.1	10.11	3.9	1.6
Maximum	6.20	0.152	15.1	8.7	17.43	7.6	3.2
Minimum	5.39	0.049	4.3	3.9	4.71	1.0	0.7
MOP Target Range	5.5 - 8.5	<2	1.2 - 13	1.6 - 8.7	7.4 - 20.4	0.2 - 8.7	0.7 - 2.1

Rehabilitation sites

Values obtained from this monitoring program are displayed in table 11, with reference to whether values fall within criteria set out in the current MOP. Performance criteria is also set out in table 11 for soil chemistry. Most criteria are determined by reference site values within a 2-5-year period.

Sites NPN200501, NPN200502 had soil sampling undertaken only, and these results are included in table 11.

Table 11: Rehabilitation site soil chemistry results (2019).

MTW (2019)	pH (units)	Electrical Conductivity (dS/m)	Phosphorous (Colwell - ppm)	Organic Carbon (% OM)	Cation Exchange Capacity (cmol+/kg)	Exchangble Sodium (%) (ESP)	Ca:Mg ratio
CDD201101	6.34	0.112	6.6	5.3	11.90	7.3	0.8
CDD201301	7.48	0.326	82.7	6.5	17.53	7.9	2.8
CDD201401	7.14	0.103	69.5	6.5	14.84	1.8	1.8
CDD201501	8.09	0.091	42.6	4.9	11.46	2.7	1.6
CDD201701	6.52	0.855	11.5	2.8	12.10	13.5	1.4
CDD201702	6.86	0.384	70.2	4.4	12.46	7.4	2.2
CDD201801	6.55	0.829	76.1	6.3	18.23	14.0	2.2
MTO201601	7.72	1.183	88.2	5.0	21.77	17.8	2.1
MTO201701	7.80	1.037	264.0	16.2	27.58	24.8	9.5
MTO201702	7.55	0.395	181.1	9.9	21.62	10.6	4.4
MTO201703	8.29	0.366	39.4	4.7	16.76	10.6	1.9
MTO201704	6.86	0.486	50.5	3.5	14.54	10.5	1.9
MTO201801	6.34	0.222	15.7	3.8	11.96	6.6	1.5
MTO201802	7.54	1.251	80.7	9.7	25.57	7.6	3.5
MTO201803	8.11	0.512	422.8	18.6	27.53	19.6	11.1
NPN200501	6.30	0.159	15.1	5.5	12.17	3.3	1.0
NPN200502	6.22	0.125	7.2	5.4	11.86	2.6	0.8
NPN200901	6.31	0.104	10.8	5.1	14.28	2.8	1.2
NPN201101	7.25	0.099	7.5	4.5	14.62	1.0	1.4
NPN201301	6.54	0.379	28.5	3.6	11.31	7.3	2.4
NPN201401	6.69	0.066	30.8	3.9	12.02	2.3	1.6
NPN201601	7.36	1.863	74.5	5.7	24.74	19.0	1.4
NPN201602	6.76	0.704	42.6	4.8	22.85	16.8	0.8
NPN201701	6.98	0.338	94.8	5.7	17.84	6.1	1.7
NPN201702	8.08	0.692	16.4	2.9	17.00	23.9	1.1
NPN201703	7.37	0.941	102.3	5.1	23.64	13.3	1.5
NPN201801	7.42	0.245	147.9	6.2	15.53	6.4	4.5
NPN201802	6.78	0.272	45.3	3.9	9.45	6.8	2.5
NPN201803	7.64	1.234	275.5	15.7	29.86	17.0	3.6
SPN201401	7.64	0.111	56.7	5.5	14.59	4.7	2.0
SPN201501	7.43	0.245	237.1	10.6	21.13	1.7	4.3
SPN201601	6.79	0.234	85.3	7.0	18.39	3.8	3.0
SPN201602	6.89	0.177	75.1	5.1	15.11	8.7	1.9
SPN201701	7.16	0.321	119.0	4.8	15.51	11.1	2.2
SPS201601	7.46	0.188	44.3	8.4	18.40	4.2	1.7
SPS201602	7.15	0.450	46.6	4.7	20.36	5.8	2.0
SPS201701	7.37	0.236	65.9	4.3	15.03	6.3	2.8
SPS201703	7.97	0.817	42.0	5.2	17.65	22.1	1.3
SPS201801	7.62	0.760	144.3	10.2	23.48	11.6	2.7
TD1201501	8.62	0.909	18.4	10.0	20.19	39.4	0.9
WDL201401	7.13	0.126	31.5	6.5	14.88	8.6	0.9
WDL201402	7.78	0.128	23.6	5.5	13.68	6.4	1.1
WDL201801	7.57	0.576	312.9	11.8	28.90	7.3	3.7
Reference (Mean)	5.68	0.089	8.6	6.1	10.11	3.9	1.6
Reference (Max)	6.20	0.152	15.1	8.7	17.43	7.6	3.2
Reference (Min)	5.39	0.049	4.3	3.9	4.71	1.0	0.7
MTW Sites (Mean)	7.24	0.469	84.2	6.5	17.28	9.8	2.4
MTW Sites (Max)	8.62	1.863	422.8	18.6	29.86	39.4	11.1
MTW Sites (Min)	6.22	0.066	6.6	2.8	9.45	1.0	0.8
MOP Target Range	5.5 - 8.5	<2	1.2 - 13	1.6 - 8.7	7.4 - 20.4	0.2 - 8.7	0.7 - 2.1
Outside MOP criterion							
Within MOP criterion							

4.2 Soil microbial analysis

Both reference and rehabilitation sites presented as adequate in bacterial diversity, in terms of certain broader classification groups, including: *Pseudomonas, Actinomycetes* and gram-positive bacteria. Being the case, their abundance was not presented in the following tables for visual clarity. Although microbe composition appeared similar, rehabilitation site results surpassed many reference indices of microbial health (table 12). In should be noted that some of the reference sites such as the BEL sites are regenerating from previous thinning from forestry activity (NPWS, 2010). Specific associations appear to be congruent for reference and rehabilitation sites, with low diversity and greater abundance of bacteria groups versus fungi. The main exceptions in similarity are Protozoa and Vesicular-Arbuscular Mycorrhiza (VAM) levels.

Table 12: Summary statistics for microbial condition, including reference and rehabilitation sites (2019).

MTW 2019 Sites	Nutrient solubilisation rate	Nutrient cycling rate	Disease resistance	Drought resistance	Nutrient accessibility (VAM)	Residue breakdown rate	Overall microbial balance	Total Microbes	Microbial diversity	Protozoa	Mycorrhizal fungi	Gram negative
Mean	84.7	78.7	84.5	85.3	71.1	90.2	78.9	65.3	38.4	2.661	8.488	5.302
Max	100.0	90.5	100.0	100.0	100.0	100.0	89.5	98.7	48.3	5.794	18.611	6.831
Min	66.7	44	62	72.1	44.1	60	57.7	32.4	33.5	0.298	4.414	3.338
Reference Sites												
Mean	62.4	79.8	75.0	66.0	32.1	95.7	75.9	54.9	37.3	1.148	3.207	6.576
Max	77.2	92.9	84.8	77.2	54.4	100.0	84.2	80.8	45.9	3.950	5.441	9.015
Min	36.1	57	57.4	56.5	13	79.6	57.3	31	32.4	0.391	1.305	4.237

Reference site soil microbial results

Table 13 contains the results for microbial analysis of the reference site samples. Lack of diversity in some microbe populations of those sampled sites presents in the form of less than expected presence of protozoa, mycorrhizal fungi, gram-negative bacteria, and in considered aerated conditions, diminished methane oxidising bacteria. WamboSpot3 also deviates from the other site results, with alternative anaerobic bacteria presenting in numbers greater than expected, (True anaerobes). Microbial attributes for overall function for the reference sites mostly appear as expected for a typical natural state. Expected values for ideal conditions, including general microbial community health, were provided by Microbiology Labs Australia, and are referred to in table 13.Those results observed below 30% of these designated values or considered exceeding normal condition for anaerobic conditions are highlighted below.

Table 13: Reference site results for microbial soil condition. [1] Aggregated result. * Only values exceeding deemed common concentrations are displayed.

MTW (2019)	Nutrient solubilisation rate	Nutrient cycling rate	Disease resistance	Drought resistance	Nutrient accessibility (VAM)	Residue breakdown rate	Overall microbial balance	Total Microbes	Microbial diversity	Protozoa	Mycorrhizal fungi	Gram negative	Methane oxidisers*	Sulphur reducers*	True anaerobes*
BEL01	68.2	86.2	78.8	68.2	36.4	100	80.2	80.8	32.4	0.84	3.638	8.816	0	0	0.645
BEL02[1]	70.3	80.1	80.2	70.3	40.6	100	78.3	56.4	38.7	0.837	4.057	6.151	0	0	0.649
BEL03[1]	69	91.9	79.4	69	38.1	100	83.2	63	34.8	1.669	3.807	7.438	0	0	0.269
WAMBOGB01	54.6	72.2	69.8	62.3	24.7	100	72.2	50.8	41.2	0.449	2.465	5.979	0	0	0.650
WAMBOGB2	76.1	77.6	84	76.1	52.1	99.7	80	51.8	45.9	0.65	5.213	6.7001	0	0	0.725
WAMBOSPOT1	60.7	67	73.8	60.7	21.5	88.9	69.3	40.3	35.6	0.489	2.146	5.79	0	0	0.357
WAMBOSPOT2	77.2	87.7	84.8	77.2	54.4	100	84.2	70.4	41.8	0.897	5.441	9.015	0	0	0.785
WAMBOSPOT3	54.6	85.1	69.8	59.5	19	95.4	75.6	45.2	33.9	1.356	1.902	5.469	0	0	0.339
WARKGB01	69.5	92.9	79.7	69.5	39	100	84.2	71.7	38.1	3.95	3.896	7.873	0	0	0.705
WARKGB02	65.5	82.9	77	65.5	31	100	78.5	61.6	35.5	0.872	3.098	7.093	0	0	0.459
WARKGB03	47.1	77.4	64.8	57.6	15.1	85.1	68.1	35.2	33.1	1.372	1.515	4.354	0	0	0.287
WARKGB04	36.1	57	57.4	56.5	13	79.6	57.3	31	36.3	0.391	1.305	4.237	0	0	0.450
Below ideal values															

Rehabilitation site soil microbial results

Table 14 contains the results for microbial analysis of the rehabilitation site samples. Many attributes are shared with the reference sites, including lack of general diversity. The greater presence or absence of some anaerobic bacteria and methane oxidisers is also more prevalent in the rehabilitated site data then reference sites. Desired attributes for soil microbiome that align with reference values (50-100% of reference value) are displayed as green cells in table 14.

Table 14: Rehabilitated site results for microbial soil condition in. * Only values exceeding deemed common concentration are displayed.

MTW (2019)	Nutrient solubilisation rate	Nutrient cycling rate	Disease resistance	Drought resistance	Nutrient accessibility (VAM)	Residue breakdown rate	Overall microbial balance	Total microbes	Microbial diversity	Protozoa	Mycorrhizal fungi	Gram negative	Methane oxidisers*	Sulphur reducers*	True anaerobes*
MTWCDD201101	88.6	88.5	92.4	88.6	77.2	100	85.9	68	43.8	3.726	7.718	5.955	0.000	0.000	0.579
MTWCDD201501	83.3	60.8	69.4	81.3	66.6	69.9	66.2	41.4	33.5	0.949	6.663	3.338	0.000	0.081	0.268
MTWNPN200501	72.1	88.2	81.4	72.1	44.1	100	83.4	50.1	48.3	1.603	4.414	5.799	0.000	0.000	0.493
MTWNPN200901	73	87.7	82	73	45.9	100	80.5	84.7	35.8	2.634	4.591	5.596	0.000	0.000	0.472
MTWNPN201101	100	90.5	100	100	100	100	89.5	98.7	37.8	5.794	18.611	6.831	0.000	0.000	0.491
MTWNPN201301	80.7	76.3	82.9	80.7	61.4	93.5	74.8	43.6	38.1	1.063	6.137	3.983	0.000	0.000	0.277
MTWNPN201403	97.5	88.1	98.4	97.5	95.1	100	86.5	78.6	35.2	3.258	9.508	5.776	0.000	0.000	0.433
MTWSPN201401	100	84.6	92.2	100	100	88.3	85.5	89.9	35.2	4.628	13.827	6.789	0.000	0.000	0.647
MTWTD1201501	66.7	44	62	74.6	49.3	60	57.7	32.4	37.8	0.298	4.927	3.65	0.000	0.149	0.502
MTW 2019 Mean	84.7	78.7	84.5	85.3	71.1	90.2	78.9	65.3	38.4	2.661	8.488	5.302	0.000	0.026	0.462
MTW 2019 Max	100.0	90.5	100.0	100.0	100.0	100.0	89.5	98.7	48.3	5.8	18.6	6.8	0.0	0.149	0.6
MTW 2019 Min	66.7	44	62	72.1	44.1	60	57.7	32.4	33.5	0.298	4.414	3.338	0	0.000	0.268
Reference Mean	62.4	79.8	75.0	66.0	32.1	95.7	75.9	54.9	37.3	1.148	3.207	6.576	0.000	0.000	0.527
Reference Max	77.2	92.9	84.8	77.2	54.4	100	84.2	80.8	45.9	3.95	5.441	9.015	0.000	0.000	0.785
Reference Min	36.1	57	57.4	56.5	13	79.6	57.3	31	32.4	0.391	1.305	4.237	0.000	0.000	0.269

4.3 Ecosystem and land-use establishment

4.3.1 Landscape Function Analysis

Surface values assessed for the 2019 monitoring program are displayed in Table 16 for reference sites, along with Rehabilitation sites in table 17. Both summary statistics are presented below in table 15. Most parameters of the Landscape function analysis for rehabilitated sites are displayed as within reference site values, except for Level of Order Index (LOI) and nutrient cycling, which display numerous site values under 50% that of reference values. Many rehabilitation site values do not satisfy MOP LFA criteria as demonstrated in table 17.

Table 15: LFA Summary statistics for 2019.

Reference	LOI	Stability	Infiltration	Nutrient Cycling
Mean	1.0	66.1	49.0	43.5
Max	1.0	71.8	56.7	50.6
Min	0.9	62.0	43.1	38.0
MTW 2019	LOI	Stability	Infiltration	Nutrient Cycling
Mean	0.5	55.6	33.8	27.4
Max	1.0	75.9	47.4	48.8
Min	0.0	43.8	23.5	14.1

Temporal variation in landscape function for each site is displayed in the individual reports in the appendices, facilitating ease of interpretation regarding trajectory of each site's landscape function. Specific temporal variance of site surface function differences is illustrated in the following figures (1-4), with mean values from 2019 and 2016/2017 displayed to demonstrate wider change over MTW.

Table 16: Reference site LFA observations for 2019.

Site (Reference)	LOI	Stability	Infiltration	Nutrient Cycling
BEL01	1.00	69.4	50.6	46.8
BEL02	0.98	67.8	49.7	43.8
BEL03	1.00	68.1	56.7	50.6
WAMBOGB1	0.99	71.8	48.4	45.3
WAMBOGB2	0.86	62.5	47.0	40.6
WAMBOSPOT1	0.95	65.9	54.5	48.0
WAMBOSPOT2	0.96	64.4	46.6	40.7
WAMBOSPOT3	0.98	65.2	54.0	46.8
WARKGB1	0.94	62.0	44.4	38.0
WARKGB2	1.00	62.5	47.0	40.6
WARKGB3	0.94	67.3	45.9	39.4
WARKGB4	0.90	66.1	43.1	40.9
Mean	0.96	66.1	49.0	43.5

Table 17: Rehabilitation site surface assessment values for 2019.

MTW (2019)	LOI	Stability	Infiltration	Nutrient
CDD201101	1.00	65.8	38.1	35.1
CDD201301	0.02	50.7	31.4	27.9
CDD201401	1.00	61.1	40.9	36.8
CDD201501	1.00	58.0	34.9	27.4
CDD201701	0.47	48.1	26.6	21.4
CDD201702	0.81	61.4	33.9	33.3
CDD201801	0.30	51.3	27.9	20.2
MTO201601	0.02	52.0	23.7	21.8
MTO201701	0.15	53.2	27.4	16.7
MTO201702	0.55	50.4	28.0	18.1
MTO201703	0.29	43.8	24.5	17.8
MTO201704	0.53	49.1	27.1	21.1
MTO201801	0.09	43.9	23.5	14.1
MTO201802	0.05	46.6	32.1	22.5
MTO201803	0.03	45.4	30.3	22.0
NPN200901	0.64	61.6	47.1	40.8
NPN201101	0.24	57.1	35.7	36.2
NPN201301	1.00	75.9	46.3	48.8
NPN201401	0.33	55.2	36.0	31.7
NPN201601	0.00	55.9	36.6	30.3
NPN201602	0.68	46.8	24.6	24.6
NPN201701	0.83	60.1	33.7	24.4
NPN201702	0.80	53.8	32.5	29.4
NPN201703	0.12	50.3	30.3	15.5
NPN201801	0.27	55.0	39.7	24.9
NPN201802	0.17	50.5	33.5	18.3
NPN201803	0.04	58.2	40.2	32.5
SPN201401	0.93	67.6	43.6	40.3
SPN201501	0.40	65.6	46.1	37.7
SPN201601	0.96	57.9	34.6	27.6
SPN201602	0.92	61.1	47.4	38.0
SPN201701	0.78	48.0	27.0	18.9
SPS201601	0.66	57.4	28.9	25.0
SPS201602	0.59	49.1	31.2	22.5
SPS201701	1.00	57.3	33.1	24.5
SPS201703	0.01	46.3	24.3	20.9
SPS201801	0.90	64.4	37.2	33.2
TD1201501	0.67	52.0	29.0	22.7
WDL201401	0.89	65.9	42.2	34.6
WDL201402	1.00	66.8	37.2	32.4
WDL201801	0.96	58.2	37.8	32.8
MOP Ranges	0.84 - 1.00	53.9 - 81.8	48.4 - 73.9	38.5 - 79.8
Within MOP range				
Performing above MOP range				
Below MOP Range				

Level of Order Index (LOI)

LOI temporally, is one of the most variable outcomes of the rehabilitation progression, indicating overall integrity of site – its ability to retain resources. Some fluctuation is observed for some sites, but an increase in Level of Order (Mean 0.54) is apparent in many sites with the previous year's data available, despite a lowering of the reference mean value (0.96).

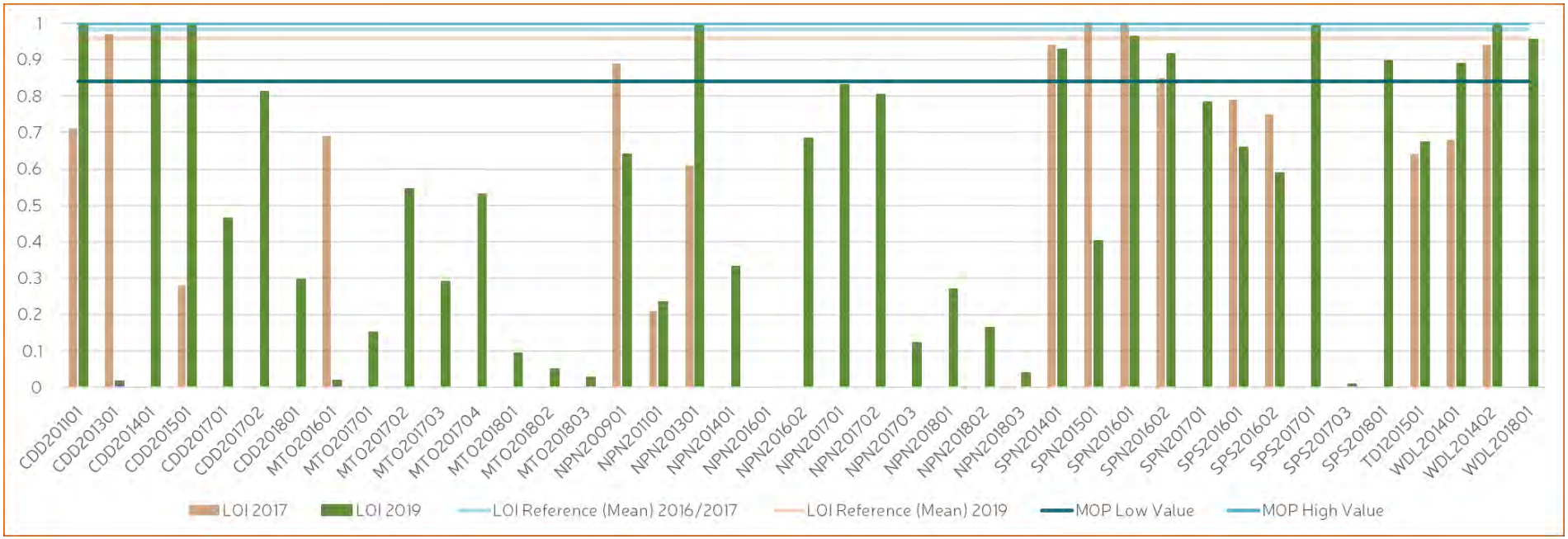


Figure 1: Surface assessment, Level of Order Index (LOI) 2017-2019.

Stability

Some sites follow the trend of raising in stability with the raise in mean stability for the reference sites. The mean rehabilitation value (55.6) and the below figure demonstrate how readily sites are tracking towards reference values for this surface assessment. CDD201501 has improved to near reference mean value within the period displayed.

Figure 2: Surface assessment, stability 2017-2019.

Infiltration

While values for the majority of sites has decreased, the mean reference value has also decreased by over 10 units, exhibiting a phenomenon impacting landscape function for the region. The overall site's mean value of 33.8 is still less than 10 units below that of the current reference mean.

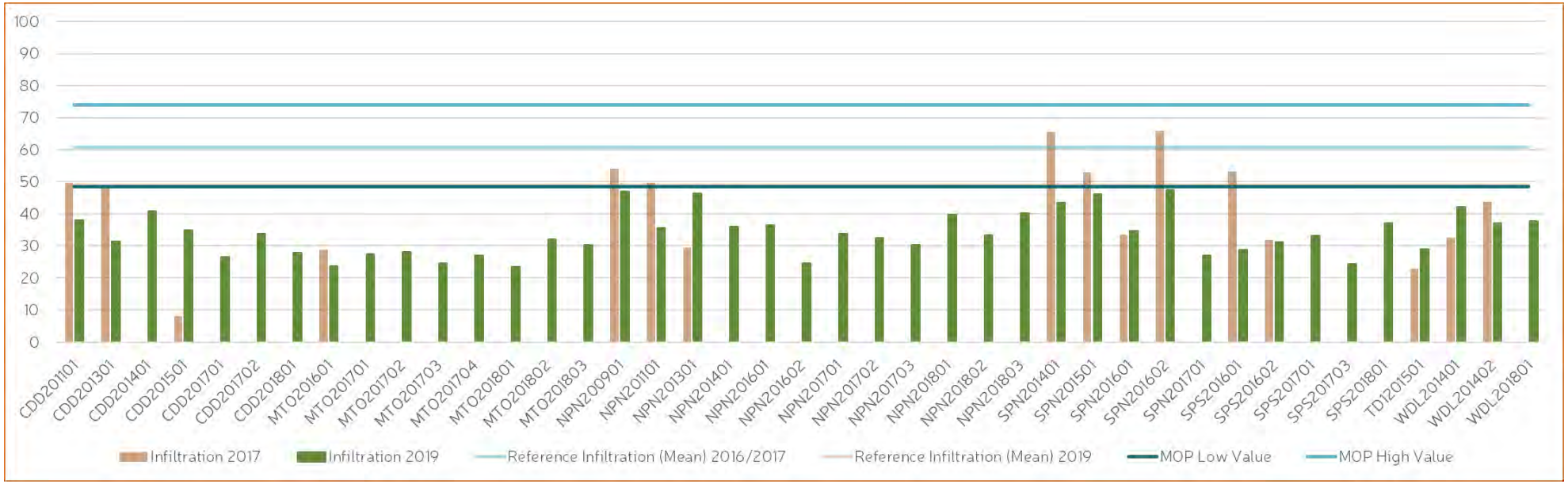


Figure 3: Surface assessment, infiltration 2017-2019.

Nutrient Cycling

A decrease in mean reference values is seen also in rehabilitation results for 2019, with the mean site value 63% that of the current reference mean value (43.5). CDD201501 and MTO201601 still have demonstrated a markable improvement in nutrient cycling for this period.

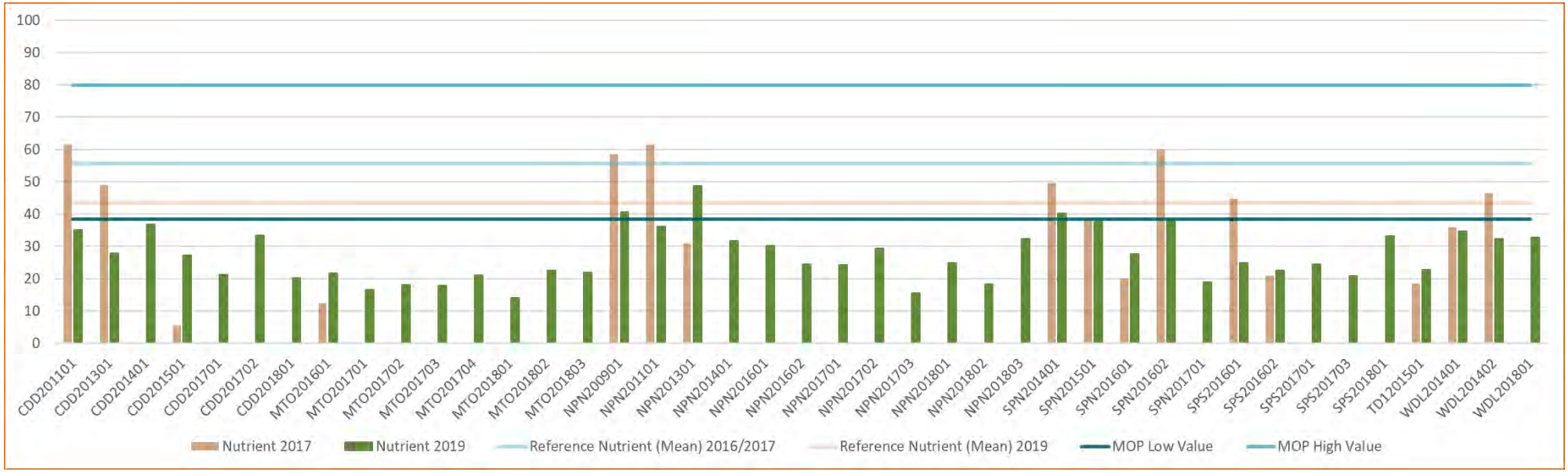


Figure 4: Surface assessment, nutrient cycling 2017-2019.

4.3.2 Species Richness

The diversity in species for each site is displayed for total observed and in those observed in different strata, in the following figures (figures 5-9). As depicted in figure 5, total species richness satisfies the MOP performance criteria for most sites as depicted by the mean value lying within the designated MOP values.

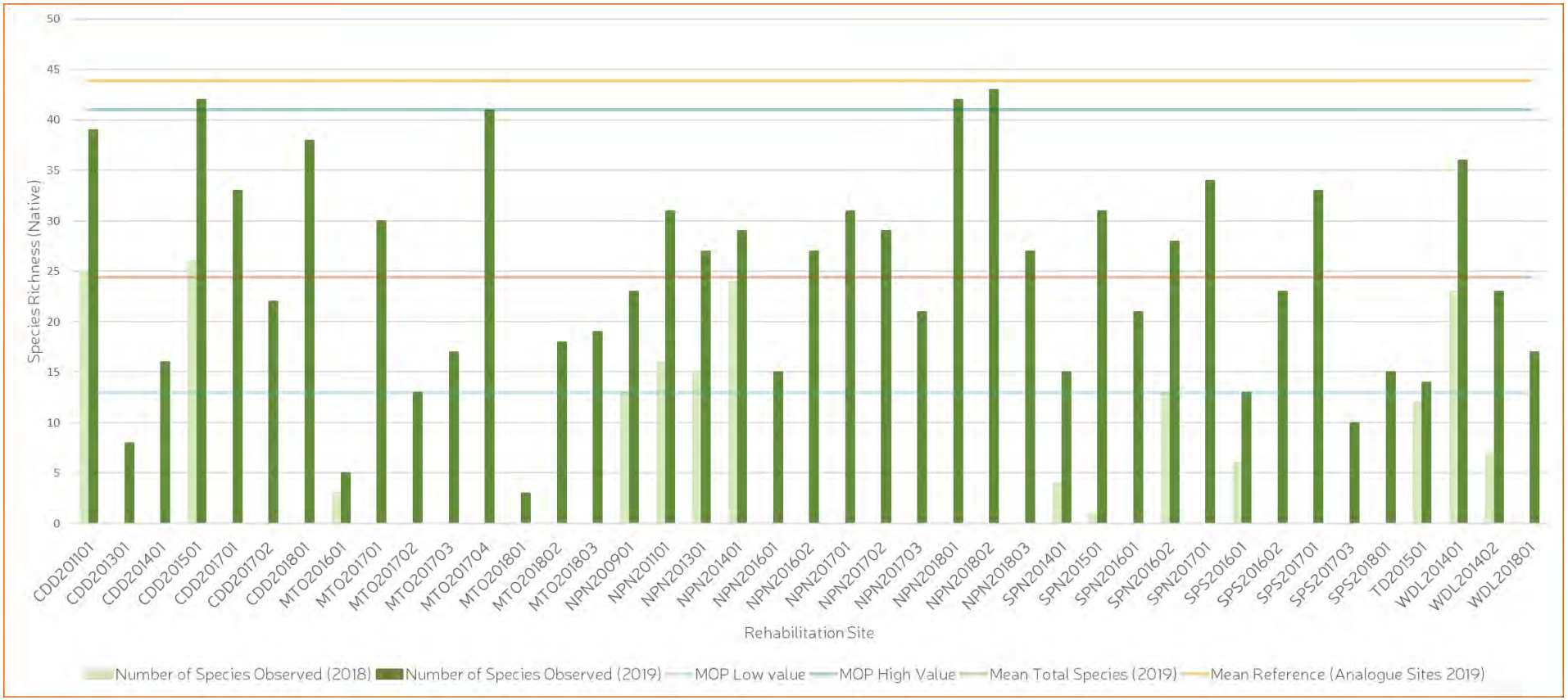


Figure 5: Total species richness observed at MTW in 2019.

Tree species richness

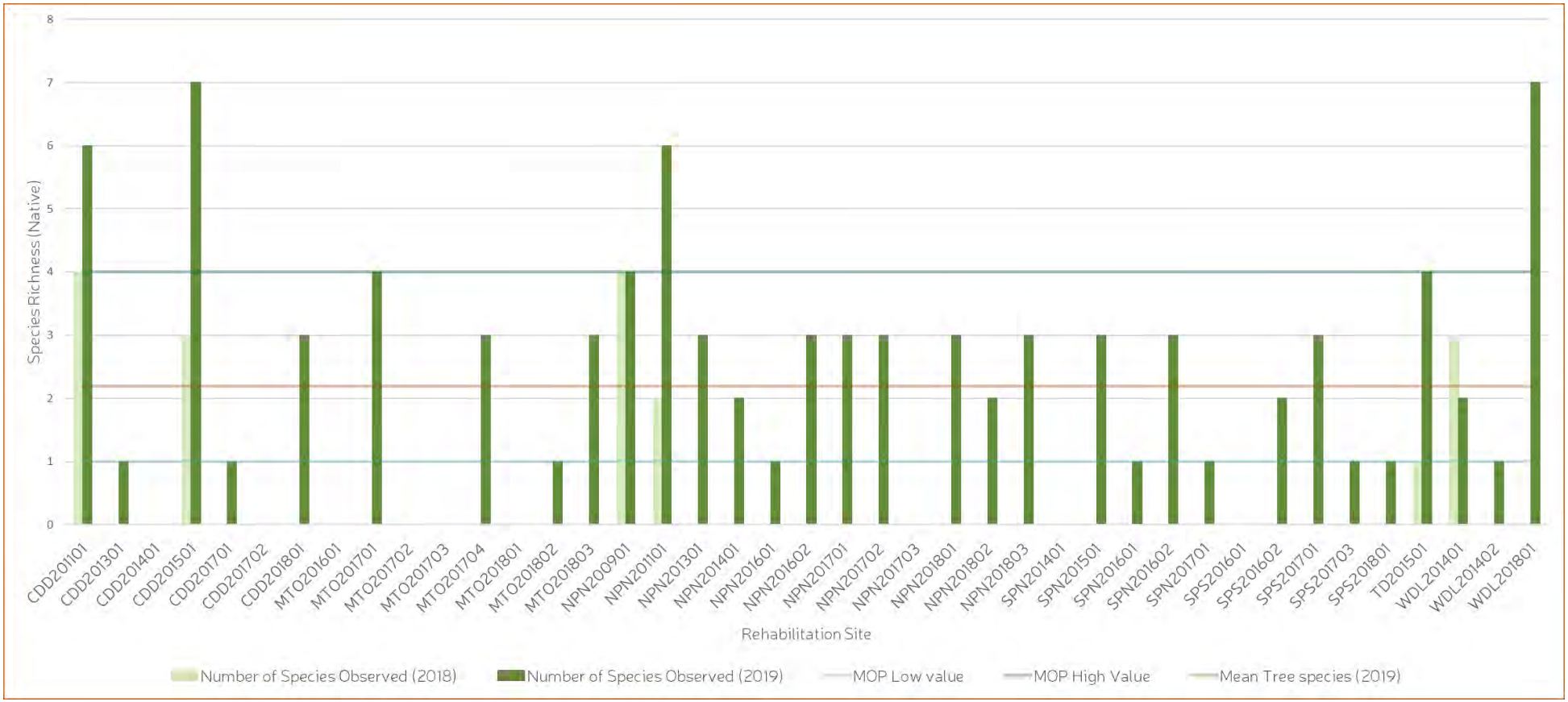


Figure 6: Tree species richness observed at MTW in 2019.

Shrub species richness

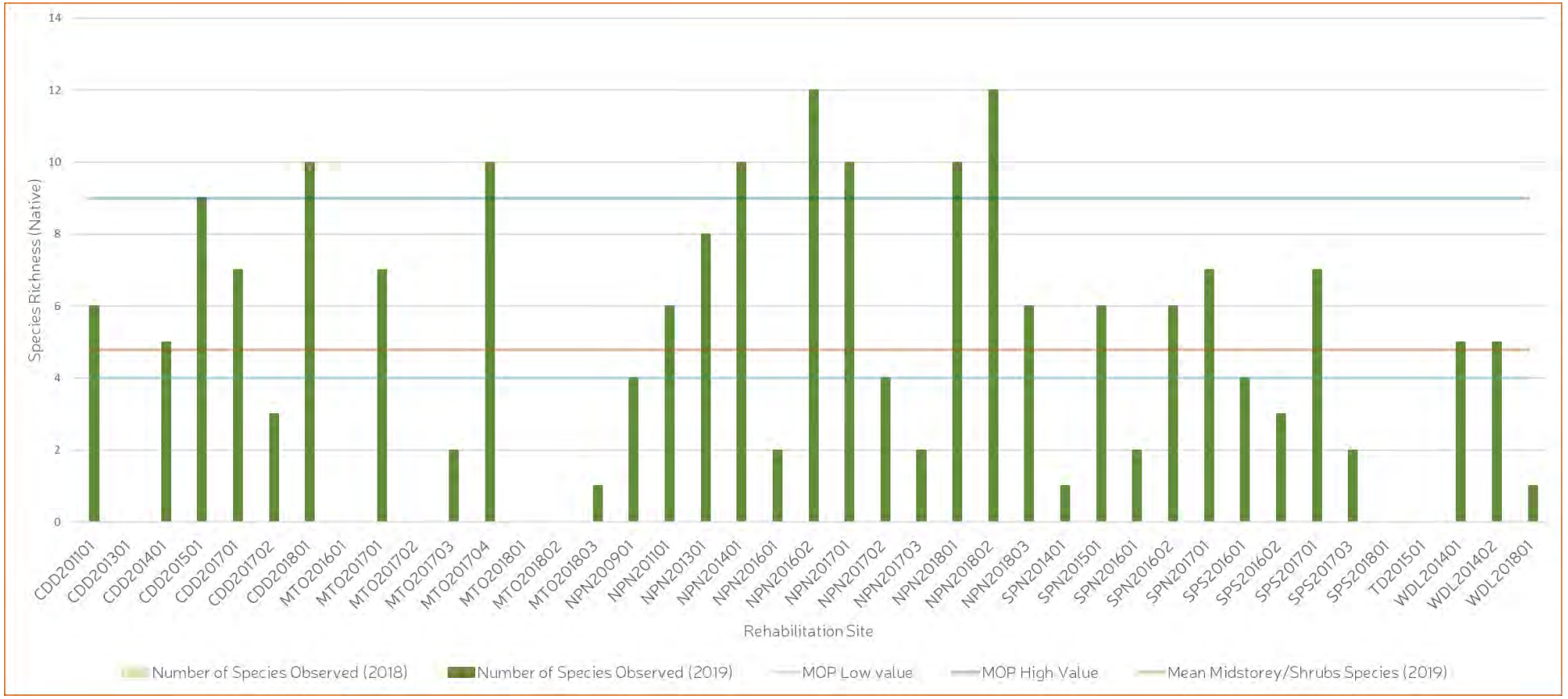


Figure 7: Shrub species richness observed at MTW in 2019.

Grass species richness

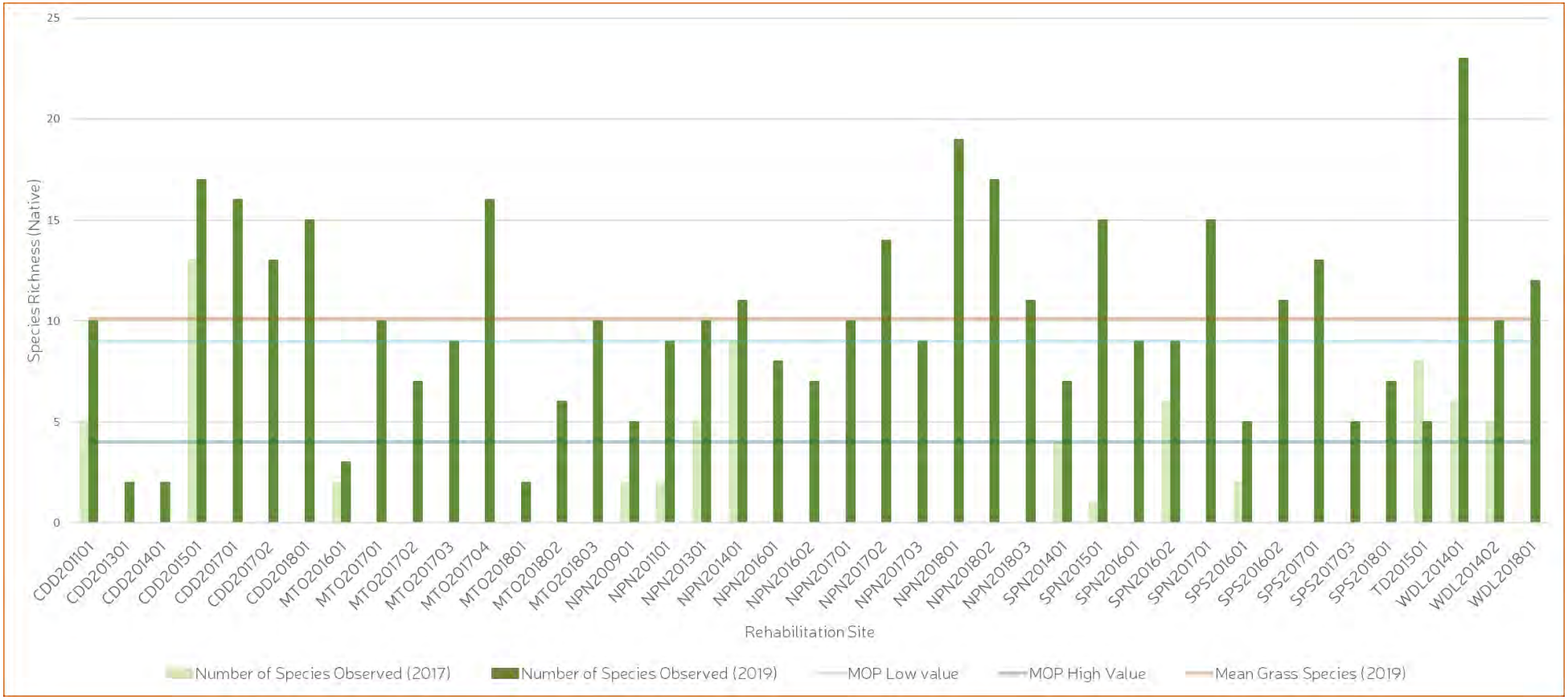


Figure 8: Grass species richness observed at MTW in 2019.

Other groundcover species richness

Figure 9: Other groundcover species richness observed at MTW in 2019.

4.3.3 Canopy Development

Specific observations made concerning canopy development have been placed in the individual site reports (appendices) due to the limited number of relevant sites (7 sites - CDD201101, CDD201501. NPN200901, NPN201101, NPN201301, NPN201401, WLD201401).

Stem density, MTW 2019 sites.

Established sites are reaching the desired stem density, but in the case of NPN200901 presented in figure 10, such sites are obtaining densities beyond reference values (reference mean 1658 stems ha^{-1}) – see figure 11. NPN200901 2019 Stem density of 30000 ha^{-1} not depicted in full.

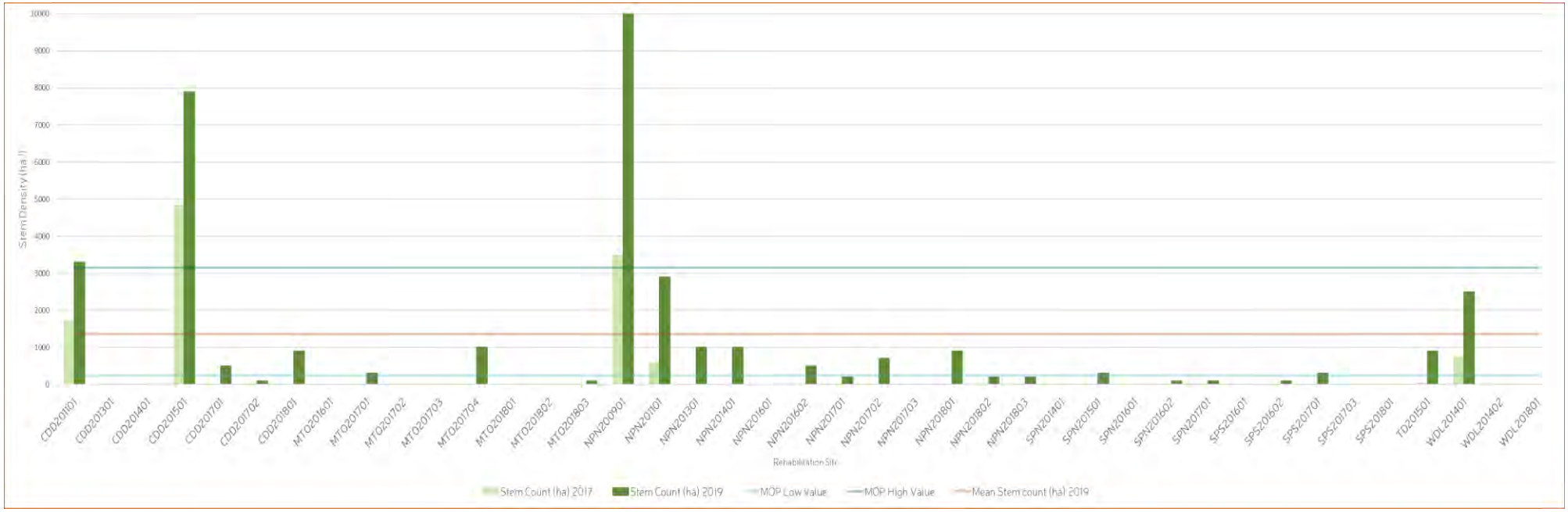


Figure 10: Stem density (ha^{-1}) observed at MTW in 2019.

Stem density, Reference sites.

The mean value for reference sites is 1658 stems ha^{-1}. The mean rehabilitation site value is depicted below in figure 11, with many of the reference sites intersected by the mean value. This rehabilitation mean value comprises of all stems, including those under 5 cm DBH, as most sites do not contain such mature specimens yet (1360 stems ha^{-1}).

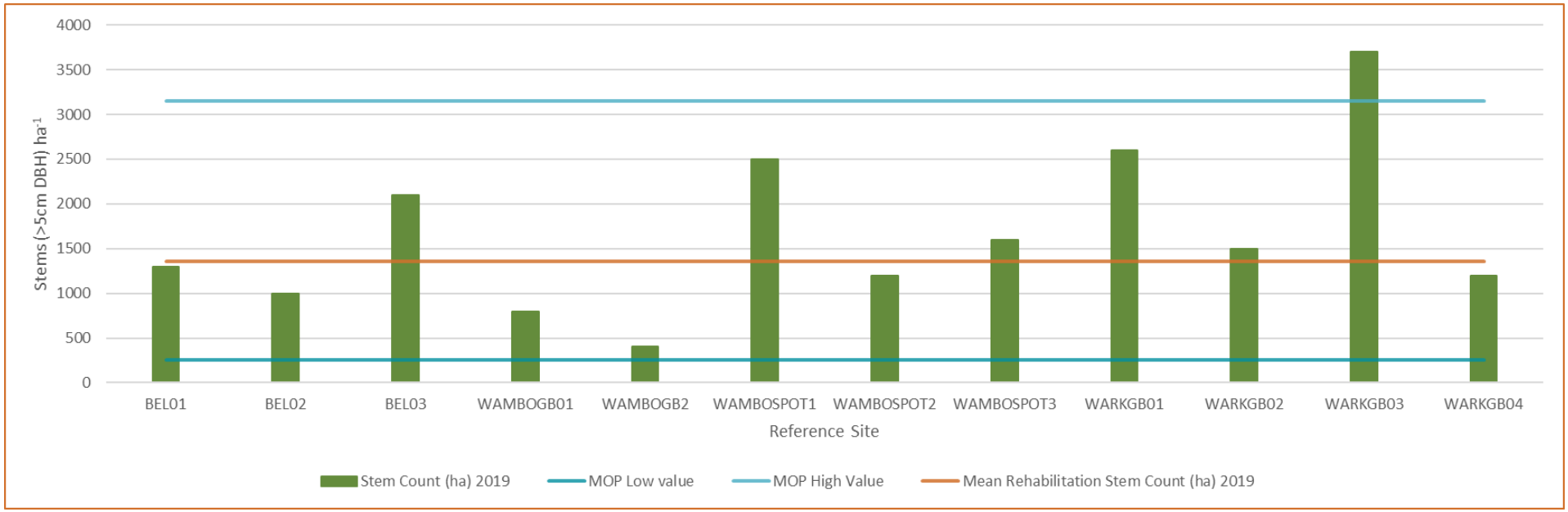


Figure 11: Stem density (ha^{-1}) observed at reference sites in 2019.

4.4 Ecosystem and Land Use Sustainability

4.4.1 Vegetation Structure and Species Richness

All cover values observed, along with habitat features are summarised in Table 18. Individual characteristics of sites are contained in the appendix 8.5, including relation of strata cover to stem density.

Table 18: Summary statistics for cover and habitat features. Foliage projective cover in percentages.

MTW-2019	Native species	Native Overstorey (%)	Native Midstorey (%)	Native grass cover (%)	Native cover - shrubs (%)	Native cover other (%)	Exotic plant cover (%)	Total groundcover (%)	Trees with hollows	Fallen logs (m)	Overstorey regen
Reference											
Mean	43.9	20.0	4.8	18.2	0.7	13.7	0.5	33	0	15	1.0
Max	60.0	34.5	13.7	46.0	2.0	30.0	4.0	64	0	39	1.0
Min	30	1.5	0	4	0	4	0	16	0	2	1
MTW 2019											
Mean	24.4	1.3	3.9	25.4	3.1	8.8	22.0	59	0	1	0.1
Max	43.0	33.0	35.0	66.0	40.0	30.0	72.0	100	0	20	1.0
Min	3	0	0	0	0	0	0	0	0	0	0
MOP Target Range	13 - 41	15 - 50	5 - 60	5 - 50	5 - 10	5 - 40	5 - 33	32 - 74	>0.5	>3	0.5 - 1

Reference site cover and habitat attributes are displayed in table 19. The younger age of vegetation at these sites is evident in that there are no records of trees with hollows. Exotic plant cover was also recorded for some of these sites, an instance not observed for four rehabilitated sites, as displayed in table 20.

Table 19: Cover and habitat features of reference sites. Foliage projective cover in percentages.

Reference	Native species	Native Overstorey (%)	Native Midstorey (%)	Native grass cover (%)	Native cover - shrubs (%)	Native cover other (%)	Exotic plant cover (%)	Total Groundcover (%)	Trees with hollows	Fallen logs (m)	Overstorey regen
BELL01	38.0	24.5	0.0	18.0	0.0	12.0	0.0	30	0.0	10.0	1.0
BELL02	37.0	21.5	0.5	22.0	2.0	30.0	2.0	56	0.0	10.0	1.0
BELL03	43.0	34.5	6.2	16.0	2.0	18.0	0.0	36	0.0	20.0	1.0
WAMBOGB1	36.0	28.5	7.0	14.0	0.0	18.0	0.0	32	0.0	4.0	1.0
WAMBOGB2	60.0	21.4	2.0	16.0	0.0	10.0	0.0	26	0.0	22.0	1.0
WAMBOSPOT03	46.0	18.4	5.0	16.0	2.0	16.0	0.0	34	0.0	4.0	1.0
WAMBOSPOT1	52.0	9.0	13.7	24.0	0.0	6.0	0.0	30	0.0	39.0	1.0
WAMBOSPOT2	45.0	31.0	8.0	16.0	0.0	6.0	0.0	22	0.0	7.0	1.0
WARKGB01	53.0	11.0	5.0	4.0	2.0	6.0	4.0	16	0.0	22.0	1.0
WARKGB02	39.0	19.0	2.0	46.0	0.0	18.0	0.0	64	0.0	27.0	1.0
WARKGB03	30.0	20.0	1.5	18.0	0.0	4.0	0.0	22	0.0	11.0	1.0
WARKGB04	48.0	1.5	6.2	8.0	0.0	20.0	0.0	28	0.0	2.0	1.0

Table 20 displays rehabilitation site data in relation to MOP performance criterion. Native grass and high native species diversity; lowered exotic plant cover, along with overall groundcover account for the majority of data values that align with MOP criterion. Low values of understorey cover (Shrub cover) are an apparent issue for the larger portion of sites. Although understorey species account for less cover than required, total understorey species (including grass species) for many sites fall within the respective MOP criteria as displayed in figure 12.

Table 20: 2019 Cover scores and habitat features in relation to MOP criterion.

MTW (2019)	Native species	Native Overstorey (%)	Native Midstorey (%)	Native grass cover (%)	Native cover - shrubs (%)	Native cover other (%)	Exotic plant cover (%)	Total groundcover (%)	Trees with hollows	Fallen logs (m)	Overstorey regen
CDD201101	39	4	9	8	0	6	12	26	0	0	1.00
CDD201301	8	0	0	22	0	0	16	38	0	0	0
CDD201401	16	0	0	52	2	2	36	92	0	0	0
CDD201501	42	1	3	38	14	6	8	66	0	0	1.00
CDD201701	33	0	2	20	0	6	38	64	0	0	0
CDD201702	22	0	0	56	4	10	34	100	0	0	0
CDD201801	38	0	2	20	8	14	12	54	0	0	0
MTO201601	5	0	0	6	0	0	32	38	0	0	0
MTO201701	30	0	0	20	0	2	8	30	0	0	0
MTO201702	13	0	0	4	0	30	30	64	0	0	0
MTO201703	17	0	0	28	0	12	0	40	0	0	0
MTO201704	41	0	1	54	2	8	8	72	0	20	0
MTO201801	3	0	0	2	0	0	2	4	0	0	0
MTO201802	18	0	0	10	0	10	26	46	0	0	0
MTO201803	19	0	0	18	0	4	2	24	0	0	0
NPN200901	23	33	0	2	0	2	0	4	0	2	0.50
NPN201101	31	9	11	10	0	0	10	20	0	0	0.30
NPN201301	27	2	12	50	0	12	26	88	0	0	0
NPN201401	29	6	21	30	0	0	14	44	0	0	0
NPN201601	15	0	0	2	0	2	68	72	0	0	0
NPN201602	27	0	5	16	14	22	22	74	0	0	0
NPN201701	31	0	2	66	2	4	16	88	0	14	0
NPN201702	29	0	1	44	6	14	10	74	0	0	0
NPN201703	21	0	0	14	0	2	10	26	0	0	0
NPN201801	42	0	1	50	0	2	12	64	0	0	0
NPN201802	43	0	2	30	0	16	20	66	0	1	0
NPN201803	27	0	35	2	40	10	0	52	0	0	0
SPN201401	15	0	0	46	0	0	34	80	0	0	0
SPN201501	31	0	0	23	1	2	19	45	0	0	0
SPN201601	21	0	0	20	0	10	48	78	0	0	0
SPN201602	28	0	22	24	12	30	26	92	0	0	0
SPN201701	34	0	3	30	4	20	34	88	0	0	0
SPS201601	13	0	0	20	0	10	48	78	0	0	0
SPS201602	23	0	9	14	2	22	46	84	0	0	0
SPS201701	33	0	1	38	0	16	36	90	0	0	0
SPS201703	10	0	0	8	0	0	10	18	0	0	0
SPS201801	15	0	0	22	2	2	72	98	0	0	0
TD1201501	14	0	0	24	4	18	34	80	0	0	0
WDL201401	36	1	20	44	10	30	8	92	0	0	0.85
WDL201402	23	0	0	0	0	0	0	0	0	0	0
WDL201801	17	0	0	54	2	4	16	76	0	0	0

Below MOP Criteria
Satisfys MOP Criteria
Performing beyond MOP Criteria

Total understorey species richness

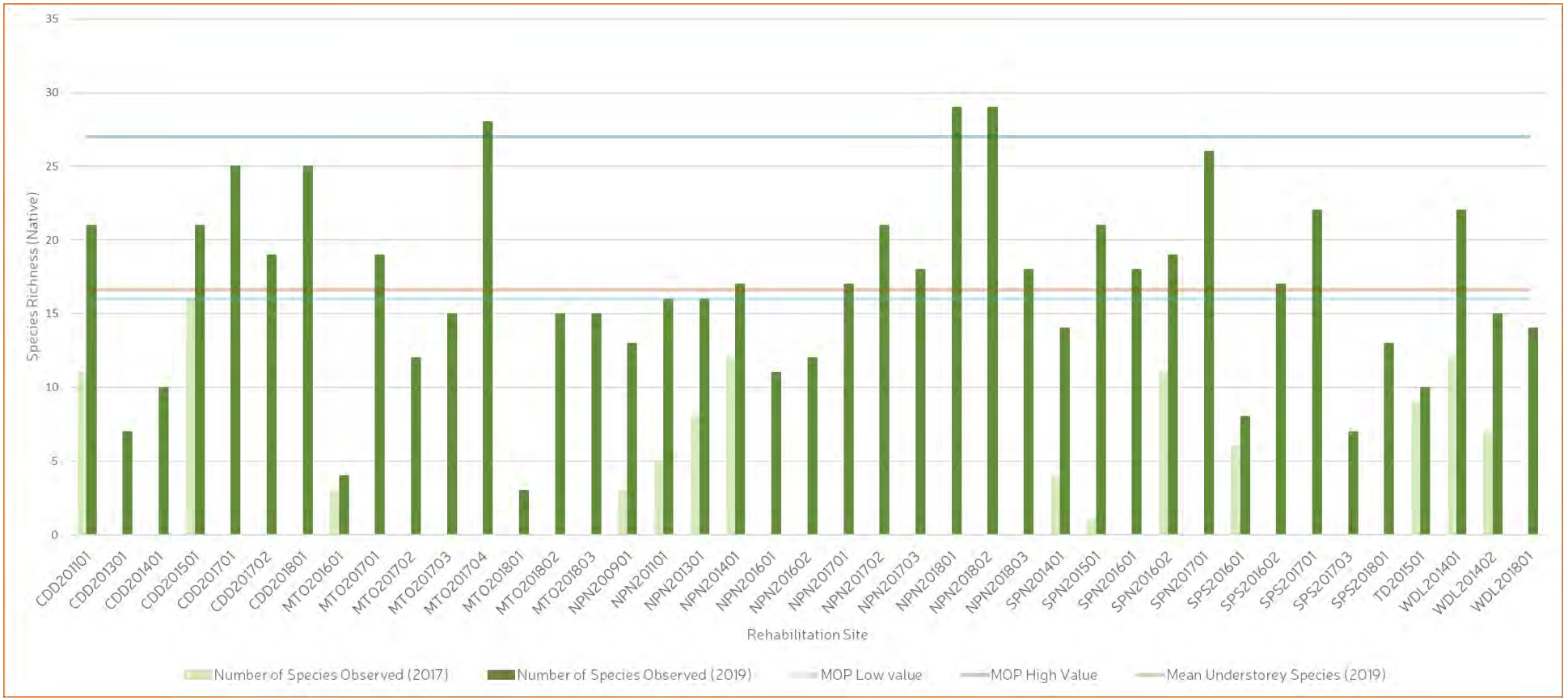


Figure 12: Total understorey species richness.

5. Discussion

Performance criteria are summarised in the introduction. Please refer to Tables 5, 6 and 7 as required.

5.1 Growth Medium Development

5.1.1 Soil analysis

Many sites sampled for this monitoring program satisfied benchmark MOP performance criteria for soil chemistry, with the only evident issues present in the form of high concentrations of available phosphorus, as well the undesirable sodium occupation of cation exchange capacity at some sites.

The organic carbon mean value for rehabilitation sites differed little from reference sites (Reference = 6.1, Rehabilitation = 6.6), although sites with higher organic carbon tended to have less exotic cover and, in some instances, greater species richness and native cover. For these cases, organic carbon appears to be a likely predictor of site performance in establishing native vegetation for the rehabilitation sites. While not all sites conform with this notion, results obtained from organic carbon assays can sometimes be confounded by coal contamination from coal tailings, dust etc., produced by mining operations (pers comm L McGrath, Landloch). If differentiated in a customised set of analyses, geogenic carbon has been demonstrated to constitute around 9%, and up to 20% of measured soil organic carbon from soil samples taken from remediated areas in Australian mines (Chan *et al.*, 2017). Therefore, some sites that are not performing well but exhibiting complying soil carbon values may well not be valid examples. Quantification of organic carbon should provide a measure of humus concentration in the soil, which if in a sufficient concentration, will facilitate a higher capacity of cation exchange sites and therefore, micronutrient retention, along with the other benefits of organic matter, including microbial nutrient provision and holding of moisture.

Exchangeable Sodium Percentage (ESP) above or near 15% values are present in this monitoring dataset for rehabilitation sites. Whilst these same sites comply with normal soil condition Electrical Conductivity measurements, as defined in the MOP, these soil characteristics indicate a lowered source of neutral salts and can therefore be considered somewhat Sodic (vanLoon & Duffy, 2011). This could explain some of the elevation in the pH measurement observed in TD1201501, as such a dominance of sodium tends to consist of

sodium carbonate, which after hydrolysis from soil pore water, produces hydroxide ions and raises pH (Brady, 1984). Such sodium concentrations also present as a potential factor in inhibiting the growth of native species, this considering reference site ranges of ESP and pH are well below that of rehabilitated sites. The observed levels of sodium concentration would also have an impact on soil condition, producing more dispersive soils, and thus, reduce the structure of these soils.

Phosphorus in different forms is exceedingly high for nearly all sites and may be impacting growth and recruitment of specific species, particularly available phosphorus as detailed by the Bray and Colwell analysis results. Mean reference site values are 10-fold less than that of rehabilitation sites. Nutrient imbalances involving phosphorus are thought to restrict the recruitment of healthy sclerophyll species in grassland communities (Specht and Specht, 1999).

Nitrogen supply appears to be adequate with carbon to nitrogen ratios for rehabilitated sites only slightly lower than that for reference sites (depicted in table 21), although carbon measures may be affected by coal contamination.

Table 21: Carbon to Nitrogen ratios across sites.

C:N	Reference sites	Rehabilitation sites	Expected (agronomy)
Mean	18.1	16.3	10 to 12
SD	1.7	3.5	NA

Calcium to magnesium ratios appear to compliant and if not, were elevated in calcium. These higher concentration sites are still within the desired agronomic range for calcium. Generally, calcium concentrations in the soil sampling results for this monitoring were higher in the rehabilitation sites than reference sites, most probably owing to initial gypsum applications. This may be of benefit in offsetting some of the effects of the sodium content of soils on some sites, particularly enhancing soil structure (Brady, 1984).

Potassium concentrations appear sufficient for all rehabilitation sites.

5.1.2 Microbial analysis

Analysis of soil samples was carried out by Microbiology Labs Australia (MLA). Their reports for each site are included in the Appendices. The microbial analysis results showed that many of the target values, as defined by the Microbiology Laboratories Australia, were not achieved by either the mine sites or the reference sites. Microbial diversity, for example, was much lower for all sites. This is probably due to the guide values being generated from more productive environments (e.g. higher rainfall forest sites). Many mine sites scored higher on some of the measures than the reference sites, for example nutrient solubilisation rate, drought resistance and Nutrient accessibility were over the guide levels for several mine sites but none of the reference sites.

Many of the mine sites compared favourably to the reference site scores on most measures, although some sites had elevated levels of Sulphur reducing or true anaerobic bacteria which indicate anaerobic soil conditions such as water logging or compaction.

5.2 Ecosystem and Landuse Establishment – Woodland EEC

5.2.1 Flora – Species richness

- Total species richness is quite good on many of the rehabilitation sites, with only six out of forty-two failing to meet the minimum MOP criterion. Several sites recorded species diversity of at least double the minimum and three sites met or exceeded the upper level required by the MOP.
- Overstorey diversity was generally good with few sites failing to meet the MOP minimum and several meeting or exceeding the MOP range. The sites with few or no native overstorey species recorded are usually younger sites which have either not yet been sown with native seed or where trees have not yet germinated. Some older sites, however, have generally poor native establishment in all categories.
- Midstorey diversity (shrubs >1m) was often good, though less consistently so with seventeen sites failing to meet the MOP minimum.
- Groundlayer shrub and herb diversity in the ground layer was often lower than the MOP minimum.
- Native grass diversity was generally good, with most sites achieving the MOP range and many exceeding it.

Total species richness	MOP range	Reference site range 2019	Rehabilitation sites within MOP range
Lower	13	31	
Upper	41	58	36
Overstorey species	**MOP range**	**Reference site range**	**Rehabilitation sites within MOP range**
Lower	1	2	
Upper	4	6	32
Midstorey species	**MOP range**	**Reference site range**	
Lower	4	0	
Upper	9	10	24
Ground cover shrubs and herbs	**MOP range**	**Reference site range**	
Lower	10	16	
Upper	20	36	8
Grasses	**MOP range**	**Reference site range**	
Lower	4	5	
Upper	9	12	37

5.2.2 Patterns of native vegetation establishment

It is difficult to make broad statements about native vegetation establishment due to the variability of conditions across the MTW rehabilitation sites. Soils can differ widely across the site and climatic conditions at the time of sowing have varied considerably in the ten years prior to this current monitoring season. Nevertheless it seems apparent that it is possible to establish diverse and functional native plant communities at MTW. Several sites have achieved most of the MOP performance criteria for Ecosystem and Landuse Establishment.

There may be several reasons for poor native establishment including soil quality, climatic factors following sowing and weed competition. Some sites have not yet been sown with native species and these of course are showing poor results e.g. MTO201801 and the eastern half of MTO201601 (where the monitoring transect is located).

At sites such as SPN201401 and SPS201601 this lack of native establishment seems to be due to weed competition because these sites are almost entirely dominated by exotic grasses.

At sites such as MTO201702 the relatively low native species diversity and cover may reflect soil conditions, or less favourable climatic conditions. However, this site is relatively young and so may prove successful over time.

5.2.3 Successful rehab species

The most successful species (recorded from at least 15 sites) are presented in the following table:

Family	Vegetation layer	Genus	Species	number of rehab sites sp. Present
Chenopodiaceae	Ground layer shrub	*Atriplex*	*semibaccata*	30
Chenopodiaceae	Ground layer shrub	*Enchylaena*	*tomentosa*	25
Fabaceae	GL shrub	*Hardenbergia*	*violaceaea*	15
Poaceae	Grass	*Bothriochloa*	*decipiens*	24
Poaceae	Grass	*Capillipedium*	*spicigerum*	23
Poaceae	Grass	*Chloris*	*truncata*	39
Poaceae	Grass	*Chloris*	*ventricosa*	21
Poaceae	Grass	*Cynodon*	*dactylon*	26
Poaceae	Grass	*Dichanthium*	*sericeum*	31
Poaceae	Grass	*Digitaria*	*divaricatissima*	22
Poaceae	Grass	*Eriochloa*	*pseudacrotricha*	32
Poaceae	Grass	*Panicum*	*queenslandicum*	19
Poaceae	Grass	*Sporobolus*	*creber*	29
Asteraceae	Herb	*Vittadinia*	*cuneata*	15
Chenopodiaceae	Herb	*Einadia*	*polygonoides*	18
Chenopodiaceae	Herb	*Einadia*	*trigonos*	27
Chenopodiaceae	Herb	*Einadia*	*nutans*	23
Fabaceae	Shrub	*Acacia*	*amblygona*	24
Fabaceae	Shrub	*Acacia*	*cultriformis*	20
Fabaceae	Shrub	*Acacia*	*decora*	23
Sapindaceae	Shrub	*Dodonaea*	*viscosa subsp. cuneata*	17
Solanaceae	Shrub	*Solanum*	*cinereum*	18
Fabaceae	Small tree	*Acacia*	*implexa*	15
Fabaceae	Small tree	*Acacia*	*salicina*	19
Myrtaceae	Tree	*Corymbia*	*maculata*	19

Many other species were recorded at more than one rehabilitation site and a total of 118 species was recorded for all sites. The plant families of Fabaceae, Chenopodiaceae and Poaceae are the best represented in this list. As may be expected primary and secondary colonisers have been the most successful the rehabilitation landscape. On the other hand, few long lived, shade tolerant species were recorded, even on older sites. This is most likely because ecological conditions on the rehabilitation sites are not yet suited to these species. While they may be included in seed mixes the monitoring results would suggest that they do not establish in early

stage rehabilitation. It may take many years before soil, light and biotic factors change enough to allow establishment of these species. While many local native plants have long-lived seed it is likely that the germinability of any seed sown as part of the rehabilitation program will decline quite quickly and that therefore these species will be lost from the seedbank.

This may explain why many sites do not achieve the performance criteria levels for understorey species other than grasses. If these species are required in the mine vegetation to meet MOP criteria then they will probably need to be re-sown once conditions have become more favourable or introduced by planting tube stock or by translocation.

Whilst many sites are approaching the species diversity levels required by the MOP the actual species composition of the sites does not always reflect that of the target Endangered Ecological Community (Central Hunter Grey Box-Ironbark Woodland). *Corymbia maculata,* for example was the most often recorded canopy species and whilst it may be found in CHGBIW remnants it is not usually a dominant species. A review of the seed mixes used at MTW and comparison of rehabilitation areas with nearby CHGBIW remnants may be useful in achieving the species composition of the target EEC. The location of reference sites may need to be reviewed to provide the most meaningful comparison between target EEC and rehabilitation vegetation types.

5.2.4 Canopy species stem density

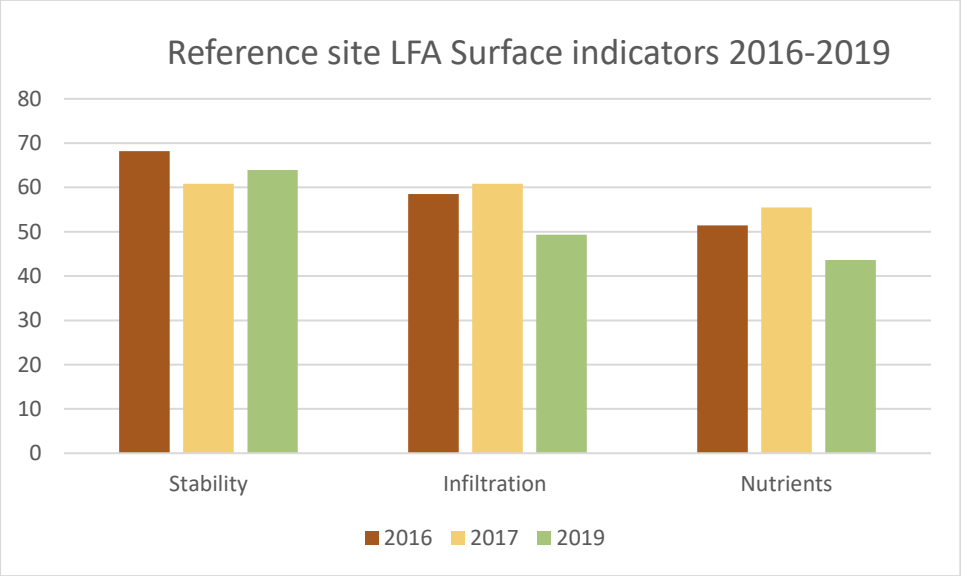
The MOP criterion for stem density is to have between 250 and 3150 stems per Hectare and 50-725 maturing trees with a DBH >5cm. Many sites are yet to reach the lower limit for stem density due to having been only recently sown. 14 sites are within the MOP criteria range and three sites exceed the range. The stem density maximum value is very high compared to the MOP range for maturing trees and also to published guidelines for Hunter Valley Woodland vegetation (Kerle, 2005). This means that several of the rehabilitation sites have stem densities too high for long-term stability and sustainability even though they are within the MOP range. High stem densities of canopy species leads to increased competition for moisture, light and other resources and can result in a decline in shrub and ground layer diversity and cover. This effect is demonstrated by the vegetation at sites such as NPN200901 which has very high stem density, low ground cover and lower ground layer diversity.

These sites would benefit from thinning of the dense canopy layer to reduce competition, particularly for water.

5.2.5 LFA

5.2.5.1 Comparison of reference site data

Survey year	LOI	Stability	Infiltration	Nutrient Cycling
2016	1	68.2	58.5	51.4
2017	1.0	60.8	60.8	55.5
2019	0.96	63.08	49.3	43.6



As can be seen in the table and graph above, there was a significant difference in the reference site LFA indices between 2017 and 2019. The differences in the reference site data between 2016 and 2017 are not enormous and may be within the standard error of the LFA calculations although raw data was unavailable to confirm this. However, the difference between 2017 and 2019 is significant, particularly for infiltration and nutrient cycling.

This difference may be because of different observers performing the LFA surveys (Niche in 2016/17 and Umwelt in 2019), although the LFA methodology is specifically designed to reduce the effect of observer difference when followed correctly. It may also be due to climatic factors which have reduced some of the soil surface indicator scores and thereby the overall indices (Tongway, Pers. Comm. 2019).

Infiltration is derived from perennial cover, litter cover, microtopography, slake test and soil texture. It is unlikely that slake test or soil texture would have changed significantly but perennial cover and litter cover may well have reduced as a result of prolonged drought.

Nutrient cycling is derived from perennial cover, litter cover, biological crust cover and microtopography. Some of these may have changed enough to affect the nutrient cycling index.

Reference site data was reviewed by CPS and Umwelt and it was felt that the decline in the reference site values is most likely a combination of observer differences and a reflection of the drought conditions prevailing since monitoring was begun.

5.2.6 LFA interpretation of site results

5.2.6.1 Landscape of MTW

The rehabilitated landscape at MTW is characterised by high dumps with flat tops and quite steep slopes. The slopes are constructed with contour banks to help control erosion and manage water runoff. The soil is composed of crushed overburden (spoil) which is often affected by alkalinity, salinity and sodicity, or a combination of these and other characteristics. Topsoils are usually thin and often naturally dispersive.

Soil is often covered only by living plants or litter from dried-off grasses and annuals. There is relatively little dead wood or rock cover in rehabilitation areas.

Vegetation growing in this landscape (at least on the sites surveyed during the 2019 monitoring period) is quite variable but it's character changes over the course of the year. Where trees and shrubs are present the canopy and mid-storey cover change little through the year. In grassland sites or sites where trees and shrubs are still in a juvenile state, the vegetation cover and therefore soil protection, is reliant on perennial grasses, sub-shrubs and herbs. Native perennial grasses often dry off during prolonged drought periods and reduce the amount of cover they provide. The herbs and sub shrubs which are successful in early stages of rehabilitation are usually chenopods such as *Atriplex*, *Einadia* and *Enchylaena*. *Einadia* species in particular defoliate and dry off at certain times of year. This means that ground cover on the rehabilitated land can change quite quickly with changes in climatic conditions and result in lower soil cover.

For LFA interpretation this means that sites which appear stable at one point in the year can be exposed to erosion or other negative influence at a different time of year. Because most sites lack coarse woody debris and large rocks a decline in vegetation cover can be particularly problematic.

An increase in mulch, woody debris and large rocks would help to stabilise rehabilitation slopes during times when vegetation cover was decreased and would help to increase and maintain LFA scores.

It is possible that older rehab sites may be declining in LFA measures because of too much competition from shrub and canopy species. This may also be linked to drought conditions which have prevailed in the last two seasons. These two factors, both by themselves and together, could be responsible for a decline in perennial ground cover and litter cover.

5.2.6.2 Assumptions for Landscape Organisation and Surface assessments

Some early stage rehab blocks had very few patches, or many small patches. In some cases where vegetation had not yet established (e.g. WDL201801) the only patches observed were formed by a large rock or piece of timber, or by the contour bank swale. In other cases the patches were often only single perennial plants. In this case larger patches (i.e. large plants or collections of small plants) were counted as patches, whereas single small perennial plants were counted as part of the interpatch.

Eriochloa pseudacrotricha, an annual native grass, was considered to form part of a patch for the purposes of Landscape Organisation. i.e. the plants help to stabilise an area which is overall gaining resources rather than losing them. Even though it is an annual plant it grows year-round and germinates readily on mine sites. However, when conducting surface assessments *E. pseudacrotricha* was counted as litter and not perennial cover.

Chenopods and Galenia form a large proportion of the ground cover on many sites. These plants usually have a central root stock and the stems sprawl or trail across the ground surface. While ground soil cover appears to be high, and one would expect higher LFA scores, these plants contribute less to patch quality than do perennial grasses because of their growth habit. The central root stock contributes less to soil stability than a grass tussock. The soil surface beneath a chenopod or Galenia plant is often crusted and has a lower organic matter content than amongst perennial grasses. This means that while these plants contribute to landscape patches, the patch quality is lower than for a grassy patch, resulting in lower LFA indices.

5.2.6.3 Comparing reference site and mine site scores.

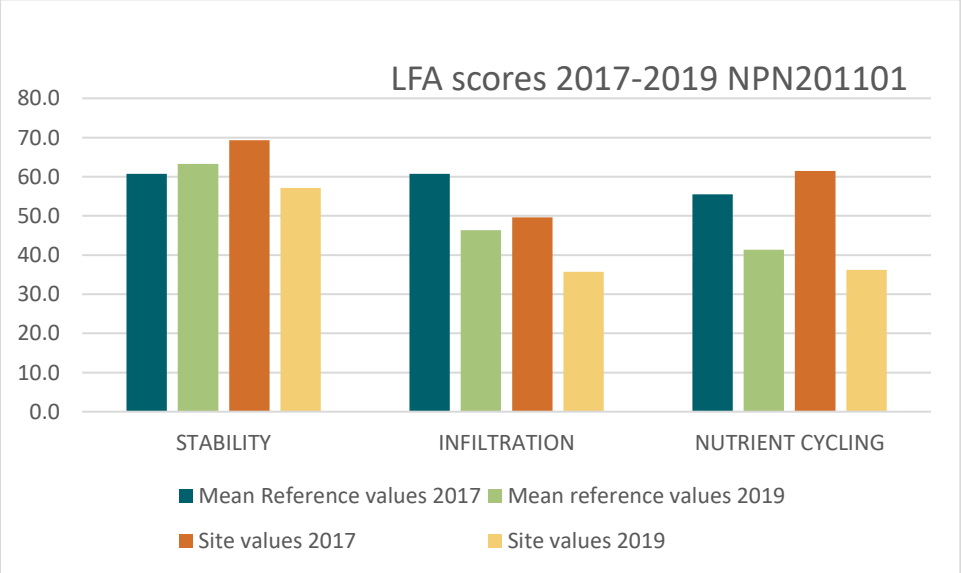
The reference sites are located in areas of remnant woodland and their topography is relatively flat. Water erosion in particular is partly a function of gradient and therefore erosive potential is higher on a steeper slope. Taking this into consideration a lower LFA index on a reference site or on a flat rehabilitation site may be less concerning than a low score on a sloping site.

The sites surveyed in 2019 ranged in age from 2009 to 2018. It would be expected that the older sites would have LFA indices closer to the reference site values. However, in some cases the older rehab sites have lower scores and some of the younger sites are performing much better.

Low LFA scores are not in themselves a problem, so long as they are comparable to reference site values. In the case of sloping sites, however, they may indicate the imminent decline of a site, because of the increased exposure to erosion.

An example of this is NPN201101. This site covers a large area – 43.3 Ha – and stretches from the flat top of the North Pit North Dump down the north west slope of the dump. The monitoring transect is located at the top of this slope and the vegetation here is characterised by well-established Eucalypts and Acacias with a low ground cover of 20% (10% Native Grass cover and 10% exotic grasses). The LFA indices are declining when compared to the 2017 values and because of the slope on this site there is an increased risk of instability.

Native sp. Richness	Native overstorey % cover	Native midstorey % cover	% Ground cover grasses	% Ground cover shrubs	% Ground cover other	% Exotic plant cover	Trees with hollows	Overstorey regeneration	Fallen logs (m)	Stem density (stem/Ha)
31	9	11	10	0	0	10	0	0.3	0	2900



In order to avert a decline at this site the causes of the decline in LFA indices should be addressed. Stability would be increased by the addition of coarse litter which would have

several effects: an increase in soil rain-splash protection (physical protection for the soil surface); provide organic matter for biological activity (increase biological crust protection) and increased soil stability (stability is increase by a higher organic matter content).

Infiltration and nutrient cycling can both be easily increased by the addition of litter, an increase in perennial grass cover and a roughening of the soil surface (microtopography).

At this site these increases could be achieved by mulching or otherwise thinning some of the standing vegetation. This would decrease stem density and reduce competition for perennial grasses and other ground covers. Mulching residue and fallen timber would increase soil litter cover and available organic matter. Soil surface roughness and infiltration could be further increased by ripping or aeration.

It is interesting to note the soil microbial results for this site in the context of the LFA indices.

Indicator/ microbial group	Target range (Recommended by lab)	reference average	MTWNPN 201101
Nutrient solubilisation rate	80.7	62.4	100.0
Nutrient Cycling rate	76.3	79.8	90.5
Disease resistance	82.9	75.0	100.0
Drought resistance	80.7	66.0	100.0
Nutrient accessibility (VAM)	61.7	32.1	100.0
Residue breakdown rate	93.5	95.7	100.0
Overall microbial balance	74.8	75.9	89.5
Total Microbes	50.0	54.9	98.7
Microbial diversity	80.0	37.3	37.8
Protozoa	1.3	1.1	5.8
Mycorrhizal fungi	10.0	3.2	18.6
Gram negative	11.0	6.6	6.8
Fungi:bacteria	2.3		4.4
Methane oxidisers	0.5		0.0
Sulphur reducers	<0.005		0.0
True anaerobes	<0.005		0.5

All the calculated microbial soil indicators are high (at the top of the guide ranges). Fungi are elevated compared to bacteria, which may indicate a lack of available simple organic matter, or an overabundance of resistant organic matter. True anaerobes are elevated which can indicate waterlogging or compaction. This aligns with the low LFA Infiltration index for this site.

Although the soil function indicators supplied by MLA appear to be positive the LFA results do not support this and the site is not performing well on floristic measures (native plant cover).

This brief comparison of LFA, floristic and microbial data suggests that further investigation of the data for this and other declining sites would be warranted.

5.3 Ecosystem and Landuse Sustainability

As can be seen from the table summarising the measurements for this MOP phase many sites are achieving some of the MOP criteria but no site sampled in 2019 achieves all of the criteria. This is not surprising given the age of the sites sampled in 2019. Most sites were less than 10 years old and many considerably younger. This is not enough time to build the vegetation diversity and structure necessary to fulfil the MOP criteria. The monitoring data does, however, give some clues as to which sites may achieve the MOP criteria for this phase with little intervention, and which sites are likely to fail to meet them without significant management.

Particular threats to the future success of the rehabilitation vegetation are:

- Exotic species, particularly perennial grasses
- High stem density of canopy species
- Poor establishment of native species in any layer defined by the MOP

Exotic plant cover was high for many sites sampled in 2019. However, the figures calculated from the field observations may be slightly misleading because of the observation methods used under the Biobanking methodology. The methodology differentiates between threatening and non-threatening exotic species, i.e. those which compete strongly with native plants and will therefore limit their establishment or reduce native cover over time. However, the sampling method does not differentiate between these two types of weeds. Therefore a site with a high Exotic Plant Cover (EPC) score may in fact be infested only with annual species which do not persist well in the rehab landscape and whose cover will decline quite rapidly over time. Conversely another site may have a low EPC score but be infested with exotic perennial species which are long lived, persist well in the rehabilitation environment and pose a serious threat to the establishment of native vegetation.

Further examination of the rehabilitation sites is therefore necessary to properly inform the management decisions for each site.

5.3.1 Habitat Features

Logs, frog ponds, rocks and other habitat features are to be found in some sites, providing valuable habitat complexity. Frog ponds and dams have been constructed across the rehabilitation landscape though these were often observed to be dry. Water was also observed ponding in other locations which may in time become ephemeral wetlands. Logs have been imported at some sites which has resulted in a fallen log score for some very young sites.

6 Conclusions

There has been some success in establishing diverse native vegetation on rehabilitation sites at MTW in spite of the challenges posed by the growth media, the climate and other factors such as weed invasion. However, these challenges are not yet fully overcome and while the landscape function, native plant diversity and cover are promising at some sites, other sites are failing to meet the MOP criteria on one or more measures.

Primary colonising plants have been most successful in establishing on the rehabilitation sites. Whilst diversity is often meeting MOP criteria in the canopy and mid-storey layers the species present are mostly Acacias, with other plant groups poorly represented by comparison. Diversity in the ground layer is good overall and often exceeds the MOP targets the diversity is low in species other than grasses.

Stem density is often too high on older sites, resulting in increased competition pressure for all plant groups in all vegetation layers.

Landscape function analysis may be giving inaccurate results for some sites due to the difference in slope between many rehabilitation sites and that at the reference sites. Further investigation of reference site suitability is warranted. There is also a need to examine the suitability of reference sites for floristic and habitat quality comparison to ensure a meaningful comparison with the target EEC vegetation.

Further investigation and interpretation of results presented in this report would give valuable insights into the future management and revegetation of rehabilitation sites at MTW.

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8 Appendices

8.1 ACARP Project C27038 details (provided by Bill Baxter, MTW)

Project title - Establishing Self-Sustaining Ecological Mine Rehabilitation that Achieves Recognised Ecological Communities.

The objectives of this project are to examine the performance of mine rehabilitation:
- Determine whether mine rehabilitation can support recognisable and self-sustaining ecological communities in temperate woodland Australian environments.
- Determine whether mine rehabilitation can support habitat for a range of threatened fauna species, including bats, birds and mammals.
- Develop a set of principles to inform the establishment of appropriate rehabilitation objectives, performance criteria and completion criteria for the establishment of recognisable and self-sustaining ecological communities (focusing on temperate woodlands).
- Provide guidance to industry to inform the establishment of benchmark successional stage criteria and a monitoring program to guide progressive ecological rehabilitation success or adaptive management.

8.2 Reference site monitoring transect locations

Central Hunter Grey Box-Ironbark Woodland site locations			
Label	Position	Latitude	Longitude
WamboGB01	Start	-32.58711339	150.9672765
WamboGB01	Finish	-32.58749743	150.9670441
WamboGB02	Start	-32.59344382	150.9705852
WamboGB02	Finish	-32.59304192	150.9708286
WARKGB01	Start	-32.58692534	151.0347976
WARKGB01	Finish	-32.58671198	151.0344187
WARKGB02	Start	-32.63008462	151.017324
WARKGB02	Finish	-32.63049866	151.0172723
WARKGB03	Start	-32.64038972	151.0268497
WARKGB03	Finish	-32.64035185	151.0273089
WARKGB04	Start	-32.64778948	151.0311537
WARKGB04	Finish	-32.6474165	151.0309487

Central Hunter Ironbark-Spotted Gum – Grey Box Forest			
Label	Position	Latitude	Longitude
BEL01	Start	-32.64713278	151.2949779
BEL01	Finish	-32.64713456	151.2944448
BEL02	Start	-32.65228506	151.2976595
BEL02	Finish	-32.65244961	151.2979687
BEL03	Start	-32.65465531	151.2990037
BEL03	Finish	-32.65428909	151.2992665
WamboSpot01	Start	-32.60801953	150.9567884
WamboSpot01	Finish	-32.6077463	150.9571782
WamboSpot02	Start	-32.60602176	150.9592737
WamboSpot02	Finish	-32.60563723	150.9594742
WamboSpot03	Start	-32.60913759	150.9567736
WamboSpot03	Finish	-32.60926623	150.9563658

8.3 Rehabilitation monitoring transect locations

Label	Position	Latitude	Long	Label	Position	Latitude	Long
CDC201101	Start	-32.61010468	151.0774038	SPS201601	Start	-32.6186	151.0912
CDC201101	Finish	-32.61002488	151.0769047	SPS201601	Finish	-32.6184	151.0916
CDD201301	Start	-32.61134434	151.0764929	SPS201602	Start	-32.6224	151.0903
CDD201301	Finish	-32.61092369	151.0767044	SPS201602	Finish	-32.6223	151.0908
CDD201401	Start	-32.6084847	151.0698623	SPS201701	Start	-32.6168	151.0886
CDD201401	Finish	-32.6085875	151.0704369	SPS201701	Finish	-32.6168	151.0892
CDD201501	Start	-32.61208847	151.0715007	SPS201703	Start	-32.6263	151.0945
CDD201501	Finish	-32.61245434	151.0718338	SPS201703	Finish	-32.6263	151.0951
CDD201701	Start	-32.60799339	151.0766701	SPS201801	Start	-32.6181	151.0872
CDD201701	Finish	-32.60840302	151.0765095	SPS201801	Finish	-32.618	151.0877
CDD201702	Start	-32.61320028	151.0802058	TDI201501	Start	-32.5932	151.0787
CDD201702	Finish	-32.61277028	151.0803348	TDI201501	Finish	-32.5927	151.0788
CDD201801	Start	-32.60703824	151.0697015	WDL201401	Start	-32.6263	151.0793
CDD201801	Finish	-32.60663066	151.069419	WDL201401	Finish	-32.6262	151.0797
NPN200901	Start	-32.5990188	151.0719939	WDL201402	Start	-32.6277	151.0774
NPN200901	Finish	-32.59891276	151.0715487	WDL201402	Finish	-32.6281	151.0773
NPN201101	Start	-32.59333509	151.0624955	WDL201801	Start	-32.6226	151.0769
NPN201101	Finish	-32.59293763	151.0627616	WDL201801	Finish	-32.6222	151.0773
NPN201301	Start	-32.59860779	151.0611141	MTO200001	Start	-32.6406	151.0869
NPN201301	Finish	-32.59888775	151.060554	MTO200001	Finish	-32.6402	151.0867
NPN201401	Start	-32.59372924	151.0570614	MTO200503	Start	-32.651	151.088
NPN201401	Finish	-32.5934127	151.0567135	MTO200503	Finish	-32.6513	151.0876
NPN201402	Start	-32.59500895	151.0568183	MTO201501	Start	-32.655	151.0955

Label	Position	Latitude	Long	Label	Position	Latitude	Long
NPN201402	Finish	-32.59463553	151.0571272	MTO201501	Finish	-32.6552	151.0959
NPN201601	Start	-32.60155668	151.0702536	NPN200501	Start	-32.6018	151.0799
NPN201601	Finish	-32.60190252	151.0706033	NPN200501	Finish	-32.6022	151.0802
NPN201602	Start	-32.60258237	151.0766643	NPN200502	Start	-32.5951	151.0785
NPN201602	Finish	-32.60240753	151.0771787	NPN200502	Finish	-32.595	151.079
NPN201701	Start	-32.58836595	151.0538148	NPN201403	Start	-32.6017	151.0619
NPN201701	Finish	-32.58796354	151.0537518	NPN201403	Finish	-32.6017	151.0614
NPN201702	Start	-32.60253761	151.0756326	MTO201601	Start	-32.6553	151.0878
NPN201702	Finish	-32.60290734	151.0753384	MTO201601	Finish	-32.6554	151.0884
NPN201703	Start	-32.58637462	151.0530814	MTO201701	Start	-32.6472	151.0741
NPN201703	Finish	-32.58597585	151.0529907	MTO201701	Start	-32.6471	151.0741
NPN201801	Start	-32.59115419	151.0523511	MTO201701	Finish	-32.6472	151.0747
NPN201801	Finish	-32.59075639	151.0524022	MTO201702	Start	-32.6488	151.0764
NPN201802	Start	-32.59886462	151.0573503	MTO201702	Finish	-32.6488	151.0769
NPN201802	Finish	-32.59864904	151.0577882	MTO201703	Start	-32.6507	151.0822
NPN201803	Start	-32.60230129	151.0672283	MTO201703	Finish	-32.6512	151.0822
NPN201803	Finish	-32.60208294	151.067677	MTO201704	Start	-32.6509	151.079
SPN201401	Start	-32.61148693	151.0834588	MTO201704	Finish	-32.6507	151.0795
SPN201401	Finish	-32.61116265	151.0836208	MTO201801	Start	-32.6354	151.0801
SPN201501	Start	-32.61028005	151.0812042	MTO201801	Finish	-32.6352	151.0807
SPN201501	Finish	-32.60991496	151.0815103	MTO201802	Start	-32.6474	151.0729
SPN201601	Start	-32.60762163	151.0831149	MTO201802	Finish	-32.6477	151.0727
SPN201601	Finish	-32.60725653	151.083421	MTO201803	Start	-32.648	151.0732
SPN201602	Start	-32.61506568	151.0863023	MTO201803	Finish	-32.6485	151.0733

Label	Position	Latitude	Long	Label	Position	Latitude	Long
SPN201602	Finish	-32.6150197	151.0868361				
SPN201701	Start	-32.60759903	151.0783467				
SPN201701	Finish	-32.60714393	151.0784705				

8.4 Floristic Data data

8.4.1 Native species recorded at reference sites

Central Hunter Ironbark-Spotted Gum - Grey Box Forest sites	Central Hunter Grey Box Ironbark Woodland sites

Species name	BELL01	BELL02	BELL03	WAMBOSPOT03	WAMBOSPOT1	WAMBOSPOT2	WAMBOGB1	WAMBOGB2	WARKGB1	WARKGB2	WARKGB3	WARKGB4
Abutilon oxycarpum						x		x	x			
Acacia amblygona						x		x		x		
Acacia bulgaensis					x							
Acacia decora								x				
Acacia falcata	x	x	x					x				
Acacia implexa				x	x			x	x			
Acacia salicina							x					x
Acacia spp.	x	x	x									
Ajuga australis			x							x		
Allocasuarina luehmannii							x	x	x	x	x	x
Alphitonia excelsa					x							
Amyema spp.								x				
Ancistrachne uncinulata				x	x			x				
Aristida acuta		x										
Aristida ramosa			x			x	x	x	x	x	x	x
Aristida vagans	x	x	x	x	x	x				x	x	x

Species name	BELL01	BELL02	BELL03	WAMBOSPOT03	WAMBOSPOT1	WAMBOSPOT2	WAMBOGB1	WAMBOGB2	WARKGB1	WARKGB2	WARKGB3	WARKGB4
Arthropodium sp. B	x	x										
Arthropodium spp.			x		x	x	x	x		x		
Austrostipa scabra						x	x	x	x	x		x
Austrostipa verticillata				x	x							
Boerhavia dominii									x			
Bothriochloa decipiens			x					x	x			
Bothriochloa spp.												x
Brachychiton populneus				x	x	x		x				
Breynia oblongifolia		x	x		x				x			
Brunoniella australis	x	x	x	x	x	x	x	x		x		x
Bursaria spinosa	x		x	x	x	x						
Calocephalus citreus								x				
Calotis cuneifolia	x	x	x					x	x	x	x	x
Calotis lappulacea									x	x		x
Carex inversa											x	
Cassinia quinquefaria									x			
Cassytha pubescens				x								
Cheilanthes distans		x	x	x	x	x	x	x	x	x		x
Cheilanthes sieberi	x	x	x	x	x	x	x	x	x	x	x	x
Chloris truncata								x				
Chloris ventricosa			x					x				x
Choretrum candollei				x	x							

Species name	BELL01	BELL02	BELL03	WAMBOSPOT03	WAMBOSPOT1	WAMBOSPOT2	WAMBOGB1	WAMBOGB2	WARKGB1	WARKGB2	WARKGB3	WARKGB4
Chrysocephalum apiculatum								x	x	x		
Clematis glycinoides				x	x				x			
Commelina cyanea			x	x	x		x	x	x	x	x	x
Convolvulus erubescens									x			
Corymbia maculata	x	x	x	x	x	x						
Crassula sieberiana												x
Cymbopogon refractus	x	x	x	x	x	x	x	x	x	x	x	x
Cynodon dactylon											x	x
Cyperus gracilis				x	x		x	x	x	x		x
Cyperus spp.												x
Daviesia ulicifolia											x	
Denhamia silvestris				x								
Desmodium brachypodum	x		x	x	x	x	x	x	x	x		
Desmodium gunnii	x	x	x	x	x	x	x					
Desmodium rhytidophyllum	x											
Desmodium varians	x	x	x	x	x	x		x	x	x	x	x
Dianella caerulea		x										
Dianella longifolia	x		x			x	x			x	x	x
Dianella revoluta	x	x	x	x	x	x	x					
Dianella spp.								x				
Dichondra repens	x	x	x	x	x	x		x	x	x		x
Digitaria parviflora					x							

Species name	BELL01	BELL02	BELL03	WAMBOSPOT03	WAMBOSPOT1	WAMBOSPOT2	WAMBOGB1	WAMBOGB2	WARKGB1	WARKGB2	WARKGB3	WARKGB4
Digitaria spp.						x						
Dodonaea boroniifolia						x						
Dodonaea viscosa				x	x	x						
Einadia hastata				x					x			x
Einadia nutans							x	x	x	x	x	x
Enchylaena tomentosa									x			x
Enteropogon acicularis							x	x				x
Entolasia marginata	x	x	x	x								
Entolasia stricta	x	x	x									
Eragrostis brownii											x	x
Eragrostis leptostachya		x		x			x	x	x			x
Eremophila debilis		x	x		x	x	x	x	x	x	x	x
Eriochloa pseudoacrotricha												x
Eucalyptus amplifolia											x	
Eucalyptus crebra				x	x		x		x	x	x	x
Eucalyptus fibrosa	x		x									
Eucalyptus moluccana		x	x			x	x	x				
Eucalyptus punctata				x	x							
Euphorbia drummondii									x		x	
Euphorbia spp												x
Evolvulus alsinoides									x	x		x
Fimbristylis dichotoma								x	x	x		x

Species name	BELL01	BELL02	BELL03	WAMBOSPOT03	WAMBOSPOT1	WAMBOSPOT2	WAMBOGB1	WAMBOGB2	WARKGB1	WARKGB2	WARKGB3	WARKGB4
Gahnia aspera		x	x	x	x			x		x		
Galenia pubescens									x			x
Geijera salicifolia								x	x			
Geitonoplesium cymosum						x						
Glossocardia bidens	x		x				x	x	x	x		x
Glycine clandestina		x			x							
Glycine tabacina	x	x	x	x	x	x	x	x	x	x	x	x
Goodenia hederacea											x	
Goodenia rotundifolia	x	x			x					x		x
Grevillea montana						x						
Hardenbergia violacea	x					x						
Heliotropium amplexicaule												x
Hibbertia linearis		x		x	x							
Jacksonia scoparia					x							
Laxmannia gracilis										x	x	x
Lepidium spp								x	x			x
Lepidosperma laterale	x	x										
Linum marginale												x
Lissanthe strigosa	x	x	x									
Lomandra confertifolia				x								
Lomandra filiformis	x	x	x	x	x	x	x	x			x	x
Lomandra glauca				x								

Species name	BELL01	BELL02	BELL03	WAMBOSPOT03	WAMBOSPOT1	WAMBOSPOT2	WAMBOGB1	WAMBOGB2	WARKGB1	WARKGB2	WARKGB3	WARKGB4
Lomandra multiflora subsp. multiflora	x	x	x	x	x	x	x	x	x	x	x	
Macrozamia spp.					x							
Maireana enchylaenoides						x	x	x	x			x
Maireana microphylla							x	x	x			
Marsdenia viridiflora	x					x						
Melaleuca decora											x	
Minuria leptophylla							x	x				
Notelaea microcarpa var. microcarpa					x	x		x	x			
Olearia elliptica	x			x	x	x		x				
Opercularia diphylla	x											
Oplismenus aemulus					x							
Oxalis exilis					x			x		x		
Oxalis perennans								x			x	x
Pandorea pandorana						x						
Panicum effusum										x		
Panicum simile				x					x			
Panicum spp.						x						
Paspalidium distans	x	x	x	x	x	x	x	x	x	x	x	
Persoonia linearis				x	x							
Phyllanthus gunnii				x								
Phyllanthus virgatus	x		x	x	x		x	x	x	x		x
Pimelea latifolia subsp. elliptifolia					x							

Species name	BELL01	BELL02	BELL03	WAMBOSPOT03	WAMBOSPOT1	WAMBOSPOT2	WAMBOGB1	WAMBOGB2	WARKGB1	WARKGB2	WARKGB3	WARKGB4
Plantago debilis						x						
Plantago spp.								x				
Pomax umbellata	x	x	x									
Pratia purpurascens	x	x	x	x	x							
Psydrax odorata						x						
Pultenaea spinosa	x											
Pultenaea spp.			x									
Rostellularia adscendens								x				
Rytidosperma fulvum			x									
Rytidosperma spp.						x	x	x	x		x	
Rytidosperma tenuius		x										
Sarcostemma australe							x					
Scleria mackaviensis						x						
Sida corrugata				x	x	x	x	x	x	x		
Sida hackettiana					x		x	x	x			
Solanum brownii								x				
Solanum prinophyllum			x		x				x			
Solanum spp.								x				
Spartothamnella juncea		x							x			
Sporobolus creber			x					x	x			
Stackhousia viminea	x			x	x	x	x	x				x
Templetonia stenophylla						x					x	

Species name	BELL01	BELL02	BELL03	WAMBOSPOT03	WAMBOSPOT1	WAMBOSPOT2	WAMBOGB1	WAMBOGB2	WARKGB1	WARKGB2	WARKGB3	WARKGB4
Vernonia cinerea	x	x	x	x					x	x		
Veronica plebeia				x					x	x	x	
Vittadinia spp.					x			x				
Vittadinia sulcata									x			
Wahlenbergia communis								x				
Wahlenbergia gracilis												x
Wahlenbergia spp.					x							
Zornia dyctiocarpa										x		

8.4.2 Reference sites exotic Species presence/absence by site

Genus	Species	BELL1	BELL2	BELL3	WAMBOGB1	WAMBOGB2	WAMBOSPOT3	WAMBOSPOT1	WAMBOSPOT2	WARKGB1	WARKGB2	WARKGB3	WARKGB4	Number of reference sites sp. present
Bidens	*pilosa*										x		x	2
Bidens	*sp.*						x							1
Lantana	*camara*									x				1
Eragrostis	*curvula*												x	1
Gomphocarpus	*fruticosus*			x										1
Gomphrena	*celodioides*				x							x	x	3
Lycium	*ferocissimum*													0
Heliotropium	*amplexicaule*												x	1
Opuntia	*aurantiaca*									x	x	x	x	4
Opuntia	*humifusa*				x					x				2
Pavonia	*hastata*										x			1
Phytolacca	*octandra*													0
Plantago	*lanceolata*												x	1
Polygonum	*arenastrum*													0
Richardia	*stellaris*		x			x							x	3
Senecio	*madagascariensis*				x	x			x	x	x	x	x	7
Olea	*europaea subsp. Cuspidata*	x	x	x										3
Sida	*rhombifolia*												x	1

8.4.3 Exotic species observed on rehabilitation sites

Genus	Species	number of sites Present	CDD201101	CDD201301	CDD201401	CDD201501	CDD201701	CDD201702	CDD201801	MTO201601	MTO201701	MTO201702	MTO201703	MTO201704	MTO201801	MTO201802	MTO201803	WDL201401	WDL201402	WDL201801	TD201501	NPN200901	NPN201101	NPN201301	NPN201401	NPN201601
Galenia	*pubescens*	28		x	x		x	x	x		x		x	x	x	x	x				x			x	x	x
Chloris	*gayana*	31	x		x	x	x	x	x	x	x	x	x	x			x	x	x		x		x	x	x	
Chloris	*virgata*	20			x				x		x			x			x		x	x	x			x		x
Sida	*rhombifolia*	23	x				x	x	x					x				x	x	x		x	x			x
Brassica	*rapa*	20		x										x				x	x			x		x		x
Setaria	*parviflora*	21	x				x		x				x	x				x	x		x	x	x	x	x	
Panicum	*maximum var. trichoglume*	15		x	x		x						x						x	x	x			x		
Senecio	*madagascariensis*	17	x	x	x	x					x		x			x			x	x	x				x	
Echinochloa	*crus-galli*	12		x						x						x			x							
Solanum	*nigrum*	12		x					x							x				x						x
Euphorbia	*sp.*	11			x											x			x	x						x
Sida	*spinosa*	11							x				x	x						x						x
Acacia	*saligna*	9								x	x	x	x			x			x				x			
Eragrostis	*parviflora*	8					x													x				x		
Lysimachia	*arvensis*	8		x					x						x	x									x	
Malva	*parviflora*	8						x		x			x						x							x
Modiola	*caroliniana*	10	x		x				x						x							x				x
Urochloa	*panicoides*	8			x			x						x												x
Bidens	*pilosa*	8			x			x				x			x			x								
Conyza	*bonariensis*	9				x					x		x					x			x					
Paspalum	*dilatatum*	8				x			x										x							
Eragrostis	*curvula*	8	x						x						x					x			x			
Phytolacca	*octandra*	6									x					x										
Aster	*subulatus*	5									x						x		x		x					
Chenopodium	*album*	6						x					x					x		x						
Medicago	*sp.*	5								x						x	x			x						
Melinus	*repens*	6				x								x									x			
Plantago	*lanceolata*	7	x			x						x				x							x			
Schkuhria	*pinnata*	6		x				x	x						x								x			

Genus	Species	number of sites Present	CDD201101	CDD201301	CDD201401	CDD201501	CDD201701	CDD201702	CDD201801	MTO201601	MTO201701	MTO201702	MTO201703	MTO201704	MTO201801	MTO201802	MTO201803	WDL201401	WDL201402	WDL201801	TD201501	NPN200901	NPN201101	NPN201301	NPN201401	NPN201601
Sonchus	*asper*	5		x													x		x							
Cenchrus	*clandestinus*	4											x													
Richardia	*brasiliensis*	4					x																			
Echinochloa	*esculenta (utilis)*	3												x	x		x									
Gomphocarpus	*fruticosus*	6	x							x			x									x	x			
Macroptilium	*atropurpureum*	3																								
Medicago	*sativa*	3			x				x																	
Bromus	*sp.*	2														x										
Opuntia	*humifusa*	2																						x		
Panicum	*antidotale*	1																		x						
Panicum	*capillare*	2												x												
Amaranthus	*sp.*	1																								
Cichorium	*intybus*	1																								
Cirsium	*vulgare*	1			x																					
Digitaria	*cilliaris*	1															x									
Eleusine	*tristachya*	1																								
Lycium	*ferocissimum*	1							x																	
Polygonum	*arenastrum*	1																								
Rumex	*sp.*	1																								x
Sisymbrium	*sp.*	1								x																
Trifolium	*repens*	1																								
Verbena	*bonariensis*	2																					x			

Genus	Species	number of sites sp. Present	NPN201602	NPN201701	NPN201702	NPN201703	NPN201801	NPN201802	NPN201803	SPN201401	SPN201501	SPN201601	SPN201602	SPN201701	SPS201601	SPS201602	SPS201701	SPS201703	SPS201801
Galenia	*pubescens*	28	x	x			x	x	x	x	x	x	x	x	x	x	x		
Chloris	*gayana*	31	x	x	x		x	x	x	x	x		x	x	x	x	x		
Chloris	*virgata*	20	x	x			x		x		x	x		x		x	x		x
Sida	*rhombifolia*	23		x		x		x		x	x	x	x	x		x	x	x	x
Brassica	*rapa*	20			x	x		x	x	x	x		x	x	x	x	x	x	x
Setaria	*parviflora*	21	x			x		x			x		x		x	x	x	x	
Panicum	*maximum var. trichoglume*	15					x			x	x	x				x	x		x
Senecio	*madagascariensis*	17	x		x					x			x			x		x	
Echinochloa	*crus-galli*	12		x		x	x	x	x					x		x			x
Solanum	*nigrum*	12	x	x		x	x	x			x					x			
Euphorbia	*sp.*	11		x							x				x	x	x		x
Sida	*spinosa*	11		x			x		x		x	x				x			
Acacia	*saligna*	9													x	x			
Eragrostis	*parviflora*	8			x									x		x		x	x
Lysimachia	*arvensis*	8						x		x						x			
Malva	*parviflora*	8		x												x			x
Modiola	*caroliniana*	10					x	x		x			x						
Urochloa	*panicoides*	8								x	x	x			x				
Bidens	*pilosa*	8	x									x				x			
Conyza	*bonariensis*	9			x					x	x					x			
Paspalum	*dilatatum*	8		x				x	x							x		x	
Eragrostis	*curvula*	8	x									x				x			
Phytolacca	*octandra*	6			x		x	x						x					
Aster	*subulatus*	5	x																
Chenopodium	*album*	6		x															x
Medicago	*sp.*	5																x	

Genus	Species	number of sites sp. Present	NPN201602	NPN201701	NPN201702	NPN201703	NPN201801	NPN201802	NPN201803	SPN201401	SPN201501	SPN201601	SPN201602	SPN201701	SPS201601	SPS201602	SPS201701	SPS201703	SPS201801
Melinus	*repens*	6			x		x									x			
Plantago	*lanceolata*	7			x	x													
Schkuhria	*pinnata*	6						x											
Sonchus	*asper*	5								x						x			
Cenchrus	*clandestinus*	4		x												x		x	
Richardia	*brasiliensis*	4					x						x	x					
Echinochloa	*esculenta (utilis)*	3																	
Gomphocarpus	*fruticosus*	6	x																
Macroptilium	*atropurpureum*	3									x				x			x	
Medicago	*sativa*	3																x	
Bromus	*sp.*	2																x	
Opuntia	*humifusa*	2					x												
Panicum	*antidotale*	1																	
Panicum	*capillare*	2										x							
Amaranthus	*sp.*	1				x													
Cichorium	*intybus*	1														x			
Cirsium	*vulgare*	1																	
Digitaria	*cilliaris*	1																	
Eleusine	*tristachya*	1						x											
Lycium	*ferocissimum*	1																	
Polygonum	*arenastrum*	1							x										
Rumex	*sp.*	1																	
Sisymbrium	*sp.*	1																	
Trifolium	*repens*	1				x													
Verbena	*bonariensis*	2																	x

8.4.4 Native species observed on rehabilitation sites

Vegetation layer	Genus	Species	number of rehab sites sp. Present	CDD201101	CDD201301	CDD201401	CDD201501	CDD201701	CDD201702	CDD201801	TD201501	WDL201402	WDL201801	WLD201401	MTO201601	MTO201701	MTO201702	MTO201703	MTO201704	MTO201801	MTO201802	MTO201803
Tree	*Acacia*	*implexa*	14	x			x			x				x		x						
Tree	*Acacia*	*salicina*	18	x	x		x	x			x	x		x							x	
Tree	*Corymbia*	*maculata*	19	x			x			x	x			x		x			x			x
Tree	*Eucalyptus*	*crebra*	10	x			x							x		x			x			x
Tree	*Eucalyptus*	*dawsonii?*	5							x				x		x						x
Tree	*Eucalyptus*	*fibrosa*	7	x			x				x	x										
Tree	*Eucalyptus*	*moluccana*	11	x			x				x		x	x								
Tree	*Eucalyptus*	*punctata*	1				x															
Tree	*Eucalyptus*	*spp.*	1											x								
Tree	*Eucalyptus*	*tereticornis?*	2																x			
Tree	*Eucalyptus*	*sp.*	3																			
Shrub	*Acacia*	*amblygona*	23	x			x	x	x	x		x	x	x					x			
Shrub	*Acacia*	*binervata*	1				x															
Shrub	*Acacia*	*cultriformis*	19	x		x	x	x	x	x		x		x		x			x			
Shrub	*Acacia*	*deanei*	2	x			x															
Shrub	*Acacia*	*decora*	22			x	x	x		x		x		x		x			x			
Shrub	*Acacia*	*decurrens*	1																			
Shrub	*Acacia*	*falcata*	13				x			x		x		x		x			x			
Shrub	*Acacia*	*filicifolia*	2							x												
Shrub	*Acacia*	*leiocalyx*	2																			
Shrub	*Acacia*	*linearifolia?*	6							x		x						x				
Shrub	*Acacia*	*longifolia*	3	x			x															
Shrub	*Acacia*	*paradoxa*	8													x		x	x			
Shrub	*Acacia*	*parvipinnula*	5																			
Shrub	*Acacia*	*sp.*	6																			
Shrub	*Acacia*	*spectabilis*	13	x			x	x	x	x									x			
Shrub	*Allocasuarina*	*sp.*	1				x															
Shrub	*Cassinia*	*uncata*	3																x			

Vegetation layer	Genus	Species	number of rehab sites sp. Present	CDD201101	CDD201301	CDD201401	CDD201501	CDD201701	CDD201702	CDD201801	TD201501	WDL201402	WDL201801	WLD201401	MTO201601	MTO201701	MTO201702	MTO201703	MTO201704	MTO201801	MTO201802	MTO201803
Shrub	*Daviesia*	*genistifolia*	1																			
Shrub	*Daviesia*	*ulicifolia*	2																			
Shrub	*Dodonaea*	*viscosa subsp. cuneata*	16			x		x		x									x			
Shrub	*Indigofera*	*australis*	10			x				x									x			
Shrub	*Myoporum*	*montanum*	5													x						
Shrub	*Olearia*	*elliptica*	1													x						
Shrub	*Salsola*	*australis*	9					x						x								
Shrub	*Sclerolaena*	*muricata var. muricata*	1																			
Shrub	*Senna*	*artemisioides subsp. zygophylla*	1																			
GL shrub	*Atriplex*	*semibaccata*	30	x		x	x	x	x	x	x	x	x	x		x	x	x			x	x
GL shrub	*Einadia*	*nutans*	23	x		x		x	x	x	x		x			x	x	x	x		x	x
GL shrub	*Einadia*	*nutans subsp. linifolia*	1											x								
GL shrub	*Einadia*	*nutans subsp. nutans*	1											x								
GL shrub	*Enchylaena*	*tomentosa*	25	x		x	x	x	x	x	x	x		x		x		x	x		x	x
GL shrub	*Hardenbergia*	*violaceaea*	14			x	x			x				x		x			x			
GL shrub	*Lotus*	*australis*	2																			
GL shrub	*Sida*	*hackettiana*	4																			
GL Shrub	*Solanum*	*cinereum*	18			x		x		x						x			x			x
GL Shrub	*Solanum*	*sp.*	1	x																		
Grass	*Aristida*	*ramosa*	7				x		x					x								
Grass	*Austrostipa*	*ramosissima*	12							x						x	x	x	x			x
Grass	*Austrostipa*	*scabra*	9				x												x			
Grass	*Austrostipa*	*sp.*	2																			
Grass	*Bothriochloa*	*biloba*	2																			
Grass	*Bothriochloa*	*decipiens*	23	x			x	x		x	x	x	x	x					x			x
Grass	*Capillipedium*	*spicigerum*	23	x			x	x	x	x		x	x			x		x	x			x
Grass	*Chloris*	*truncata*	39	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Grass	*Chloris*	*ventricosa*	21				x	x	x	x		x		x		x		x	x		x	x

Vegetation layer	Genus	Species	number of rehab sites sp. Present	CDD201101	CDD201301	CDD201401	CDD201501	CDD201701	CDD201702	CDD201801	TD201501	WDL201402	WDL201801	WLD201401	MTO201601	MTO201701	MTO201702	MTO201703	MTO201704	MTO201801	MTO201802	MTO201803
Grass	*Cymbopogon*	*refractus*	14				x	x	x	x			x	x			x		x			
Grass	*Cynodon*	*dactylon*	25				x	x	x			x	x	x	x			x	x	x	x	
Grass	*Dactyloctenium*	*radulans*	10		x				x			x	x						x			
Grass	*Dichanthium*	*sericeum*	31	x		x	x	x	x	x	x		x	x				x	x			x
Grass	*Digitaria*	*brownii*	8					x	x	x									x			
Grass	*Digitaria*	*diffusa*	2																			
Grass	*Digitaria*	*divaricatissima*	22				x			x		x		x		x	x	x	x			x
Grass	*Digitaria*	*spp.*	1																			
Grass	*Eragrostis*	*benthamii*	1																			
Grass	*Eragrostis*	*brownii*	6	x			x	x		x												
Grass	*Eragrostis*	*leptostachya*	13				x	x	x				x	x		x			x			
Grass	*Eragrostis*	*sp.*	3														x					
Grass	*Eriochloa*	*procera*	10								x	x	x									
Grass	*Eriochloa*	*pseudacrotricha*	31	x		x	x	x	x	x		x		x		x	x	x	x		x	x
Grass	*Heteropogon*	*contortus*	1																			
Grass	*Panicum*	*effusum*	12				x					x	x	x								
Grass	*Panicum*	*queenslandicum*	19					x	x	x		x				x	x		x		x	x
Grass	*Panicum*	*simile?*	1																			
Grass	*Paspalidium*	*breviflorum*	8					x		x												
Grass	*Paspalidium*	*distans*	2	x																		
Grass	*Perotis*	*rara*	1																			
Grass	*Rytidosperma*	*richardsonii*	4					x								x						
Grass	*Rytidosperma*	*tenuius*	2	x			x															
Grass	*Sporobolus*	*creber*	28	x			x	x	x	x	x			x	x	x		x	x		x	x
Grass	*Themeda*	*triandra*	9	x			x	x		x												
Forb	*Alternanthera*	*denticulata*	1																			
Forb	*Asteraceae*	*sp.*	1																			
Forb	*Brachyscome*	*sp.*	1											x								
Forb	*Calotis*	*cuneifolia*	4							x												

Vegetation layer	Genus	Species	number of rehab sites sp. Present	CDD201101	CDD201301	CDD201401	CDD201501	CDD201701	CDD201702	CDD201801	TD201501	WDL201402	WDL201801	WLD201401	MTO201601	MTO201701	MTO201702	MTO201703	MTO201704	MTO201801	MTO201802	MTO201803
Forb	*Calotis*	*lappulacea*	11			x		x						x					x			
Forb	*Cheilanthes*	*sieberi*	1																			
Forb	*Commelina*	*cyanaea*	1																			
Forb	*Convolvulus*	*erubescens*	0																			
Forb	*Convolvulus*	*gramenitinus*	4																x		x	
Forb	*Cyperus*	*aggregatus*	1	x																		
Forb	*Cyperus*	*gracilis*	1											x								
Forb	*Cyperus*	*sp.*	3																			
Forb	*Cyperus*	*sp. II*	1																			
Forb	*Desmodium*	*brachypodum*	2																x			
Forb	*Dichondra*	*repens*	6	x	x																	
Forb	*Dysphania*	*pumilio*	3		x																	x
Forb	*Einadia*	*hastata*	2				x			x												
Forb	*Einadia*	*polygonoides*	18					x	x	x			x			x	x	x	x		x	
Forb	*Einadia*	*trigonos*	27					x	x	x		x	x			x	x	x	x		x	x
Forb	*Eremophila*	*debilis*	3																			
Forb	*Erodium*	*crinitum*	10	x						x									x	x	x	
Forb	*Euphorbia*	*dallachyiana*	1	x																		
Forb	*Euphorbia*	*SPP.*	0																			
Forb	*Evolvulus*	*alcinoides*	3																			
Forb	*Geranium*	*sp.*	1		x																	
Forb	*Glycine*	*clandestina*	2																			
Forb	*Glycine*	*tabacina*	10	x															x			
Forb	*Lepidium*	*sp.*	16		x	x		x			x	x				x	x				x	
Forb	*Oxalis*	*perennans*	4	x		x																
Forb	*Phyllanthus*	*virgatus*	3	x																		
Forb	*Portulaca*	*oleracea*	12		x						x			x	x	x			x		x	
Forb	*Sida*	*corrugata*	5	x																		
Forb	*Sida*	*hackettiana*	1											x								

Vegetation layer	Genus	Species	number of rehab sites sp. Present	CDD201101	CDD201301	CDD201401	CDD201501	CDD201701	CDD201702	CDD201801	TD201501	WDL201402	WDL201801	WLD201401	MTO201601	MTO201701	MTO201702	MTO201703	MTO201704	MTO201801	MTO201802	MTO201803
Forb	*Vernonia*	*sp.*	2																			
Forb	*Vittadinia*	*cuneata*	15			x		x	x	x						x		x	x			
Forb	*Vittadinia*	*muelleri*	3					x														
Forb	*Vittadinia*	*sp.*	0																			
Forb	*Wahlenbergia*	*communis*	1																			

Vegetation layer	Genus	Species	NPN200901	NPN201101	NPN201301	NPN201401	NPN201601	NPN201602	NPN201701	NPN201702	NPN201703	NPN201801	NPN201802	NPN201803	SPN201401	SPN201501	SPN201601	SPN201602	SPN201701	SPS201601	SPS201602	SPS201701	SPS201703	SPS201801
Tree	*Acacia*	*implexa*		x	x	x		x	x			x		x				x				x		
Tree	*Acacia*	*salicina*		x	x	x	x		x			x	x				x				x	x		
Tree	*Corymbia*	*maculata*	x		x			x	x	x		x	x	x				x	x			x		
Tree	*Eucalyptus*	*crebra*	x	x				x								x								
Tree	*Eucalyptus*	*dawsonii?*														x								
Tree	*Eucalyptus*	*fibrosa*	x	x						x														
Tree	*Eucalyptus*	*moluccana*	x	x												x					x		x	x
Tree	*Eucalyptus*	*punctata*																						
Tree	*Eucalyptus*	*spp.*																						
Tree	*Eucalyptus*	*tereticornis?*																x						
Tree	*Eucalyptus*	*sp.*		x						x				x										
Shrub	*Acacia*	*amblygona*	x	x	x	x		x	x		x	x	x					x	x	x	x	x		
Shrub	*Acacia*	*binervata*																						
Shrub	*Acacia*	*cultriformis*		x	x	x		x	x			x	x	x		x								
Shrub	*Acacia*	*deanei*																						
Shrub	*Acacia*	*decora*	x	x	x	x		x	x			x	x	x	x	x		x		x	x			
Shrub	*Acacia*	*decurrens*	x																					
Shrub	*Acacia*	*falcata*			x			x	x			x	x						x			x		
Shrub	*Acacia*	*filicifolia*										x												
Shrub	*Acacia*	*leiocalyx*			x			x																
Shrub	*Acacia*	*linearifolia?*				x			x				x											
Shrub	*Acacia*	*longifolia*											x											
Shrub	*Acacia*	*paradoxa*			x	x		x									x		x					
Shrub	*Acacia*	*parvipinnula*			x	x		x					x	x										
Shrub	*Acacia*	*sp.*	x					x			x	x	x			x								
Shrub	*Acacia*	*spectabilis*							x	x		x	x					x			x	x		

Vegetation layer	Genus	Species	NPN200901	NPN201101	NPN201301	NPN201401	NPN201601	NPN201602	NPN201701	NPN201702	NPN201703	NPN201801	NPN201802	NPN201803	SPN201401	SPN201501	SPN201601	SPN201602	SPN201701	SPS201601	SPS201602	SPS201701	SPS201703	SPS201801
Shrub	*Allocasuarina*	*sp.*																						
Shrub	*Cassinia*	*uncata*				x											x							
Shrub	*Daviesia*	*genistifolia*										x												
Shrub	*Daviesia*	*ulicifolia*		x				x																
Shrub	*Dodonaea*	*viscosa subsp. cuneata*		x		x			x	x		x	x	x		x		x	x			x	x	
Shrub	*Indigofera*	*australis*			x	x		x	x				x			x						x		
Shrub	*Myoporum*	*montanum*							x									x	x			x		
Shrub	*Olearia*	*elliptica*																						
Shrub	*Salsola*	*australis*		x			x	x	x	x				x						x				
Shrub	*Sclerolaena*	*muricata var. muricata*																	x					
Shrub	*Senna*	*artemisioides subsp. zygophylla*				x																		
GL shrub	*Atriplex*	*semibaccata*			x			x	x	x	x		x	x	x	x	x	x	x		x	x		x
GL shrub	*Einadia*	*nutans*						x		x				x	x			x	x	x	x	x		x
GL shrub	*Einadia*	*nutans subsp. linifolia*																						
GL shrub	*Einadia*	*nutans subsp. nutans*																						
GL shrub	*Enchylaena*	*tomentosa*		x		x	x	x	x	x	x	x	x	x				x						
GL shrub	*Hardenbergia*	*violaceaea*			x	x		x				x	x	x					x				x	
GL shrub	*Lotus*	*australis*										x		x										
GL shrub	*Sida*	*hackettiana*			x						x						x		x					
GL Shrub	*Solanum*	*cinereum*					x	x		x		x	x	x		x		x	x	x		x	x	
GL Shrub	*Solanum*	*sp.*																						
Grass	*Aristida*	*ramosa*		x						x	x						x							
Grass	*Austrostipa*	*ramosissima*			x	x				x						x			x			x		
Grass	*Austrostipa*	*scabra*			x	x		x		x		x		x			x							

Vegetation layer	Genus	Species	NPN200901	NPN201101	NPN201301	NPN201401	NPN201601	NPN201602	NPN201701	NPN201702	NPN201703	NPN201801	NPN201802	NPN201803	SPN201401	SPN201501	SPN201601	SPN201602	SPN201701	SPS201601	SPS201602	SPS201701	SPS201703	SPS201801
Grass	*Austrostipa*	*sp.*			x												x							
Grass	*Bothriochloa*	*biloba*											x			x								
Grass	*Bothriochloa*	*decipiens*	x	x	x	x			x		x	x	x		x	x		x	x		x			
Grass	*Capillipedium*	*spicigerum*				x			x	x		x	x	x		x	x	x	x		x	x		
Grass	*Chloris*	*truncata*		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Grass	*Chloris*	*ventricosa*					x			x	x	x	x	x		x			x		x	x		
Grass	*Cymbopogon*	*refractus*	x							x		x	x	x							x			
Grass	*Cynodon*	*dactylon*		x	x	x	x		x	x	x		x		x			x		x		x	x	x
Grass	*Dactyloctenium*	*radulans*					x					xs							x		x	x		x
Grass	*Dichanthium*	*sericeum*		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Grass	*Digitaria*	*brownii*					x				x			x			x							
Grass	*Digitaria*	*diffusa*										x	x											
Grass	*Digitaria*	*divaricatissima*	x		x		x		x	x	x	x	x	x		x			x		x	x		
Grass	*Digitaria*	*spp.*	x																					
Grass	*Eragrostis*	*benthamii*										x												
Grass	*Eragrostis*	*brownii*											x						x					
Grass	*Eragrostis*	*leptostachya*								x			x			x			x			x	x	
Grass	*Eragrostis*	*sp.*										x	x											
Grass	*Eriochloa*	*procera*							x						x	x				x	x		x	x
Grass	*Eriochloa*	*pseudacrotricha*		x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x		
Grass	*Heteropogon*	*contortus*				x																		
Grass	*Panicum*	*effusum*		x				x				x			x						x	x	x	x
Grass	*Panicum*	*queenslandicum*						x	x	x		x	x	x		x		x	x			x		

Vegetation layer	Genus	Species	NPN200901	NPN201101	NPN201301	NPN201401	NPN201601	NPN201602	NPN201701	NPN201702	NPN201703	NPN201801	NPN201802	NPN201803	SPN201401	SPN201501	SPN201601	SPN201602	SPN201701	SPS201601	SPS201602	SPS201701	SPS201703	SPS201801
Grass	*Panicum*	*simile?*										x												
Grass	*Paspalidium*	*breviflorum*						x				x	x			x		x	x					
Grass	*Paspalidium*	*distans*	x																					
Grass	*Perotis*	*rara*										x												
Grass	*Rytidosperma*	*richardsonii*				x													x					
Grass	*Rytidosperma*	*tenuius*																						
Grass	*Sporobolus*	*creber*		x	x			x	x	x	x	x	x			x	x	x	x		x	x		x
Grass	*Themeda*	*triandra*		x		x						x		x		x								
Forb	*Alternanthera*	*denticulata*								x														
Forb	*Asteraceae*	*sp.*																			x			
Forb	*Brachyscome*	*sp.*																						
Forb	*Calotis*	*cuneifolia*														x	x	x						
Forb	*Calotis*	*lappulacea*				x			x								x	x	x		x	x		
Forb	*Cheilanthes*	*sieberi*	x																					
Forb	*Commelina*	*cyanaea*										x												
Forb	*Convolvulus*	*erubescens*																						
Forb	*Convolvulus*	*gramenitinus*							x													x		
Forb	*Cyperus*	*aggregatus*																						
Forb	*Cyperus*	*gracilis*																						
Forb	*Cyperus*	*sp.*										x	x					x						
Forb	*Cyperus*	*sp. II*										x												
Forb	*Desmodium*	*brachypodum*		x																				
Forb	*Dichondra*	*repens*	x	x							x				x									

Vegetation layer	Genus	Species	NPN200901	NPN201101	NPN201301	NPN201401	NPN201601	NPN201602	NPN201701	NPN201702	NPN201703	NPN201801	NPN201802	NPN201803	SPN201401	SPN201501	SPN201601	SPN201602	SPN201701	SPS201601	SPS201602	SPS201701	SPS201703	SPS201801
Forb	*Dysphania*	*pumilio*										x												
Forb	*Einadia*	*hastata*																						
Forb	*Einadia*	*polygonoides*							x				x		x	x	x	x	x			x		x
Forb	*Einadia*	*trigonos*			x	x	x		x	x	x	x	x	x			x	x	x	x	x	x		x
Forb	*Eremophila*	*debilis*	x			x							x											
Forb	*Erodium*	*crinitum*	x		x						x					x	x							
Forb	*Euphorbia*	*dallachyiana*																						
Forb	*Euphorbia*	*SPP.*																						
Forb	*Evolvulus*	*alcinoides*											x		x			x						
Forb	*Geranium*	*sp.*																						
Forb	*Glycine*	*clandestina*										x	x											
Forb	*Glycine*	*tabacina*	x	x	x							x	x						x		x	x		
Forb	*Lepidium*	*sp.*				x					x		x	x	x	x						x	x	
Forb	*Oxalis*	*perennans*	x												x									
Forb	*Phyllanthus*	*virgatus*	x										x											
Forb	*Portulaca*	*oleracea*						x								x		x	x	x				
Forb	*Sida*	*corrugata*	x								x						x		x					
Forb	*Sida*	*hackettiana*																						
Forb	*Vernonia*	*sp.*		x													x							
Forb	*Vittadinia*	*cuneata*		x			x		x	x	x								x			x		x
Forb	*Vittadinia*	*muelleri*								x														x
Forb	*Vittadinia*	*sp.*																						
Forb	*Wahlenbergia*	*communis*		x																				

Central Hunter Ironbark-Spotted Gum-Grey Box forest reference sites

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Figure 1

Central Hunter Grey Box-Ironbark Woodland reference sites

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Figure 2

Central Hunter Ironbark-Spotted Gum-Grey Box forest reference sites

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Figure 3

031123_F3_RehabMon_2019_190703_v01

Central Hunter Grey Box-Ironbark Woodland reference sites

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Figure 4

031123_F4_RehabMon_2019_190703_v01

CD Dump, South Pit North and South monitoring sites

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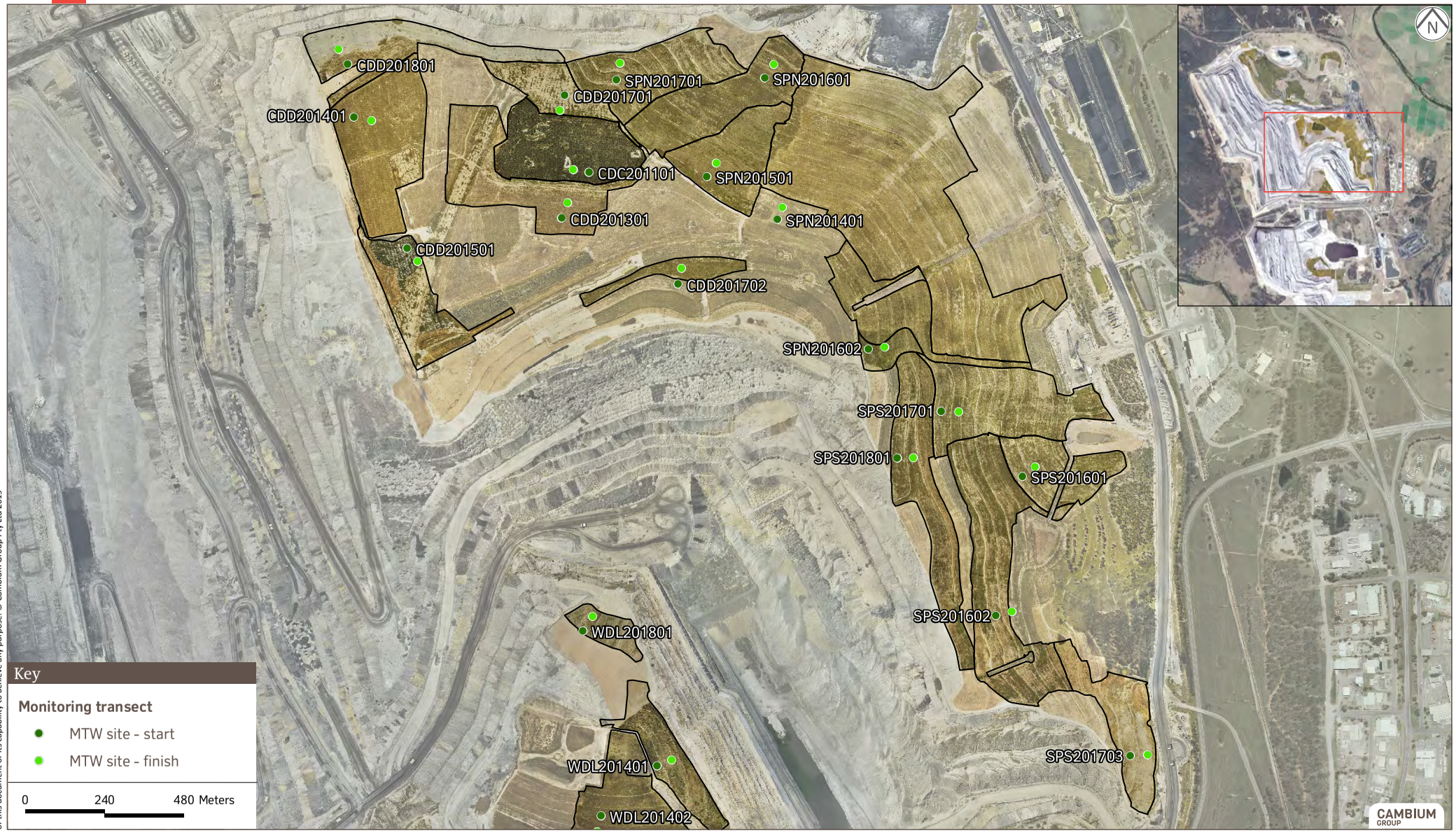
Figure 5



Mount Thorley Operation monitoring transect locations

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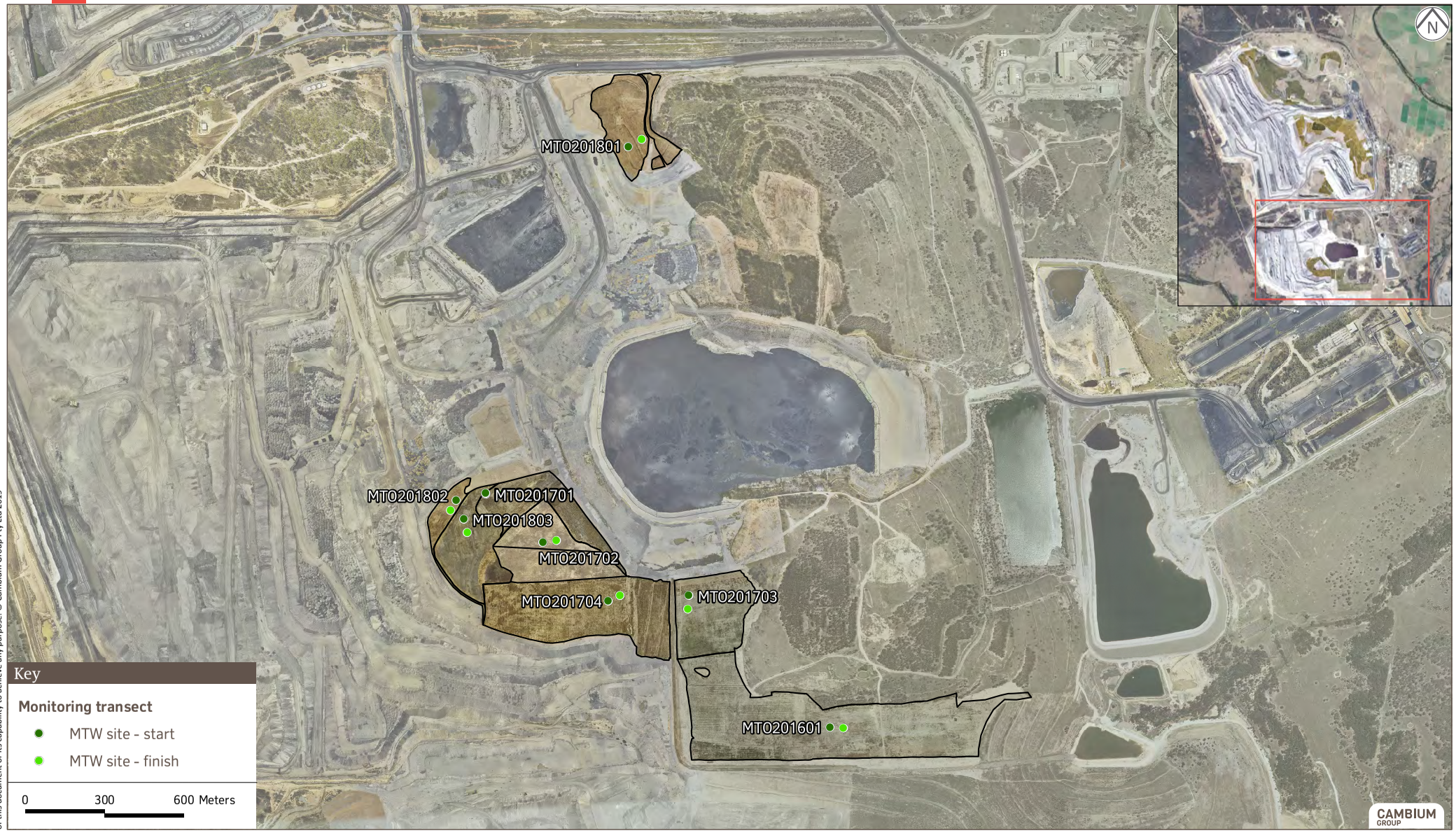
Figure 6



North Pit North/ Tailings Dam 1 monitoring transect locations

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Figure 7

Woodlands monitoring transect locations

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Figure 8

031123_F8_RehabMon_2019_190704_v01

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

			Sample 1	Sample 2	Sample 3	Sample 41	Sample 1A
		Sample ID:	BEL01	BEL02	BEL03	WAMBOGB01	Wambog602
		Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Area
		Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	Mount Thorley Warkworth
	Parameter	Method reference	I2408/1	I2408/2	I2408/3	I2408/41	I3218/1
	Soluble Calcium (mg/kg)	**Inhouse S10 - Morgan 1	268	636	438	505	788
	Soluble Magnesium (mg/kg)		363	172	334	433	494
	Soluble Potassium (mg/kg)		155	113	156	138	189
	Soluble Phosphorus (mg/kg)		2.2	2.4	1.8	3.6	2.2
	Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9E2 (Bray 1)	2.1	1.2	1.4	6.5	4.1
		**Rayment & Lyons 2011 - 9B2 (Colwell)	6.2	5.2	4.9	15	13
		**Inhouse S3A (Bray 2)	3.6	2.3	2.3	15	6
	Nitrate Nitrogen (mg/kg N)	**Inhouse S37 (KCl)	2.3	3.6	5.0	11	24.1
	Ammonium Nitrogen (mg/kg N)		9.7	5.4	7.6	5.7	5.2
	Sulfur (mg/kg S)		16	12	15	30	16.0
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.39	5.85	5.59	5.52	5.98
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.082	0.049	0.089	0.121	0.152
	Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	8.7	4.7	7.5	6.3	5.3
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	3.01	6.08	4.60	5.23	7.93
	Exchangeable Calcium (kg/ha)		1353	2731	2065	2347	3558
	Exchangeable Calcium (mg/kg)		604	1219	922	1048	1588
	Exchangeable Magnesium (cmol+/kg)		4.47	1.89	4.08	6.09	6.51
	Exchangeable Magnesium (kg/ha)		1216	516	1110	1657	1773
	Exchangeable Magnesium (mg/kg)		543	230	495	740	792
	Exchangeable Potassium (cmol+/kg)		0.71	0.45	0.75	0.79	0.99
	Exchangeable Potassium (kg/ha)		622	396	659	691	864
	Exchangeable Potassium (mg/kg)		278	177	294	309	386
	Exchangeable Sodium (cmol+/kg)		0.45	0.15	0.53	0.71	0.67
	Exchangeable Sodium (kg/ha)		230	76	271	365	347
	Exchangeable Sodium (mg/kg)		103	34	121	163	155
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	0.18	0.10	0.11	0.01	<0.01
	Exchangeable Aluminium (kg/ha)		36	20	22	2	1
	Exchangeable Aluminium (mg/kg)		16	9	10	<1	<1
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.13	<0.01	0.01	0.08	0.02
	Exchangeable Hydrogen (kg/ha)		3	<1	<1	2	<1
	Exchangeable Hydrogen (mg/kg)		1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	8.94	8.67	10.08	12.91	16.13
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	33.7	70.1	45.6	40.5	49.1
	Magnesium (%)		49.9	21.8	40.5	47.2	40.4
	Potassium (%)		7.9	5.2	7.5	6.1	6.1
	Sodium - ESP (%)		5.0	1.7	5.2	5.5	4.2
	Aluminium (%)		2.0	1.1	1.1	0.1	0.0
	Hydrogen		1.4	0.0	0.1	0.6	0.1
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	0.7	3.2	1.1	0.9	1.2

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

Parameter	Method reference	Sample 1	Sample 2	Sample 3	Sample 41	Sample 1A
Sample ID:		**BEL01**	**BEL02**	**BEL03**	**WAMBOGB01**	**Wambog602**
Crop:		**Rehab Natives**	**Rehab Natives**	**Rehab Natives**	**Rehab Natives**	**Rehab Area**
Client:		**MTW Mine**	**MTW Mine**	**MTW Mine**	**MTW Mine**	**Mount Thorley Warkworth**
		I2408/1	**I2408/2**	**I2408/3**	**I2408/41**	**I3218/1**
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	6.4	4.6	5.7	4.5	3.8
Manganese (mg/kg)		23	10.3	10.4	16	18
Iron (mg/kg)		369	126	327	99	67
Copper (mg/kg)		0.3	0.4	0.4	0.6	0.3
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.58	0.55	0.67	0.56	0.45
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	25	24	29	53	51
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	4.96	2.71	4.29	3.59	3.02
Total Nitrogen (%)		0.24	0.16	0.24	0.23	0.23
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	20.6	16.7	17.8	15.5	13.1
Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	
Basic Colour		Brownish	Brownish	Brownish	Brownish	
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	53	31	57	78	97
Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	1,146	1,975	1,267	1,811	2,158
Total Magnesium (mg/kg)		1,294	768	1,029	1,516	1,838
Total Potassium (mg/kg)		1,477	1,099	1,316	1,472	1,888
Total Sodium (mg/kg)		155	73	146	235	229
Total Sulfur (mg/kg)		228	163	203	213	205
Total Phosphorus (mg/kg)		176	119	166	244	202
Total Zinc (mg/kg)		38	38	27	37	40
Total Manganese (mg/kg)		131	177	110	260	334
Total Iron (mg/kg)		11,767	7,983	11,487	16,672	12,861
Total Copper (mg/kg)		4.9	10.8	4.4	7.9	7.4
Total Boron (mg/kg)		3.1	<2	<2	2.9	14
Total Silicon (mg/kg)		1,519	1,291	1,386	1,974	1,881
Total Aluminium (mg/kg)		6,048	4,874	6,056	7,826	8,215
Total Molybdenum (mg/kg)		0.4	0.2	0.4	0.8	0.8
Total Cobalt (mg/kg)		11.7	13.9	13.8	3.3	5
Total Selenium (mg/kg)		0.8	0.5	0.6	<0.5	0.5
Total Cadmium (mg/kg)		<0.5	<0.5	<0.5	<0.5	<0.5
Total Lead (mg/kg)		11	11	12	11	13
Total Arsenic (mg/kg)		5.0	2.8	5.4	8.8	7
Total Chromium (mg/kg)		11	8.3	10.2	7.4	7
Total Nickel (mg/kg)		10	8.4	8.7	5.5	5
Total Mercury (mg/kg)		<0.1	<0.1	<0.1	<0.1	<0.1
Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
PO Box 157 Lismore NSW 2480
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		Sample 1	Sample 2	Sample 3	Sample 41	Sample 1A
	Sample ID:	BEL01	BEL02	BEL03	WAMBOGB01	Wambog602
	Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Area
	Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	Mount Thorley Warkworth
Parameter	Method reference	I2408/1	I2408/2	I2408/3	I2408/41	I3218/1

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal).

Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 42	Sample 43	Sample 44	Sample 45	Sample 46
	Sample ID:		WAMBOSPOT01	WAMBOSPOT02	WAMBOSPOT03	WARKGB01	WARKGB02
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/42	I2408/43	I2408/44	I2408/45	I2408/46
	Soluble Calcium (mg/kg)	**Inhouse S10 - Morgan 1	428	1005	285	702	420
	Soluble Magnesium (mg/kg)		177	339	176	256	167
	Soluble Potassium (mg/kg)		107	234	130	165	118
	Soluble Phosphorus (mg/kg)		2.5	3.9	2.1	2.9	2.5
	Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9E2 (Bray 1)	2.0	2.9	3.3	2.7	3.7
		**Rayment & Lyons 2011 - 9B2 (Colwell)	4.3	10	7.2	8.2	9.2
		**Inhouse S3A (Bray 2)	3.1	4.6	4.3	4.7	3.7
	Nitrate Nitrogen (mg/kg N)	**Inhouse S37 (KCl)	16	10	6.6	8.6	14
	Ammonium Nitrogen (mg/kg N)		6.0	4.7	3.8	3.6	5.1
	Sulfur (mg/kg S)		13	8.5	12	28	10
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.76	6.20	5.68	5.66	5.54
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.063	0.083	0.071	0.087	0.062
	Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	5.3	7.5	4.6	7.9	5.1
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	4.32	11.16	3.17	7.61	4.05
	Exchangeable Calcium (kg/ha)		1937	5011	1424	3416	1819
	Exchangeable Calcium (mg/kg)		865	2237	636	1525	812
	Exchangeable Magnesium (cmol+/kg)		2.06	4.85	2.24	3.36	1.92
	Exchangeable Magnesium (kg/ha)		560	1320	608	913	522
	Exchangeable Magnesium (mg/kg)		250	589	272	408	233
	Exchangeable Potassium (cmol+/kg)		0.43	0.98	0.59	0.87	0.48
	Exchangeable Potassium (kg/ha)		378	859	516	760	417
	Exchangeable Potassium (mg/kg)		169	384	230	339	186
	Exchangeable Sodium (cmol+/kg)		0.07	0.31	0.26	0.35	0.16
	Exchangeable Sodium (kg/ha)		35	158	132	178	82
	Exchangeable Sodium (mg/kg)		16	70	59	80	37
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	<0.01	0.13	0.09	0.09	0.12
	Exchangeable Aluminium (kg/ha)		<1	27	19	17	24
	Exchangeable Aluminium (mg/kg)		<1	12	8	8	11
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.04	<0.01	<0.01	<0.01	<0.01
	Exchangeable Hydrogen (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	6.91	17.43	6.34	12.27	6.72
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	62.5	64.0	50.0	62.0	60.3
	Magnesium (%)		29.8	27.8	35.2	27.4	28.5
	Potassium (%)		6.3	5.6	9.3	7.1	7.1
	Sodium - ESP (%)		1.0	1.8	4.0	2.8	2.4
	Aluminium (%)		0.0	0.8	1.5	0.7	1.8
	Hydrogen		0.5	0.0	0.0	0.0	0.0
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	2.1	2.3	1.4	2.3	2.1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 42	Sample 43	Sample 44	Sample 45	Sample 46
	Sample ID:		WAMBOSPOT01	WAMBOSPOT02	WAMBOSPOT03	WARKGB01	WARKGB02
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/42	I2408/43	I2408/44	I2408/45	I2408/46
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	1.4	2.9	1.1	5.3	3.4
	Manganese (mg/kg)		39	18	21	19	21
	Iron (mg/kg)		59	37	123	203	256
	Copper (mg/kg)		0.2	0.4	0.2	0.5	0.3
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.40	0.47	0.43	0.64	0.51
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	21	23	31	49	32
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	3.03	4.31	2.65	4.54	2.92
	Total Nitrogen (%)		0.15	0.23	0.14	0.27	0.19
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	20.9	18.8	19.3	17.0	15.7
	Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam
	Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	40	53	45	55	40
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	1,450	3,406	991	2,175	1,160
	Total Magnesium (mg/kg)		597	1,561	511	1,200	720
	Total Potassium (mg/kg)		876	1,946	735	1,500	1,220
	Total Sodium (mg/kg)		<50	159	95	174	120
	Total Sulfur (mg/kg)		137	192	112	274	168
	Total Phosphorus (mg/kg)		141	289	135	288	175
	Total Zinc (mg/kg)		20	73	9	54	24
	Total Manganese (mg/kg)		934	653	315	438	414
	Total Iron (mg/kg)		13,304	38,255	15,353	22,907	10,065
	Total Copper (mg/kg)		5.0	13.8	2.5	9.1	4.7
	Total Boron (mg/kg)		2.2	3.5	<2	2.9	2.6
	Total Silicon (mg/kg)		1,937	3,024	1,573	2,808	2,346
	Total Aluminium (mg/kg)		4,014	7,486	4,222	7,378	5,376
	Total Molybdenum (mg/kg)		<0.2	0.9	0.4	0.7	0.2
	Total Cobalt (mg/kg)		9.7	16.3	6.5	6.3	6.1
	Total Selenium (mg/kg)		<0.5	<0.5	<0.5	0.6	<0.5
	Total Cadmium (mg/kg)		<0.5	<0.5	<0.5	<0.5	<0.5
	Total Lead (mg/kg)		7.7	19	7.8	13	9.2
	Total Arsenic (mg/kg)		<2	14.6	2.4	7.2	3.1
	Total Chromium (mg/kg)		11	7.1	11	9.8	6.5
	Total Nickel (mg/kg)		9.4	13	3.7	9.7	4.6
	Total Mercury (mg/kg)		<0.1	<0.1	<0.1	<0.1	<0.1
	Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

		Sample ID:	Sample 42 WAMBOSPOT01	Sample 43 WAMBOSPOT02	Sample 44 WAMBOSPOT03	Sample 45 WARKGB01	Sample 46 WARKGB02
		Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
		Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Parameter	Method reference	I2408/42	I2408/43	I2408/44	I2408/45	I2408/46

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408
Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

			Sample 47	Sample 48	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
		Sample ID:	**WARKGB03**	**WARKGB04**				
		Crop:	**Rehab Natives**	**Rehab Natives**				
		Client:	**MTW Mine**	**MTW Mine**	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
	Parameter	**Method reference**	**I2408/47**	**I2408/48**	**Indicative guidelines - refer to Notes 6 and 8**			
	Soluble Calcium (mg/kg)		230	369	*1150*	*750*	*375*	*175*
	Soluble Magnesium (mg/kg)	**Inhouse S10 - Morgan 1	151	378	*160*	*105*	*60*	*25*
	Soluble Potassium (mg/kg)		102	115	*113*	*75*	*60*	*50*
	Soluble Phosphorus (mg/kg)		1.9	2.9	*15*	*12*	*10*	*5.0*
	Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9E2 (Bray 1)	1.8	7.7	*45 note 8*	*30 note 8*	*24 note 8*	*20 note 8*
		**Rayment & Lyons 2011 - 9B2 (Colwell)	4.9	15	*80*	*50*	*45*	*35*
		**Inhouse S3A (Bray 2)	2.1	9.2	*90 note 8*	*60 note 8*	*48 note 8*	*40 note 8*
	Nitrate Nitrogen (mg/kg N)		3.9	12	*15*	*13*	*10*	*10*
	Ammonium Nitrogen (mg/kg N)	**Inhouse S37 (KCl)	7.9	5.3	*20*	*18*	*15*	*12*
	Sulfur (mg/kg S)		16	17	*10.0*	*8.0*	*8.0*	*7.0*
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.57	5.45	*6.5*	*6.5*	*6.3*	*6.3*
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.065	0.150	*0.200*	*0.150*	*0.120*	*0.100*
	Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	3.9	6.4	*> 5.5*	*>4 .5*	*> 3.5*	*> 2.5*
	Exchangeable Calcium **(cmol+/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	2.21	3.86	*15.6*	*10.8*	*5.0*	*1.9*
	Exchangeable Calcium **(kg/ha)**		994	1733	*7000*	*4816*	*2240*	*840*
	Exchangeable Calcium **(mg/kg)**		444	774	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium **(cmol+/kg)**		1.74	4.91	*2.4*	*1.7*	*1.2*	*0.60*
	Exchangeable Magnesium **(kg/ha)**		475	1337	*650*	*448*	*325*	*168*
	Exchangeable Magnesium **(mg/kg)**		212	597	*290*	*200*	*145*	*75*
	Exchangeable Potassium **(cmol+/kg)**		0.39	0.54	*0.60*	*0.50*	*0.40*	*0.30*
	Exchangeable Potassium **(kg/ha)**		342	476	*526*	*426*	*336*	*224*
	Exchangeable Potassium **(mg/kg)**		153	213	*235*	*190*	*150*	*100*
	Exchangeable Sodium **(cmol+/kg)**		0.26	0.77	*0.3*	*0.26*	*0.22*	*0.11*
	Exchangeable Sodium **(kg/ha)**		134	399	*155*	*134*	*113*	*57*
	Exchangeable Sodium **(mg/kg)**		60	178	*69*	*60*	*51*	*25*
	Exchangeable Aluminium **(cmol+/kg)**	**Inhouse S37 (KCl)	0.10	0.06	*0.6*	*0.5*	*0.4*	*0.2*
	Exchangeable Aluminium **(kg/ha)**		20	12	*121*	*101*	*73*	*30*
	Exchangeable Aluminium **(mg/kg)**		9	5	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen **(cmol+/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	0.04	*0.6*	*0.5*	*0.4*	*0.2*
	Exchangeable Hydrogen **(kg/ha)**		<1	<1	*13*	*11*	*8*	*3*
	Exchangeable Hydrogen **(mg/kg)**		<1	<1	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	4.71	10.19	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	47.0	37.9	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)		37.0	48.2	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)		8.3	5.3	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP (%)		5.5	7.6	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium (%)		2.1	0.6	*6.0*	*7.1*	*10.5*	*12.1*
	Hydrogen		0.0	0.4				
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	1.3	0.8	*6.5*	*6.4*	*4.2*	*3.2*

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

			Sample 47	Sample 48	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
		Sample ID:	**WARKGB03**	**WARKGB04**				
		Crop:	**Rehab Natives**	**Rehab Natives**				
		Client:	**MTW Mine**	**MTW Mine**	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
	Parameter	**Method reference**	**I2408/47**	**I2408/48**	**Indicative guidelines - refer to Notes 6 and 8**			
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	1.3	3.6	*6.0*	*5.0*	*4.0*	*3.0*
	Manganese (mg/kg)		13	17	*25*	*22*	*18*	*15*
	Iron (mg/kg)		187	376	*25*	*22*	*18*	*15*
	Copper (mg/kg)		0.2	0.3	*2.4*	*2.0*	*1.6*	*1.2*
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.49	0.67	*2.0*	*1.7*	*1.4*	*1.0*
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	24	34	*50*	*45*	*40*	*35*
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	2.20	3.66	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
	Total Nitrogen (%)		0.12	0.21	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	19.0	17.3	*10–12*	*10–12*	*10–12*	*10–12*
	Basic Texture	**Inhouse S65	Loam	Loam	..	..	..	..
	Basic Colour		Brownish	Brownish	..	..	..	..
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	41	96	..	..	..	..
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	599	1,325	*1000–10 000 Ca*			
	Total Magnesium (mg/kg)		446	1,064	*500–5000 Mg*			
	Total Potassium (mg/kg)		642	746	*200–2000 K*			
	Total Sodium (mg/kg)		124	230	*100–500 Na*			
	Total Sulfur (mg/kg)		126	232	*100–1000 S*			
	Total Phosphorus (mg/kg)		103	193	*400–1500 P*			
	Total Zinc (mg/kg)		8	20	*20–50 Zn*			
	Total Manganese (mg/kg)		122	197	*200–2000 Mn*			
	Total Iron (mg/kg)		7,296	7,659	*1000–50 000 Fe*			
	Total Copper (mg/kg)		2.4	5.4	*20–50 Cu*			
	Total Boron (mg/kg)		<2	2.8	*2–50 B*			
	Total Silicon (mg/kg)		1,682	1,682	*1000–3000 Si*			
	Total Aluminium (mg/kg)		3,428	6,334	*2000–50 000 Al*			
	Total Molybdenum (mg/kg)		0.5	0.3	*0.5–3.0 Mo*			
	Total Cobalt (mg/kg)		2.5	4.0	*5–50 Co*			
	Total Selenium (mg/kg)		<0.5	0.5	*0.1–2.0 Se*			
	Total Cadmium (mg/kg)		<0.5	<0.5	*<1 Cd*			
	Total Lead (mg/kg)		5.3	9.0	*2–200 Pb*			
	Total Arsenic (mg/kg)		2.5	3.9	*1–50 As*			
	Total Chromium (mg/kg)		4.5	6.7	*5–1000 Cr*			
	Total Nickel (mg/kg)		2.6	3.8	*5–500 Ni*			
	Total Mercury (mg/kg)		<0.1	<0.1	*< 0.2 Hg*			
	Total Silver (mg/kg)		<1	<1	*.. Ag*			

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
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AGRICULTURAL SOIL ANALYSIS REPORT

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Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

		Sample 47	Sample 48	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
	Sample ID:	**WARKGB03**	**WARKGB04**				
	Crop:	**Rehab Natives**	**Rehab Natives**				
	Client:	**MTW Mine**	**MTW Mine**	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
Parameter	**Method reference**	**I2408/47**	**I2408/48**	**Indicative guidelines - refer to Notes 6 and 8**			

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter		Method reference	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
	Sample ID:			MTWCDD201101	MTWCDD201301	MTWCDD201401	MTWCDD201501	MTWCDD201701
	Crop:			Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:			MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
				I2408/4	I2408/5	I2408/6	I2408/7	I2408/8
	Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	494	1450	988	1003	783
	Soluble Magnesium (mg/kg)			421	356	404	351	385
	Soluble Potassium (mg/kg)			132	311	274	104	92
	Soluble Phosphorus (mg/kg)			1.3	24	11	8.9	2.3
	Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	<1	21	17	17	3.5
			**Rayment & Lyons 2011 - 9B2 (Colwell)	6.6	83	70	43	11
			**Inhouse S3A (Bray 2)	4.5	181	88	152	15
	Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	5.1	37	2.0	2.4	30
	Ammonium Nitrogen (mg/kg N)			6.6	6.3	5.8	4.3	6.0
	Sulfur (mg/kg S)			38	88	13	22	439
	pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.34	7.48	7.14	8.09	6.52
	Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.112	0.326	0.103	0.091	0.855
	Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	5.3	6.5	6.5	4.9	2.8
	Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	4.59	10.81	8.49	6.66	5.88
		(kg/ha)		2059	4853	3809	2988	2638
		(mg/kg)		919	2167	1701	1334	1178
	Exchangeable Magnesium	(cmol+/kg)		5.67	3.89	4.83	4.04	4.11
		(kg/ha)		1544	1058	1315	1099	1120
		(mg/kg)		689	472	587	491	500
	Exchangeable Potassium	(cmol+/kg)		0.72	1.40	1.22	0.39	0.39
		(kg/ha)		631	1225	1069	344	340
		(mg/kg)		282	547	477	154	152
	Exchangeable Sodium	(cmol+/kg)		0.87	1.39	0.27	0.31	1.63
		(kg/ha)		450	717	138	161	839
		(mg/kg)		201	320	61	72	374
	Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	0.05	0.04	0.04	0.07	0.09
		(kg/ha)		10	9	8	13	18
		(mg/kg)		5	4	3	6	8
	Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	<0.01
		(kg/ha)		<1	<1	<1	<1	<1
		(mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	11.90	17.53	14.84	11.46	12.10
	Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	38.5	61.7	57.2	58.1	48.6
	Magnesium (%)			47.6	22.2	32.5	35.2	34.0
	Potassium (%)			6.0	8.0	8.2	3.4	3.2
	Sodium - ESP (%)			7.3	7.9	1.8	2.7	13.5
	Aluminium (%)			0.4	0.2	0.3	0.6	0.7
	Hydrogen			0.0	0.0	0.0	0.0	0.0
	Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	0.8	2.8	1.8	1.6	1.4

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
	Sample ID:		MTWCDD201101	MTWCDD201301	MTWCDD201401	MTWCDD201501	MTWCDD201701
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/4	I2408/5	I2408/6	I2408/7	I2408/8
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	2.6	17	12	12	2.2
	Manganese (mg/kg)		7.2	9.1	4.5	0.8	13
	Iron (mg/kg)		80	26	26	17	53
	Copper (mg/kg)		0.8	1.9	1.6	2.1	0.4
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.54	0.55	0.46	0.29	0.48
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	47	31	28	13	31
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	3.00	3.69	3.71	2.78	1.58
	Total Nitrogen (%)		0.15	0.26	0.24	0.15	0.10
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	20.3	14.3	15.7	19.0	16.3
	Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam
	Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	71	209	66	58	547
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	1,401	4,633	3,170	7,802	1,930
	Total Magnesium (mg/kg)		1,296	1,457	1,531	3,375	1,291
	Total Potassium (mg/kg)		1,158	1,591	1,547	1,182	931
	Total Sodium (mg/kg)		260	426	157	197	526
	Total Sulfur (mg/kg)		184	457	240	167	520
	Total Phosphorus (mg/kg)		125	530	363	439	100
	Total Zinc (mg/kg)		38	84	67	81	27
	Total Manganese (mg/kg)		184	181	178	220	113
	Total Iron (mg/kg)		17,112	15,867	16,520	13,458	7,339
	Total Copper (mg/kg)		8.7	24.8	18.7	19.6	5.3
	Total Boron (mg/kg)		3.5	4.5	<2	<2	<2
	Total Silicon (mg/kg)		1,017	901	850	832	1,030
	Total Aluminium (mg/kg)		7,445	6,171	6,014	3,607	5,225
	Total Molybdenum (mg/kg)		0.7	1.0	0.6	0.5	0.3
	Total Cobalt (mg/kg)		7.4	6.1	7.3	8.8	3.9
	Total Selenium (mg/kg)		0.7	<0.5	0.6	<0.5	<0.5
	Total Cadmium (mg/kg)		<0.5	<0.5	<0.5	<0.5	<0.5
	Total Lead (mg/kg)		13	25	19	17	8.0
	Total Arsenic (mg/kg)		5.2	5.2	5.8	4.8	2.5
	Total Chromium (mg/kg)		8.6	8.8	7.3	5.1	3.7
	Total Nickel (mg/kg)		7.4	8.4	7.9	11.7	4.0
	Total Mercury (mg/kg)		<0.1	<0.1	<0.1	<0.1	<0.1
	Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

		Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
Sample ID:		MTWCDD201101	MTWCDD201301	MTWCDD201401	MTWCDD201501	MTWCDD201701
Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Parameter	**Method reference**	I2408/4	I2408/5	I2408/6	I2408/7	I2408/8

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium,
122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal).

Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

			Sample 9	Sample 10	Sample 11	Sample 12	Sample 13
		Sample ID:	MTWCDD201702	MTWCDD201801	MTWMTO021803	MTWMTO201601	MTWMTO201701
		Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
		Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Parameter	**Method reference**	**I2408/9**	**I2408/10**	**I2408/11**	**I2408/12**	**I2408/13**
	Soluble Calcium (mg/kg)		1097	1336	4578	1796	3077
	Soluble Magnesium (mg/kg)	**Inhouse S10 - Morgan 1	317	440	213	544	197
	Soluble Potassium (mg/kg)		204	245	270	284	215
	Soluble Phosphorus (mg/kg)		9.2	13	65	21	41
	Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9E2 (Bray 1)	35	33	125	55	118
		**Rayment & Lyons 2011 - 9B2 (Colwell)	70	76	423	88	264
		**Inhouse S3A (Bray 2)	94	104	678	181	541
	Nitrate Nitrogen (mg/kg N)		14	29	38	188	74
	Ammonium Nitrogen (mg/kg N)	**Inhouse S37 (KCl)	5.7	20	12	3.5	9.0
	Sulfur (mg/kg S)		145	359	97	487	423
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.86	6.55	8.11	7.72	7.80
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.384	0.829	0.512	1.183	1.037
	Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	4.4	6.3	18.6	5.0	16.2
	Exchangeable Calcium	**(cmol$_+$/kg)	7.34	9.94	18.90	11.18	17.80
		**(kg/ha)	3294	4460	8483	5017	7991
		**(mg/kg)	1470	1991	3787	2240	3567
	Exchangeable Magnesium	**(cmol$_+$/kg)	3.36	4.58	1.71	5.42	1.87
		**(kg/ha)	915	1248	465	1474	510
		**(mg/kg)	408	557	207	658	228
	Exchangeable Potassium	**(cmol$_+$/kg)	0.82	1.12	1.45	1.20	1.04
		**(kg/ha)	719	982	1269	1052	913
		**(mg/kg)	321	438	566	470	408
	Exchangeable Sodium	**(cmol$_+$/kg)	0.92	2.54	5.40	3.88	6.84
		**(kg/ha)	474	1310	2782	2000	3524
		**(mg/kg)	212	585	1242	893	1573
	Exchangeable Aluminium	**(cmol$_+$/kg)	0.03	0.04	0.08	0.09	0.02
		**(kg/ha)	5	9	16	18	4
		**(mg/kg)	2	4	7	8	2
	Exchangeable Hydrogen	**(cmol$_+$/kg)	<0.01	<0.01	<0.01	<0.01	<0.01
		**(kg/ha)	<1	<1	<1	<1	<1
		**(mg/kg)	<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	12.46	18.23	27.53	21.77	27.58
	Calcium (%)		58.9	54.5	68.6	51.3	64.5
	Magnesium (%)		27.0	25.1	6.2	24.9	6.8
	Potassium (%)	**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	6.6	6.2	5.3	5.5	3.8
	Sodium - ESP (%)		7.4	14.0	19.6	17.8	24.8
	Aluminium (%)		0.2	0.2	0.3	0.4	0.1
	Hydrogen		0.0	0.0	0.0	0.0	0.0
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol$_+$/kg)	2.2	2.2	11.1	2.1	9.5

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 9	Sample 10	Sample 11	Sample 12	Sample 13
	Sample ID:		MTWCDD201702	MTWCDD201801	MTWMTO021803	MTWMTO201601	MTWMTO201701
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/9	I2408/10	I2408/11	I2408/12	I2408/13
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	12	32	127	12	54
	Manganese (mg/kg)		5.2	19	16	2.1	8.1
	Iron (mg/kg)		44	59	47	18	63
	Copper (mg/kg)		1.4	4.3	18.2	1.2	7.4
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.58	0.70	0.81	0.42	0.65
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	24	31	24	13	19
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	2.49	3.62	10.60	2.87	9.27
	Total Nitrogen (%)		0.18	0.25	0.65	0.25	0.61
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	14.0	14.7	16.3	11.6	15.3
	Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam
	Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	245	530	328	757	663
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	2,925	4,148	13,029	5,107	15,311
	Total Magnesium (mg/kg)		1,164	1,221	2,421	1,810	4,544
	Total Potassium (mg/kg)		1,137	1,197	1,630	1,313	1,670
	Total Sodium (mg/kg)		293	705	2,117	1,249	4,104
	Total Sulfur (mg/kg)		379	650	593	737	1,007
	Total Phosphorus (mg/kg)		280	436	1,431	411	1,650
	Total Zinc (mg/kg)		46	137	324	69	216
	Total Manganese (mg/kg)		99	184	274	147	332
	Total Iron (mg/kg)		7,618	12,333	11,739	9,569	18,590
	Total Copper (mg/kg)		14.3	49.9	101.4	21.0	3,038.8
	Total Boron (mg/kg)		5.4	<2	4.3	<2	3.9
	Total Silicon (mg/kg)		641	423	1,036	957	1,317
	Total Aluminium (mg/kg)		4,877	5,701	4,586	4,750	6,235
	Total Molybdenum (mg/kg)		0.5	0.6	1.0	0.4	0.8
	Total Cobalt (mg/kg)		3.9	5.7	8.0	4.4	13.0
	Total Selenium (mg/kg)		0.6	0.6	<0.5	<0.5	<0.5
	Total Cadmium (mg/kg)		<0.5	0.9	2.6	<0.5	0.9
	Total Lead (mg/kg)		14	31	98	17	41
	Total Arsenic (mg/kg)		2.8	5.6	4.4	4.4	5.4
	Total Chromium (mg/kg)		4.7	9.5	14	6.1	15
	Total Nickel (mg/kg)		5.2	8.8	17	6.8	22
	Total Mercury (mg/kg)		<0.1	<0.1	0.2	<0.1	0.1
	Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

		Sample 9	Sample 10	Sample 11	Sample 12	Sample 13
	Sample ID:	MTWCDD201702	MTWCDD201801	MTWMTO021803	MTWMTO201601	MTWMTO201701
	Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Parameter	Method reference	I2408/9	I2408/10	I2408/11	I2408/12	I2408/13
Notes:							

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18
	Sample ID:		MTWMTO201702	MTWMTO201703	MTWMTO201704	MTWMTO201801	MTWMTO201802
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/14	I2408/15	I2408/16	I2408/17	I2408/18
	Soluble Calcium (mg/kg)	**Inhouse S10 - Morgan 1	2283	1480	1016	698	3548
	Soluble Magnesium (mg/kg)		329	468	375	335	566
	Soluble Potassium (mg/kg)		251	177	173	138	226
	Soluble Phosphorus (mg/kg)		52	5.4	7.7	2.2	12
	Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9E2 (Bray 1)	107	24	26	6.3	37
		**Rayment & Lyons 2011 - 9B2 (Colwell)	181	39	51	16	81
		**Inhouse S3A (Bray 2)	408	60	71	6.8	139
	Nitrate Nitrogen (mg/kg N)	**Inhouse S37 (KCl)	14	27	39	55	144
	Ammonium Nitrogen (mg/kg N)		6.6	3.2	3.7	5.7	7.1
	Sulfur (mg/kg S)		191	151	184	58	688
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.55	8.29	6.86	6.34	7.54
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.395	0.366	0.486	0.222	1.251
	Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	9.9	4.7	3.5	3.8	9.7
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	14.70	9.23	7.94	6.26	17.39
	Exchangeable Calcium (kg/ha)		6601	4143	3563	2809	7807
	Exchangeable Calcium (mg/kg)		2947	1850	1591	1254	3485
	Exchangeable Magnesium (cmol+/kg)		3.36	4.93	4.23	4.18	5.03
	Exchangeable Magnesium (kg/ha)		915	1341	1152	1137	1371
	Exchangeable Magnesium (mg/kg)		408	599	514	508	612
	Exchangeable Potassium (cmol+/kg)		1.16	0.77	0.78	0.70	1.12
	Exchangeable Potassium (kg/ha)		1019	678	682	616	985
	Exchangeable Potassium (mg/kg)		455	303	304	275	440
	Exchangeable Sodium (cmol+/kg)		2.29	1.77	1.53	0.79	1.96
	Exchangeable Sodium (kg/ha)		1181	913	788	406	1007
	Exchangeable Sodium (mg/kg)		527	407	352	181	450
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	0.10	0.05	0.07	0.04	0.06
	Exchangeable Aluminium (kg/ha)		20	11	13	8	12
	Exchangeable Aluminium (mg/kg)		9	5	6	3	5
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Hydrogen (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	21.62	16.76	14.54	11.96	25.57
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	68.0	55.1	54.6	52.3	68.0
	Magnesium (%)		15.5	29.4	29.1	34.9	19.7
	Potassium (%)		5.4	4.6	5.4	5.9	4.4
	Sodium - ESP (%)		10.6	10.6	10.5	6.6	7.6
	Aluminium (%)		0.5	0.3	0.5	0.3	0.2
	Hydrogen		0.0	0.0	0.0	0.0	0.0
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	4.4	1.9	1.9	1.5	3.5

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
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55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

		Sample 14	Sample 15	Sample 16	Sample 17	Sample 18
	Sample ID:	MTWMTO201702	MTWMTO201703	MTWMTO201704	MTWMTO201801	MTWMTO201802
	Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
Parameter	Method reference	I2408/14	I2408/15	I2408/16	I2408/17	I2408/18
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	26	7.0	10	3.0	31
Manganese (mg/kg)		6.1	2.1	6.6	14	6.3
Iron (mg/kg)		42	18	58	57	15
Copper (mg/kg)		2.6	1.4	1.3	0.6	6.0
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.72	0.37	0.52	0.35	0.60
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	26	9	24	39	18
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	5.64	2.70	1.98	2.15	5.55
Total Nitrogen (%)		0.49	0.15	0.15	0.16	0.33
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	11.5	18.1	13.0	13.9	16.8
Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam
Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	253	234	311	142	800
Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	8,262	4,737	3,498	6,637	10,639
Total Magnesium (mg/kg)		1,450	2,224	1,372	1,356	2,582
Total Potassium (mg/kg)		1,330	1,197	992	1,292	1,621
Total Sodium (mg/kg)		733	677	404	247	607
Total Sulfur (mg/kg)		739	293	328	194	901
Total Phosphorus (mg/kg)		1,041	204	465	169	734
Total Zinc (mg/kg)		109	58	48	32	138
Total Manganese (mg/kg)		187	556	161	273	264
Total Iron (mg/kg)		19,270	18,149	11,727	13,030	17,953
Total Copper (mg/kg)		37.0	14.3	11.9	6.2	70.0
Total Boron (mg/kg)		2.5	<2	3.0	<2	2.7
Total Silicon (mg/kg)		874	904	675	820	797
Total Aluminium (mg/kg)		5,774	4,948	5,711	7,973	7,062
Total Molybdenum (mg/kg)		0.9	0.7	0.5	0.4	1.5
Total Cobalt (mg/kg)		5.7	6.7	4.2	6.9	8.6
Total Selenium (mg/kg)		0.6	<0.5	<0.5	<0.5	0.7
Total Cadmium (mg/kg)		<0.5	<0.5	<0.5	<0.5	1.1
Total Lead (mg/kg)		26	16	15	10	27
Total Arsenic (mg/kg)		7.0	6.5	4.3	4.6	5.6
Total Chromium (mg/kg)		9.0	6.0	6.6	7.5	74
Total Nickel (mg/kg)		9.4	7.5	5.2	6.3	52
Total Mercury (mg/kg)		<0.1	<0.1	<0.1	<0.1	<0.1
Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18
	Sample ID:		MTWMTO201702	MTWMTO201703	MTWMTO201704	MTWMTO201801	MTWMTO201802
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/14	I2408/15	I2408/16	I2408/17	I2408/18

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

			Sample 53	Sample 19	Sample 20	Sample 21	Sample 22
		Sample ID:	MTWNPN200901	MTWNPN201101	MTWNPN201301	MTWNPN201401	MTWNPN201602
		Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
		Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Parameter	**Method reference**	**I2408/53**	**I2408/19**	**I2408/20**	**I2408/21**	**I2408/22**
	Soluble Calcium (mg/kg)	**Inhouse S10 - Morgan 1	707	915	917	702	831
	Soluble Magnesium (mg/kg)		432	451	260	325	712
	Soluble Potassium (mg/kg)		162	165	180	165	142
	Soluble Phosphorus (mg/kg)		2.3	2.4	5.1	3.3	3.9
	Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9E2 (Bray 1)	1.3	2.9	17	14	22
		**Rayment & Lyons 2011 - 9B2 (Colwell)	11	7.5	29	31	43
		**Inhouse S3A (Bray 2)	5.8	21	36	41	73
	Nitrate Nitrogen (mg/kg N)	**Inhouse S37 (KCl)	13	12	6.7	3.2	34
	Ammonium Nitrogen (mg/kg N)		5.8	5.5	4.2	4.0	8.4
	Sulfur (mg/kg S)		45	46	184	15	383
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.31	7.25	6.54	6.69	6.76
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.104	0.099	0.379	0.066	0.704
	Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	5.1	4.5	3.6	3.9	4.8
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	7.04	7.87	6.87	6.70	8.41
	Exchangeable Calcium (kg/ha)		3161	3534	3083	3008	3774
	Exchangeable Calcium (mg/kg)		1411	1577	1377	1343	1685
	Exchangeable Magnesium (cmol+/kg)		5.90	5.70	2.84	4.26	9.95
	Exchangeable Magnesium (kg/ha)		1606	1553	772	1160	2708
	Exchangeable Magnesium (mg/kg)		717	693	345	518	1209
	Exchangeable Potassium (cmol+/kg)		0.87	0.82	0.71	0.78	0.61
	Exchangeable Potassium (kg/ha)		765	714	626	687	536
	Exchangeable Potassium (mg/kg)		342	319	279	307	239
	Exchangeable Sodium (cmol+/kg)		0.40	0.15	0.83	0.28	3.83
	Exchangeable Sodium (kg/ha)		206	78	426	143	1972
	Exchangeable Sodium (mg/kg)		92	35	190	64	880
	Exchangeable Aluminium (cmol+/kg)	**Inhouse S37 (KCl)	0.07	0.08	0.06	<0.01	0.06
	Exchangeable Aluminium (kg/ha)		13	15	12	<1	12
	Exchangeable Aluminium (mg/kg)		6	7	5	<1	5
	Exchangeable Hydrogen (cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Hydrogen (kg/ha)		<1	<1	<1	<1	<1
	Exchangeable Hydrogen (mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	14.28	14.62	11.31	12.02	22.85
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	49.3	53.9	60.7	55.7	36.8
	Magnesium (%)		41.3	39.0	25.1	35.4	43.5
	Potassium (%)		6.1	5.6	6.3	6.5	2.7
	Sodium - ESP (%)		2.8	1.0	7.3	2.3	16.8
	Aluminium (%)		0.5	0.5	0.5	0.0	0.3
	Hydrogen		0.0	0.0	0.0	0.0	0.0
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	1.2	1.4	2.4	1.6	0.8

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 53	Sample 19	Sample 20	Sample 21	Sample 22
	Sample ID:		MTWNPN200901	MTWNPN201101	MTWNPN201301	MTWNPN201401	MTWNPN201602
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/53	I2408/19	I2408/20	I2408/21	I2408/22
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	3.2	4.3	7.8	9.8	15
	Manganese (mg/kg)		5.8	5.3	4.9	5.9	9.0
	Iron (mg/kg)		71	18	39	55	29
	Copper (mg/kg)		0.8	0.9	1.1	1.6	2.4
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.46	0.31	0.36	0.53	0.55
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	51	31	34	35	28
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	2.91	2.57	2.05	2.20	2.77
	Total Nitrogen (%)		0.16	0.14	0.14	0.14	0.15
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	18.0	18.2	14.7	15.3	19.1
	Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam
	Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	67	63	243	42	450
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	2,131	3,172	2,050	1,920	2,760
	Total Magnesium (mg/kg)		1,678	1,926	785	978	2,049
	Total Potassium (mg/kg)		1,546	1,355	898	1,005	1,035
	Total Sodium (mg/kg)		155	105	223	108	916
	Total Sulfur (mg/kg)		214	177	363	186	526
	Total Phosphorus (mg/kg)		174	274	202	218	249
	Total Zinc (mg/kg)		56	42	38	44	74
	Total Manganese (mg/kg)		235	209	87	141	77
	Total Iron (mg/kg)		22,384	14,925	6,978	11,075	13,126
	Total Copper (mg/kg)		11.2	9.2	10.7	13.8	24.6
	Total Boron (mg/kg)		<2	<2	<2	<2	<2
	Total Silicon (mg/kg)		1,956	653	701	629	497
	Total Aluminium (mg/kg)		9,290	7,600	4,339	6,030	5,159
	Total Molybdenum (mg/kg)		0.9	0.7	0.6	0.5	0.6
	Total Cobalt (mg/kg)		8.0	7.9	3.1	4.6	4.3
	Total Selenium (mg/kg)		0.9	0.7	<0.5	0.6	<0.5
	Total Cadmium (mg/kg)		<0.5	<0.5	<0.5	<0.5	<0.5
	Total Lead (mg/kg)		14	8.8	19	14	23
	Total Arsenic (mg/kg)		5.3	4.7	2.8	4.0	4.0
	Total Chromium (mg/kg)		8.5	7.0	4.3	6.1	6.2
	Total Nickel (mg/kg)		8.4	8.3	4.7	5.9	8.1
	Total Mercury (mg/kg)		<0.1	<0.1	<0.1	<0.1	<0.1
	Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

		Sample 53	Sample 19	Sample 20	Sample 21	Sample 22
	Sample ID:	MTWNPN200901	MTWNPN201101	MTWNPN201301	MTWNPN201401	MTWNPN201602
	Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Parameter / Method reference	I2408/53	I2408/19	I2408/20	I2408/21	I2408/22

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

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Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter		Method reference	Sample 23	Sample 24	Sample 25	Sample 26	Sample 27
	Sample ID:			MTWNPN201701	MTWNPN201702	MTWNPN201703	MTWNPN201801	MTWNPN201802
	Crop:			Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:			MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	1113	749	1482	1535	794
	Soluble Magnesium (mg/kg)			453	431	648	221	213
	Soluble Potassium (mg/kg)			211	143	250	264	146
	Soluble Phosphorus (mg/kg)			8.9	3.2	15	31	10
	Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	32	11	43	77	30
			**Rayment & Lyons 2011 - 9B2 (Colwell)	95	16	102	148	45
			**Inhouse S3A (Bray 2)	103	78	150	246	97
	Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	15	20	104	6.7	17
	Ammonium Nitrogen (mg/kg N)			4.8	6.8	3.1	4.5	2.9
	Sulfur (mg/kg S)			139	204	354	57	100
	pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.98	8.08	7.37	7.42	6.78
	Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.338	0.692	0.941	0.245	0.272
	Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	5.7	2.9	5.1	6.2	3.9
	Exchangeable Calcium	**(cmol$_+$/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	9.79	6.34	11.47	10.91	5.80
		(kg/ha)		4395	2847	5151	4896	2602
		(mg/kg)		1962	1271	2299	2186	1161
	Exchangeable Magnesium	**(cmol$_+$/kg)**		5.82	5.82	7.62	2.43	2.35
		(kg/ha)		1583	1584	2074	661	640
		(mg/kg)		707	707	926	295	286
	Exchangeable Potassium	**(cmol$_+$/kg)**		1.11	0.72	1.32	1.11	0.61
		(kg/ha)		970	631	1154	970	537
		(mg/kg)		433	282	515	433	240
	Exchangeable Sodium	**(cmol$_+$/kg)**		1.08	4.07	3.15	1.00	0.64
		(kg/ha)		558	2096	1623	513	329
		(mg/kg)		249	936	724	229	147
	Exchangeable Aluminium	**(cmol$_+$/kg)**	**Inhouse S37 (KCl)	0.04	0.05	0.08	0.09	0.05
		(kg/ha)		7	9	15	18	11
		(mg/kg)		3	4	7	8	5
	Exchangeable Hydrogen	**(cmol$_+$/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	<0.01
		(kg/ha)		<1	<1	<1	<1	<1
		(mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	17.84	17.00	23.64	15.53	9.45
	Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	54.9	37.3	48.5	70.2	61.3
	Magnesium (%)			32.6	34.2	32.2	15.6	24.9
	Potassium (%)			6.2	4.2	5.6	7.1	6.5
	Sodium - ESP (%)			6.1	23.9	13.3	6.4	6.8
	Aluminium (%)			0.2	0.3	0.3	0.6	0.6
	Hydrogen			0.0	0.0	0.0	0.0	0.0
	Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol$_+$/kg)	1.7	1.1	1.5	4.5	2.5

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

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Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 23	Sample 24	Sample 25	Sample 26	Sample 27
	Sample ID:		MTWNPN201701	MTWNPN201702	MTWNPN201703	MTWNPN201801	MTWNPN201802
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/23	I2408/24	I2408/25	I2408/26	I2408/27
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	14	4.3	17	49	16
	Manganese (mg/kg)		8.8	2.9	10.3	7.8	4.2
	Iron (mg/kg)		69	10	53	69	46
	Copper (mg/kg)		1.8	1.9	1.9	5.8	2.3
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.67	0.40	0.84	0.95	0.62
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	20	24	20	30	29
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	3.23	1.64	2.91	3.55	2.21
	Total Nitrogen (%)		0.23	0.08	0.24	0.26	0.14
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	14.0	20.8	12.2	13.4	15.5
	Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam
	Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	216	443	602	157	174
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	3,971	2,590	3,765	5,008	2,172
	Total Magnesium (mg/kg)		1,693	1,758	1,757	660	1,015
	Total Potassium (mg/kg)		1,406	1,362	1,473	829	914
	Total Sodium (mg/kg)		319	1,008	751	251	203
	Total Sulfur (mg/kg)		388	251	583	353	263
	Total Phosphorus (mg/kg)		490	313	467	553	219
	Total Zinc (mg/kg)		72	68	79	123	52
	Total Manganese (mg/kg)		273	340	219	130	105
	Total Iron (mg/kg)		19,702	17,148	24,438	4,549	6,224
	Total Copper (mg/kg)		22.9	23.9	23.4	49.4	15.8
	Total Boron (mg/kg)		2.5	2.1	2.5	3.6	<2
	Total Silicon (mg/kg)		769	564	459	743	944
	Total Aluminium (mg/kg)		7,516	4,760	7,872	3,103	3,896
	Total Molybdenum (mg/kg)		0.7	0.7	1.1	0.4	0.4
	Total Cobalt (mg/kg)		6.4	9.8	6.2	2.4	3.1
	Total Selenium (mg/kg)		0.7	<0.5	<0.5	<0.5	<0.5
	Total Cadmium (mg/kg)		<0.5	<0.5	0.6	1.0	<0.5
	Total Lead (mg/kg)		20	15	22	34	14
	Total Arsenic (mg/kg)		4.6	6.3	6.6	2.3	2.0
	Total Chromium (mg/kg)		8.1	5.9	10.2	4.7	3.8
	Total Nickel (mg/kg)		9.6	13	8.9	5.8	5.1
	Total Mercury (mg/kg)		<0.1	<0.1	<0.1	<0.1	<0.1
	Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

		Sample 23	Sample 24	Sample 25	Sample 26	Sample 27
	Sample ID:	MTWNPN201701	MTWNPN201702	MTWNPN201703	MTWNPN201801	MTWNPN201802
	Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
Parameter	Method reference	I2408/23	I2408/24	I2408/25	I2408/26	I2408/27

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter		Method reference	Sample 28	Sample 29	Sample 30	Sample 49	Sample 31
	Sample ID:			MTWNPN201803	MTWSPN201401	MTWSPN201501	MTWSPN201501	MTWSPN201601
	Crop:			Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:			MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	3552	1108	2673	684	1316
	Soluble Magnesium (mg/kg)			516	382	365	462	314
	Soluble Potassium (mg/kg)			371	191	330	182	369
	Soluble Phosphorus (mg/kg)			33	7.3	24	5.1	11
	Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	83	28	102	13	33
			**Rayment & Lyons 2011 - 9B2 (Colwell)	276	57	237	18	85
			**Inhouse S3A (Bray 2)	455	83	432	83	132
	Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	13	3.5	23	5.4	7.3
	Ammonium Nitrogen (mg/kg N)			7.4	3.6	5.6	3.1	4.2
	Sulfur (mg/kg S)			740	39	40	330	107
	pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.64	7.64	7.43	8.62	6.79
	Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	1.234	0.111	0.245	0.909	0.234
	Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	15.7	5.5	10.6	10.0	7.0
	Exchangeable Calcium	**(cmol$_+$/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	18.17	8.66	15.75	5.46	11.78
		(kg/ha)		8157	3888	7071	2450	5288
		(mg/kg)		3642	1736	3156	1094	2361
	Exchangeable Magnesium	**(cmol$_+$/kg)**		5.06	4.29	3.64	5.84	3.96
		(kg/ha)		1378	1168	992	1589	1079
		(mg/kg)		615	521	443	709	482
	Exchangeable Potassium	**(cmol$_+$/kg)**		1.49	0.89	1.35	0.86	1.93
		(kg/ha)		1309	782	1186	753	1690
		(mg/kg)		584	349	530	336	754
	Exchangeable Sodium	**(cmol$_+$/kg)**		5.07	0.68	0.35	7.96	0.70
		(kg/ha)		2612	352	180	4101	361
		(mg/kg)		1166	157	80	1831	161
	Exchangeable Aluminium	**(cmol$_+$/kg)**	**Inhouse S37 (KCl)	0.06	0.07	0.03	0.07	0.02
		(kg/ha)		12	14	7	14	3
		(mg/kg)		5	6	3	6	1
	Exchangeable Hydrogen	**(cmol$_+$/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	<0.01
		(kg/ha)		<1	<1	<1	<1	<1
		(mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	29.86	14.59	21.13	20.19	18.39
	Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	60.9	59.3	74.5	27.0	64.1
	Magnesium (%)			17.0	29.4	17.2	28.9	21.6
	Potassium (%)			5.0	6.1	6.4	4.3	10.5
	Sodium - ESP (%)			17.0	4.7	1.7	39.4	3.8
	Aluminium (%)			0.2	0.5	0.2	0.3	0.1
	Hydrogen			0.0	0.0	0.0	0.0	0.0
	Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol$_+$/kg)	3.6	2.0	4.3	0.9	3.0

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 28	Sample 29	Sample 30	Sample 49	Sample 31
	Sample ID:		MTWNPN201803	MTWSPN201401	MTWSPN201501	MTWSPN201501	MTWSPN201601
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	76	17	45	9.5	14
	Manganese (mg/kg)		5.8	2.8	3.1	0.9	6.6
	Iron (mg/kg)		39	30	47	23	41
	Copper (mg/kg)		18	2.5	5.1	2.9	1.6
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	1.12	0.66	0.63	0.37	0.74
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	14	24	26	13	44
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	8.95	3.13	6.04	5.73	3.99
	Total Nitrogen (%)		0.53	0.20	0.46	0.18	0.30
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	16.8	15.9	13.2	32.0	13.3
	Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam
	Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	790	71	157	582	150
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	14,572	3,235	8,994	4,780	5,518
	Total Magnesium (mg/kg)		3,344	1,462	2,285	3,893	1,486
	Total Potassium (mg/kg)		1,793	1,166	1,333	1,653	2,107
	Total Sodium (mg/kg)		1,455	213	164	1,957	230
	Total Sulfur (mg/kg)		1,549	247	618	570	349
	Total Phosphorus (mg/kg)		1,997	353	1,197	324	488
	Total Zinc (mg/kg)		350	71	175	81	77
	Total Manganese (mg/kg)		296	139	188	222	318
	Total Iron (mg/kg)		13,736	11,229	11,891	14,492	14,705
	Total Copper (mg/kg)		300.2	22.7	56.5	24.9	20.7
	Total Boron (mg/kg)		5.4	<2	<2	2.9	<2
	Total Silicon (mg/kg)		723	839	743	1,039	851
	Total Aluminium (mg/kg)		4,427	5,024	5,092	3,626	8,006
	Total Molybdenum (mg/kg)		1.1	0.7	0.8	0.5	0.6
	Total Cobalt (mg/kg)		11.1	5.6	5.0	9.0	7.7
	Total Selenium (mg/kg)		0.6	<0.5	<0.5	0.7	0.6
	Total Cadmium (mg/kg)		2.5	<0.5	0.7	<0.5	<0.5
	Total Lead (mg/kg)		74	22	48	14	18
	Total Arsenic (mg/kg)		7.3	3.6	4.8	5.4	5.1
	Total Chromium (mg/kg)		12	11	9.2	4.7	8.7
	Total Nickel (mg/kg)		24	10	12	12.3	10
	Total Mercury (mg/kg)		0.2	<0.1	0.1	<0.1	<0.1
	Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 28	Sample 29	Sample 30	Sample 49	Sample 31
	Sample ID:		MTWNPN201803	MTWSPN201401	MTWSPN201501	MTWSPN201501	MTWSPN201601
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/28	I2408/29	I2408/30	I2408/49	I2408/31

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium,
122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

			Sample 50	Sample 32	Sample 33	Sample 34	Sample 35
		Sample ID:	MTWSPN201601 -Orica	MTWSPN201602	MTWSPS201601	MTWSPS201602	MTWSPS201701
		Crop:	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
		Client:	MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Parameter	**Method reference**	**I2408/50**	**I2408/32**	**I2408/33**	**I2408/34**	**I2408/35**
	Soluble Calcium (mg/kg)	**Inhouse S10 - Morgan 1	1111	939	1176	1508	1579
	Soluble Magnesium (mg/kg)		335	335	498	529	305
	Soluble Potassium (mg/kg)		195	200	210	169	171
	Soluble Phosphorus (mg/kg)		24	12	5.7	4.7	6.5
	Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9E2 (Bray 1)	64	40	18	18	28
		**Rayment & Lyons 2011 - 9B2 (Colwell)	119	75	44	47	66
		**Inhouse S3A (Bray 2)	189	141	80	63	86
	Nitrate Nitrogen (mg/kg N)	**Inhouse S37 (KCl)	15	3.1	3.1	30	9.1
	Ammonium Nitrogen (mg/kg N)		6.2	6.3	3.8	5.3	3.6
	Sulfur (mg/kg S)		261	55	63	222	90
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.16	6.89	7.46	7.15	7.37
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.321	0.177	0.188	0.450	0.236
	Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	4.8	5.1	8.4	4.7	4.3
	Exchangeable Calcium **(cmol+/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	8.82	8.36	10.32	12.18	9.78
	Exchangeable Calcium **(kg/ha)**		3961	3752	4634	5468	4392
	Exchangeable Calcium **(mg/kg)**		1768	1675	2069	2441	1961
	Exchangeable Magnesium **(cmol+/kg)**		3.96	4.41	6.25	6.05	3.44
	Exchangeable Magnesium **(kg/ha)**		1079	1201	1702	1648	936
	Exchangeable Magnesium **(mg/kg)**		481	536	760	736	418
	Exchangeable Potassium **(cmol+/kg)**		0.91	0.96	0.98	0.85	0.81
	Exchangeable Potassium **(kg/ha)**		794	839	854	743	712
	Exchangeable Potassium **(mg/kg)**		354	375	381	332	318
	Exchangeable Sodium **(cmol+/kg)**		1.73	1.32	0.77	1.19	0.94
	Exchangeable Sodium **(kg/ha)**		889	680	395	611	485
	Exchangeable Sodium **(mg/kg)**		397	304	176	273	217
	Exchangeable Aluminium **(cmol+/kg)**	**Inhouse S37 (KCl)	0.09	0.06	0.09	0.09	0.05
	Exchangeable Aluminium **(kg/ha)**		18	13	17	18	10
	Exchangeable Aluminium **(mg/kg)**		8	6	8	8	4
	Exchangeable Hydrogen **(cmol+/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	<0.01
	Exchangeable Hydrogen **(kg/ha)**		<1	<1	<1	<1	<1
	Exchangeable Hydrogen **(mg/kg)**		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	15.51	15.11	18.40	20.36	15.03
	Calcium (%)	**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	56.9	55.3	56.1	59.8	65.1
	Magnesium (%)		25.5	29.2	34.0	29.7	22.9
	Potassium (%)		5.8	6.3	5.3	4.2	5.4
	Sodium - ESP (%)		11.1	8.7	4.2	5.8	6.3
	Aluminium (%)		0.6	0.4	0.5	0.4	0.3
	Hydrogen		0.0	0.0	0.0	0.0	0.0
	Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol+/kg)	2.2	1.9	1.7	2.0	2.8

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 50	Sample 32	Sample 33	Sample 34	Sample 35
	Sample ID:		MTWSPN201601 -Orica	MTWSPN201602	MTWSPS201601	MTWSPS201602	MTWSPS201701
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Parameter	**Method reference**	**I2408/50**	**I2408/32**	**I2408/33**	**I2408/34**	**I2408/35**
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	13	12	11	11	9.9
	Manganese (mg/kg)		5.2	4.0	2.4	5.4	2.9
	Iron (mg/kg)		44	61	20	32	51
	Copper (mg/kg)		1.3	1.0	2.2	1.6	0.9
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.61	0.60	0.55	0.48	0.52
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	29	39	18	21	22
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	2.76	2.92	4.80	2.69	2.46
	Total Nitrogen (%)		0.23	0.22	0.22	0.18	0.17
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	11.8	13.5	21.5	14.8	14.9
	Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam
	Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	206	113	121	288	151
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	3,970	2,506	4,858	4,464	4,537
	Total Magnesium (mg/kg)		1,441	1,145	2,722	1,809	1,058
	Total Potassium (mg/kg)		1,310	1,200	1,528	1,356	1,096
	Total Sodium (mg/kg)		478	334	258	336	293
	Total Sulfur (mg/kg)		389	258	341	788	289
	Total Phosphorus (mg/kg)		491	391	324	366	379
	Total Zinc (mg/kg)		68	48	83	70	49
	Total Manganese (mg/kg)		112	116	280	182	133
	Total Iron (mg/kg)		8,439	6,787	16,245	17,289	8,296
	Total Copper (mg/kg)		18.0	14.0	26.5	25.2	16.6
	Total Boron (mg/kg)		2.7	<2	<2	2.0	3.0
	Total Silicon (mg/kg)		1,349	745	664	1,339	1,598
	Total Aluminium (mg/kg)		7,034	4,911	5,229	7,854	5,228
	Total Molybdenum (mg/kg)		0.5	0.4	0.6	0.7	0.6
	Total Cobalt (mg/kg)		3.8	3.8	8.8	5.7	4.0
	Total Selenium (mg/kg)		<0.5	<0.5	0.7	0.7	<0.5
	Total Cadmium (mg/kg)		<0.5	<0.5	<0.5	<0.5	<0.5
	Total Lead (mg/kg)		14	14	21	21	15
	Total Arsenic (mg/kg)		3.4	2.9	4.9	5.3	3.6
	Total Chromium (mg/kg)		6.8	4.7	6.3	7.6	5.5
	Total Nickel (mg/kg)		5.5	5.0	12	8.9	5.6
	Total Mercury (mg/kg)		<0.1	<0.1	<0.1	<0.1	<0.1
	Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
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Analysis requested by John Moen. Your Job: MTW Mine

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	Parameter	Method reference	Sample 50	Sample 32	Sample 33	Sample 34	Sample 35
	Sample ID:		MTWSPN201601 -Orica	MTWSPN201602	MTWSPS201601	MTWSPS201602	MTWSPS201701
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/50	I2408/32	I2408/33	I2408/34	I2408/35

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter		Method reference	Sample 36	Sample 37	Sample 38	Sample 39	Sample 40
	Sample ID:			MTWSPS201703	MTWSPS201801	MTWWDL201401	MTWWDL201402	MTWWDL201801
	Crop:			Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:			MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
	Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	1071	2413	642	817	3763
	Soluble Magnesium (mg/kg)			514	527	492	501	538
	Soluble Potassium (mg/kg)			143	241	219	209	309
	Soluble Phosphorus (mg/kg)			9.0	34	4.8	6.4	103
	Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	24	61	14	14	101
			**Rayment & Lyons 2011 - 9B2 (Colwell)	42	144	31	24	313
			**Inhouse S3A (Bray 2)	75	234	72	64	440
	Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	55	20	14	5.6	13
	Ammonium Nitrogen (mg/kg N)			2.5	4.1	4.1	5.0	4.3
	Sulfur (mg/kg S)			268	390	35	23	284
	pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.97	7.62	7.13	7.78	7.57
	Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.817	0.760	0.126	0.128	0.576
	Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	5.2	10.2	6.5	5.5	11.8
	Exchangeable Calcium	**(cmol$_+$/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	7.36	14.28	6.03	6.09	19.78
		(kg/ha)		3304	6411	2705	2732	8877
		(mg/kg)		1475	2862	1208	1220	3963
	Exchangeable Magnesium	**(cmol$_+$/kg)**		5.67	5.36	6.43	5.72	5.32
		(kg/ha)		1544	1459	1749	1556	1450
		(mg/kg)		689	651	781	695	647
	Exchangeable Potassium	**(cmol$_+$/kg)**		0.64	1.04	1.05	0.97	1.66
		(kg/ha)		563	913	917	848	1452
		(mg/kg)		251	407	410	378	648
	Exchangeable Sodium	**(cmol$_+$/kg)**		3.90	2.71	1.28	0.88	2.10
		(kg/ha)		2008	1398	660	454	1081
		(mg/kg)		896	624	295	203	482
	Exchangeable Aluminium	**(cmol$_+$/kg)**	**Inhouse S37 (KCl)	0.07	0.09	0.10	0.03	0.04
		(kg/ha)		15	17	19	6	8
		(mg/kg)		6	8	9	3	4
	Exchangeable Hydrogen	**(cmol$_+$/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01	<0.01
		(kg/ha)		<1	<1	<1	<1	<1
		(mg/kg)		<1	<1	<1	<1	<1
	Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	17.65	23.48	14.88	13.68	28.90
	Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	41.7	60.8	40.5	44.5	68.4
	Magnesium (%)			32.1	22.8	43.2	41.8	18.4
	Potassium (%)			3.6	4.4	7.0	7.1	5.7
	Sodium - ESP (%)			22.1	11.6	8.6	6.4	7.3
	Aluminium (%)			0.4	0.4	0.6	0.2	0.1
	Hydrogen			0.0	0.0	0.0	0.0	0.0
	Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol$_+$/kg)	1.3	2.7	0.9	1.1	3.7

Environmental Analysis Laboratory

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AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 36	Sample 37	Sample 38	Sample 39	Sample 40
	Sample ID:		MTWSPS201703	MTWSPS201801	MTWWDL201401	MTWWDL201402	MTWWDL201801
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/36	I2408/37	I2408/38	I2408/39	I2408/40
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	9.8	29	9.0	6.8	82
	Manganese (mg/kg)		2.0	4.2	2.4	2.4	8.3
	Iron (mg/kg)		19	20	58	21	24
	Copper (mg/kg)		1.5	4.8	1.1	1.1	16
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.37	0.76	0.38	0.56	1.38
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	13	22	33	24	37
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	2.95	5.81	3.69	3.13	6.77
	Total Nitrogen (%)		0.15	0.29	0.23	0.17	0.48
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	19.2	20.1	16.0	18.1	14.0
	Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam
	Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	523	486	81	82	369
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	5,354	9,243	2,264	3,686	14,002
	Total Magnesium (mg/kg)		3,050	3,835	1,856	2,622	2,442
	Total Potassium (mg/kg)		1,196	1,663	1,481	1,497	1,683
	Total Sodium (mg/kg)		985	821	394	328	691
	Total Sulfur (mg/kg)		441	1,077	275	268	780
	Total Phosphorus (mg/kg)		291	829	315	294	1,955
	Total Zinc (mg/kg)		71	159	50	59	279
	Total Manganese (mg/kg)		173	321	163	208	357
	Total Iron (mg/kg)		12,103	22,531	9,969	15,143	14,723
	Total Copper (mg/kg)		18.9	45.8	20.0	15.3	99.3
	Total Boron (mg/kg)		2.4	4.4	2.3	2.8	6.0
	Total Silicon (mg/kg)		1,227	1,612	1,926	1,410	1,181
	Total Aluminium (mg/kg)		4,084	5,192	5,590	6,525	6,580
	Total Molybdenum (mg/kg)		0.5	0.9	0.6	0.5	1.3
	Total Cobalt (mg/kg)		6.2	11.9	5.0	6.6	7.4
	Total Selenium (mg/kg)		<0.5	0.7	<0.5	<0.5	<0.5
	Total Cadmium (mg/kg)		<0.5	0.6	<0.5	<0.5	1.6
	Total Lead (mg/kg)		16	34	11	14	88
	Total Arsenic (mg/kg)		4.1	6.5	3.8	4.2	5.5
	Total Chromium (mg/kg)		4.9	11	4.5	6.2	17
	Total Nickel (mg/kg)		8.3	18	6.7	7.9	20
	Total Mercury (mg/kg)		<0.1	<0.1	<0.1	<0.1	0.2
	Total Silver (mg/kg)		<1	<1	<1	<1	<1

Southern Cross University
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AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

	Parameter	Method reference	Sample 36	Sample 37	Sample 38	Sample 39	Sample 40
	Sample ID:		MTWSPS201703	MTWSPS201801	MTWWDL201401	MTWWDL201402	MTWWDL201801
	Crop:		Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives	Rehab Natives
	Client:		MTW Mine	MTW Mine	MTW Mine	MTW Mine	MTW Mine
			I2408/36	I2408/37	I2408/38	I2408/39	I2408/40

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 cmol$_+$/kg = 230 mg/kg Sodium, 390 mg/kg Potassium,
122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Environmental Analysis Laboratory

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P: +61 2 6620 3678
E: eal@scu.edu.au
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AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

		Sample 51	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
	Sample ID:	**NPN201101**				
	Crop:	**Rehab Natives**				
	Client:	**MTW Mine**	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
	Parameter / **Method reference**	**I2408/51**	**Indicative guidelines - refer to Notes 6 and 8**			
	Soluble Calcium (mg/kg)	948	*1150*	*750*	*375*	*175*
	Soluble Magnesium (mg/kg)	336	*160*	*105*	*60*	*25*
	Soluble Potassium (mg/kg)	135	*113*	*75*	*60*	*50*
	Soluble Phosphorus (mg/kg)	4.5	*15*	*12*	*10*	*5.0*
	Phosphorus (mg/kg P) — **Rayment & Lyons 2011 - 9E2 (Bray 1)**	5.4	*45 note 8*	*30 note 8*	*24 note 8*	*20 note 8*
	Phosphorus (mg/kg P) — **Rayment & Lyons 2011 - 9B2 (Colwell)**	10	*80*	*50*	*45*	*35*
	Phosphorus (mg/kg P) — **Inhouse S3A (Bray 2)**	33	*90 note 8*	*60 note 8*	*48 note 8*	*40 note 8*
	Nitrate Nitrogen (mg/kg N)	1.7	*15*	*13*	*10*	*10*
	Ammonium Nitrogen (mg/kg N)	4.6	*20*	*18*	*15*	*12*
	Sulfur (mg/kg S)	154	*10.0*	*8.0*	*8.0*	*7.0*
	pH	7.42	*6.5*	*6.5*	*6.3*	*6.3*
	Electrical Conductivity (dS/m)	0.108	*0.200*	*0.150*	*0.120*	*0.100*
	Estimated Organic Matter (% OM)	4.5	*> 5.5*	*>4 .5*	*> 3.5*	*> 2.5*
	Exchangeable Calcium (cmol+/kg)	8.65	*15.6*	*10.8*	*5.0*	*1.9*
	Exchangeable Calcium (kg/ha)	3882	*7000*	*4816*	*2240*	*840*
	Exchangeable Calcium (mg/kg)	1733	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium (cmol+/kg)	4.15	*2.4*	*1.7*	*1.2*	*0.60*
	Exchangeable Magnesium (kg/ha)	1129	*650*	*448*	*325*	*168*
	Exchangeable Magnesium (mg/kg)	504	*290*	*200*	*145*	*75*
	Exchangeable Potassium (cmol+/kg)	0.66	*0.60*	*0.50*	*0.40*	*0.30*
	Exchangeable Potassium (kg/ha)	582	*526*	*426*	*336*	*224*
	Exchangeable Potassium (mg/kg)	260	*235*	*190*	*150*	*100*
	Exchangeable Sodium (cmol+/kg)	0.11	*0.3*	*0.26*	*0.22*	*0.11*
	Exchangeable Sodium (kg/ha)	55	*155*	*134*	*113*	*57*
	Exchangeable Sodium (mg/kg)	25	*69*	*60*	*51*	*25*
	Exchangeable Aluminium (cmol+/kg)	0.04	*0.6*	*0.5*	*0.4*	*0.2*
	Exchangeable Aluminium (kg/ha)	8	*121*	*101*	*73*	*30*
	Exchangeable Aluminium (mg/kg)	4	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen (cmol+/kg)	<0.01	*0.6*	*0.5*	*0.4*	*0.2*
	Exchangeable Hydrogen (kg/ha)	<1	*13*	*11*	*8*	*3*
	Exchangeable Hydrogen (mg/kg)	<1	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg) — **Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)**	13.61	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)	63.6	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)	30.5	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)	4.9	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP (%)	0.8	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium (%)	0.3	*6.0*	*7.1*	*10.5*	*12.1*
	Hydrogen	0.0				
	Calcium/Magnesium Ratio — **Calculation: Calcium / Magnesium (cmol+/kg)**	2.1	*6.5*	*6.4*	*4.2*	*3.2*

Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)

Inhouse S37 (KCl)

Rayment & Lyons 2011 - 15G1 (Acidity Titration)

Base Saturation Calculations - Cation cmol+/kg / ECEC x 100

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AGRICULTURAL SOIL ANALYSIS REPORT

55 samples supplied by Cumberland Plain Seeds Pty Ltd on 4th June, 2019. Lab Job No.i2408

Analysis requested by John Moen. Your Job: MTW Mine

50 Gipps Street CARRINGTON NSW 2294

			Sample 51	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
		Sample ID:	**NPN201101**				
		Crop:	**Rehab Natives**				
		Client:	**MTW Mine**	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
	Parameter	**Method reference**	**I2408/51**	**Indicative guidelines - refer to Notes 6 and 8**			
	Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	3.3	*6.0*	*5.0*	*4.0*	*3.0*
	Manganese (mg/kg)		5.3	*25*	*22*	*18*	*15*
	Iron (mg/kg)		14	*25*	*22*	*18*	*15*
	Copper (mg/kg)		0.5	*2.4*	*2.0*	*1.6*	*1.2*
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.32	*2.0*	*1.7*	*1.4*	*1.0*
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	33	*50*	*45*	*40*	*35*
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	2.56	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
	Total Nitrogen (%)		0.14	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	18.3	*10–12*	*10–12*	*10–12*	*10–12*
	Basic Texture	**Inhouse S65	Loam	..	..	..	..
	Basic Colour		Brownish	..	..	..	..
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	69	..	..	..	..
	Total Calcium (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	2,947	*1000–10 000 Ca*			
	Total Magnesium (mg/kg)		1,648	*500–5000 Mg*			
	Total Potassium (mg/kg)		1,296	*200–2000 K*			
	Total Sodium (mg/kg)		93	*100–500 Na*			
	Total Sulfur (mg/kg)		211	*100–1000 S*			
	Total Phosphorus (mg/kg)		258	*400–1500 P*			
	Total Zinc (mg/kg)		47	*20–50 Zn*			
	Total Manganese (mg/kg)		310	*200–2000 Mn*			
	Total Iron (mg/kg)		16,368	*1000–50 000 Fe*			
	Total Copper (mg/kg)		11.0	*20–50 Cu*			
	Total Boron (mg/kg)		2.7	*2–50 B*			
	Total Silicon (mg/kg)		1,307	*1000–3000 Si*			
	Total Aluminium (mg/kg)		6,089	*2000–50 000 Al*			
	Total Molybdenum (mg/kg)		0.6	*0.5–3.0 Mo*			
	Total Cobalt (mg/kg)		8.2	*5–50 Co*			
	Total Selenium (mg/kg)		<0.5	*0.1–2.0 Se*			
	Total Cadmium (mg/kg)		<0.5	*<1 Cd*			
	Total Lead (mg/kg)		10	*2–200 Pb*			
	Total Arsenic (mg/kg)		5.7	*1–50 As*			
	Total Chromium (mg/kg)		5.9	*5–1000 Cr*			
	Total Nickel (mg/kg)		9.0	*5–500 Ni*			
	Total Mercury (mg/kg)		<0.1	*< 0.2 Hg*			
	Total Silver (mg/kg)		<1	*.. Ag*			

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		Sample 51	*Heavy Soil*	*Medium Soil*	*Light Soil*	*Sandy Soil*
	Sample ID:	**NPN201101**				
	Crop:	**Rehab Natives**				
	Client:	**MTW Mine**	*Clay*	*Clay Loam*	*Loam*	*Loamy Sand*
Parameter	**Method reference**	**I2408/51**	**Indicative guidelines - refer to Notes 6 and 8**			

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
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9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
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Agricultural Co-Ordinator KS

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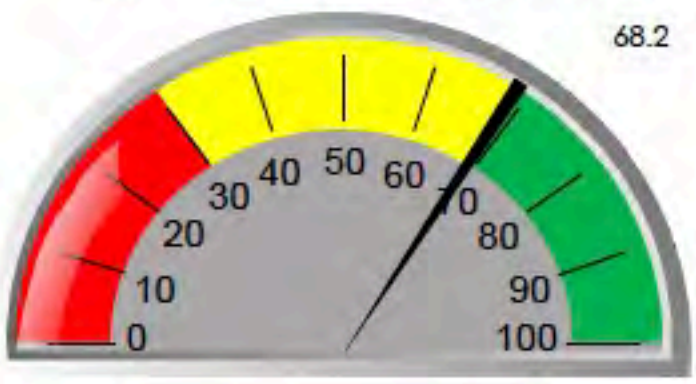
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Bell 01-52885:1** Analysis no.: **2230-1-MWSS** Date: **4/06/2019**

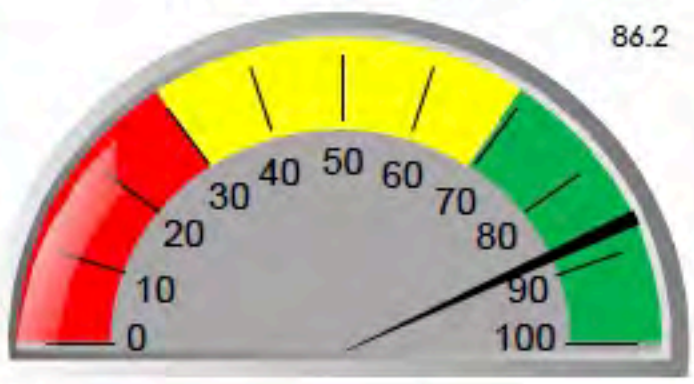
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	Bell 01-52885:1	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-1-MWSS

Microbial Soil Indicators

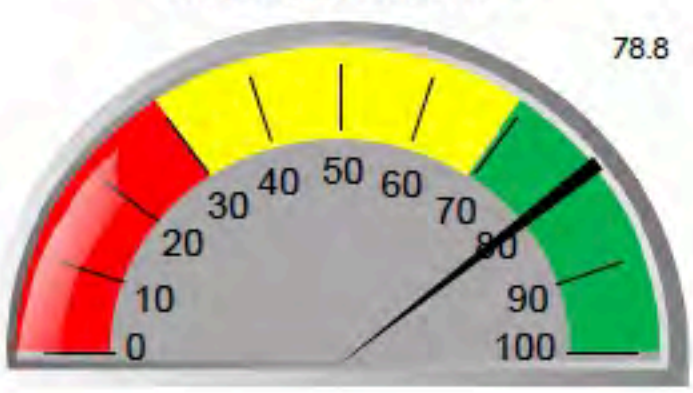
Nutrient solubilisation rate



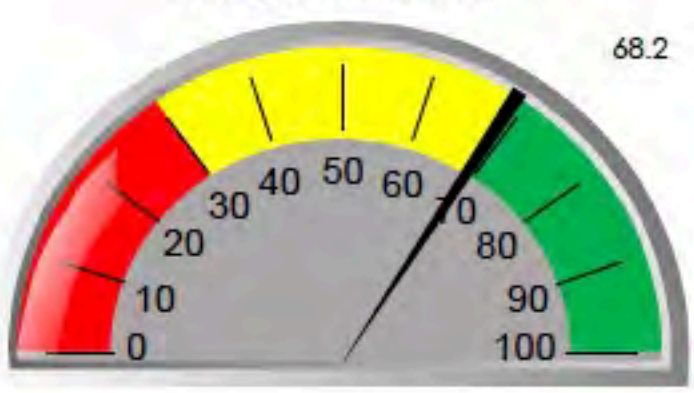
Nutrient cycling rate



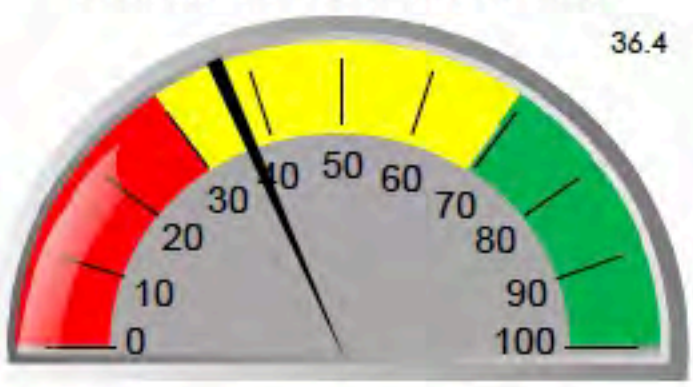
Disease resistance



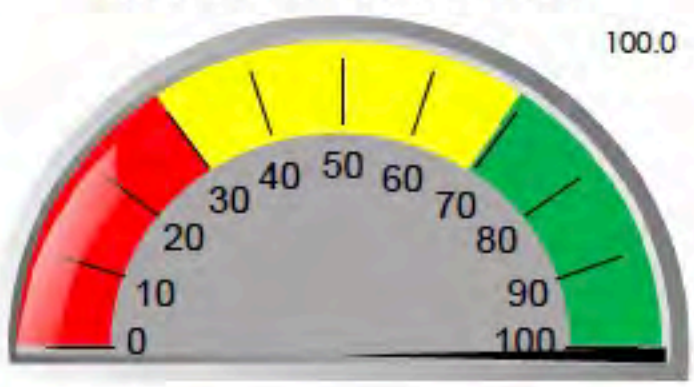
Drought resistance



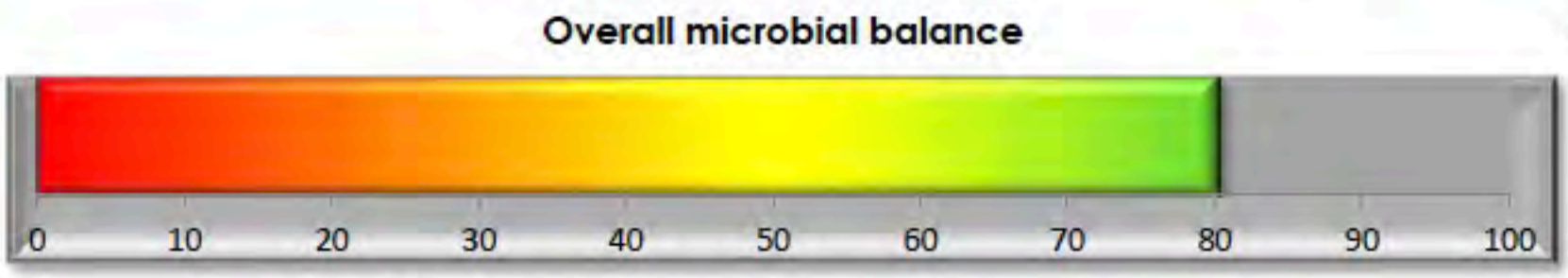
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Bell 01-52885:1** Analysis no.: **2230-1-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	80.8	50.0
Total bacteria	22.1	15.0
Total fungi	57.8	33.8

Microbial indicators	Yours	Guide
Microbial diversity	32.4	80.0
Fungi : Bacteria	2.6	2.3
Bacterial stress	1.2	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	1.368	1.000
Actinomycetes	3.839	1.000
Gram positive	13.334	4.000
Gram negative	8.816	11.000
Methane oxidisers	0.000	0.500
Sulphur reducers	0.000	< 0.005
True anaerobes	0.645	< 0.005
Eukaryotes		
Protozoa	0.840	1.300
Mycorrhizal fungi (including VAM)	3.638	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from fair, to good. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups ranged from fair to poor for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were fair to good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good indicating a balance between both groups. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit www.microbelabs.com.au for more information.

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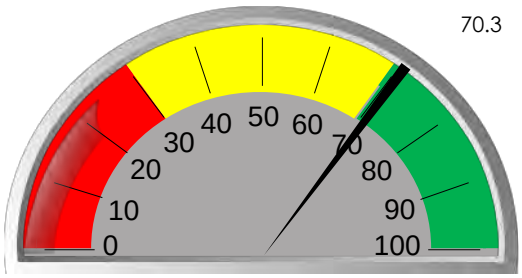
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Bell 02 - 52885:2** Analysis no.: **2230-2-MWSS** Date: **4/06/2019**

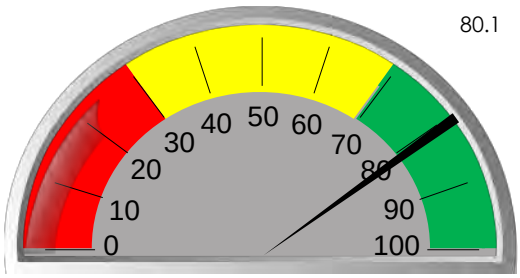
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	Bell 02 - 52885:2	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-2-MWSS

Microbial Soil Indicators

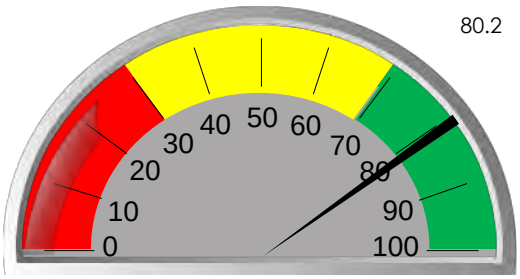
Nutrient solubilisation rate



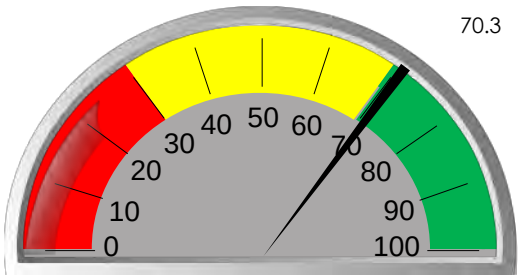
Nutrient cycling rate



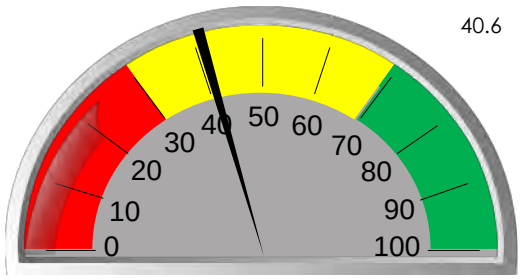
Disease resistance



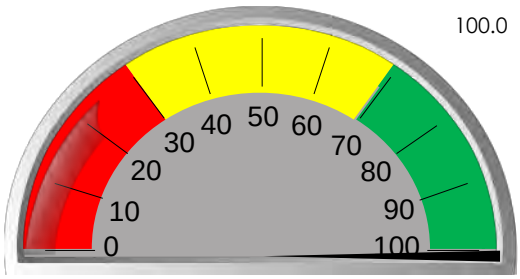
Drought resistance



Nutrient accessibility (VAM)

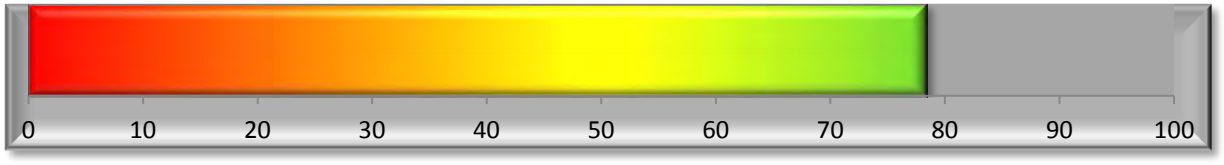


Residue breakdown rate



Overall microbial balance

78.3



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Bell 02 - 52885:2** Analysis no.: **2230-2-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**56.4**	50.0
Total bacteria	**14.3**	15.0
Total fungi	**41.2**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**38.7**	80.0
Fungi : Bacteria	**2.9**	2.3
Bacterial stress	**0.9**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.188**	1.000
Actinomycetes	**2.259**	1.000
Gram positive	**8.199**	4.000
Gram negative	**6.151**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.269**	< 0.005
Eukaryotes		
Protozoa	**0.837**	1.300
Mycorrhizal fungi (including VAM)	**4.057**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from fair, to good. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups ranged from fair for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were fair to good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good indicating a balance between both groups. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi and Gram negative bacteria. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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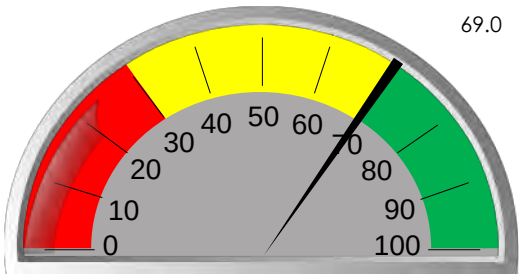
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Bell 02 - 52885:3** Analysis no.: **2230-3-MWSS** Date: **4/06/2019**

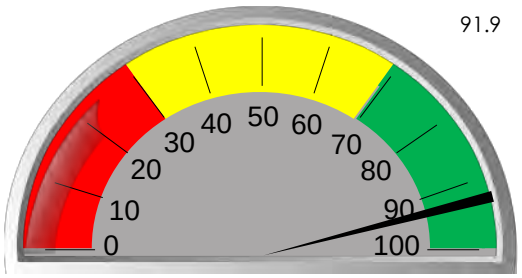
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	Bell 02 - 52885:3	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-3-MWSS

Microbial Soil Indicators

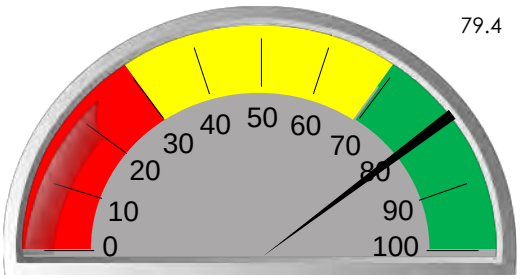
Nutrient solubilisation rate



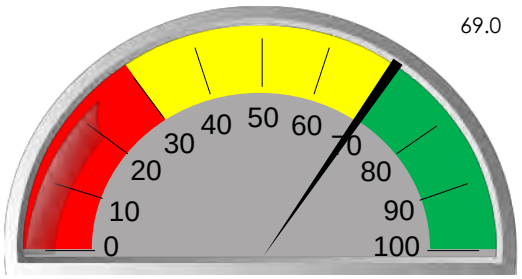
Nutrient cycling rate



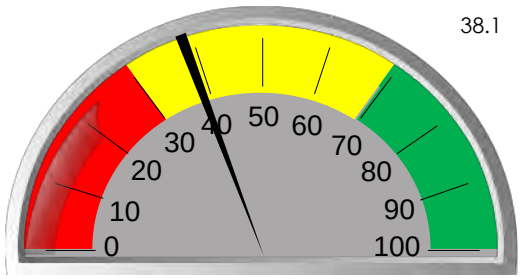
Disease resistance



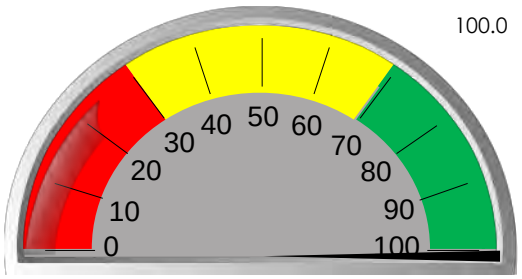
Drought resistance



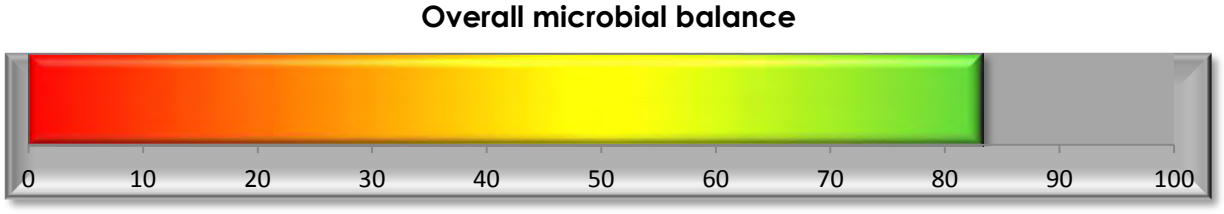
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Bell 02 - 52885:3** Analysis no.: **2230-3-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**63.0**	50.0
Total bacteria	**18.1**	15.0
Total fungi	**43.3**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**34.8**	80.0
Fungi : Bacteria	**2.4**	2.3
Bacterial stress	**1.1**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.191**	1.000
Actinomycetes	**3.115**	1.000
Gram positive	**10.615**	4.000
Gram negative	**7.438**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.649**	< 0.005
Eukaryotes		
Protozoa	**1.669**	1.300
Mycorrhizal fungi (including VAM)	**3.807**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from fair, to good. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups ranged from fair to poor for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good indicating a balance between both groups. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi and Gram negative bacteria. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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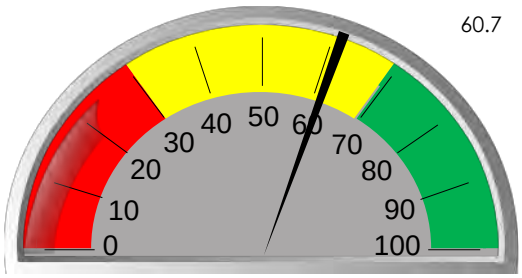
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WanboSpot 1 - 52885:8** Analysis no.: **2230-8-MWSS** Date: **4/06/2019**

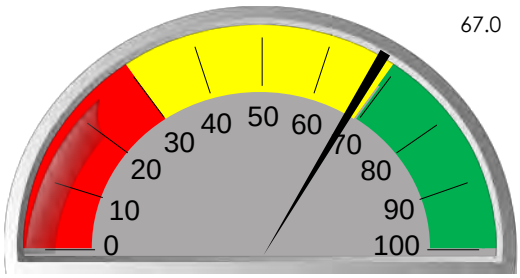
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	WanboSpot 1 - 52885:8	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-8-MWSS

Microbial Soil Indicators

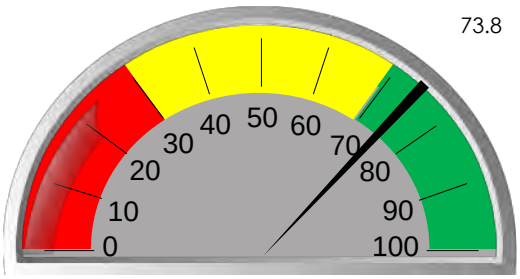
Nutrient solubilisation rate



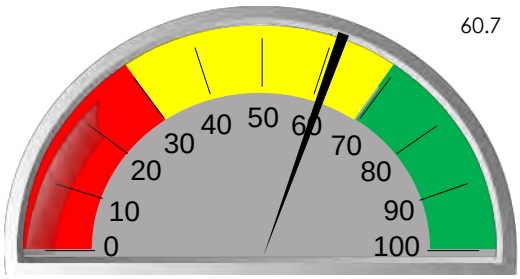
Nutrient cycling rate



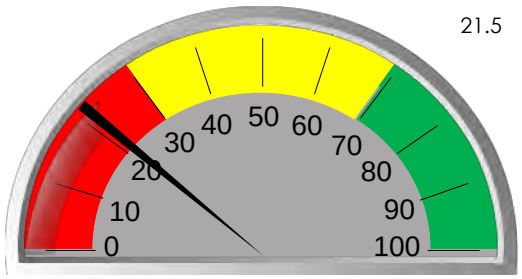
Disease resistance



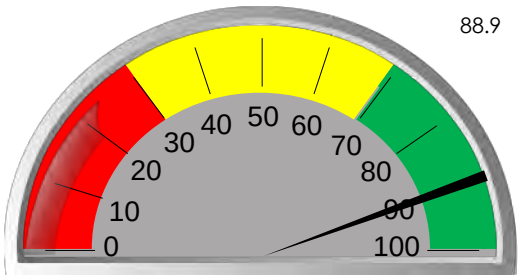
Drought resistance



Nutrient accessibility (VAM)

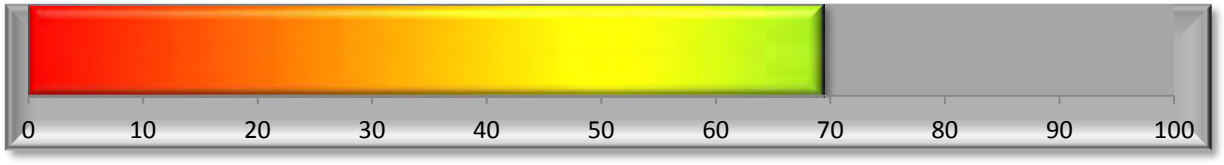


Residue breakdown rate



Overall microbial balance

69.3



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WanboSpot 1 - 52885:8** Analysis no.: **2230-8-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**40.3**	50.0
Total bacteria	**13.5**	15.0
Total fungi	**26.3**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**35.6**	80.0
Fungi : Bacteria	**1.9**	2.3
Bacterial stress	**0.9**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.075**	1.000
Actinomycetes	**1.927**	1.000
Gram positive	**7.735**	4.000
Gram negative	**5.790**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.357**	< 0.005
Eukaryotes		
Protozoa	**0.489**	1.300
Mycorrhizal fungi (including VAM)	**2.146**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from poor, to good. The total mass of microbes in your sample was fair to good. Biomasses of other key desirable microbe groups ranged from poor for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were fair to poor here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was sligtly lower than the guide but it may not be of concern here. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi and Protozoa. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

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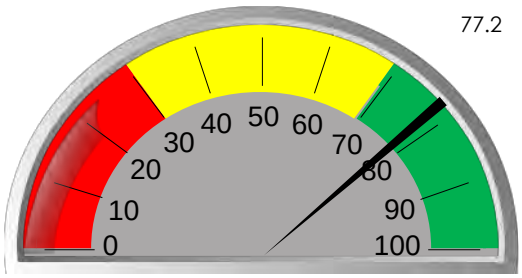
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WanboSpot 2 - 52885:9** Analysis no.: **2230-9-MWSS** Date: **4/06/2019**

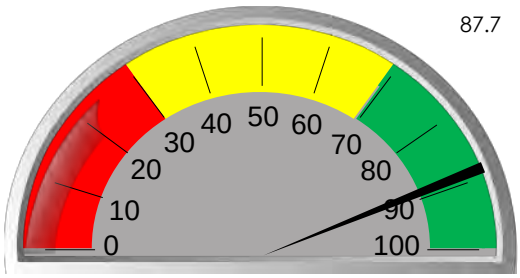
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	WanboSpot 2 - 52885:9	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-9-MWSS

Microbial Soil Indicators

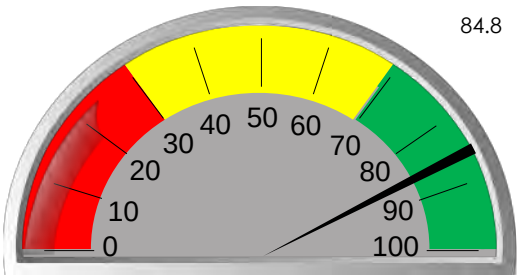
Nutrient solubilisation rate



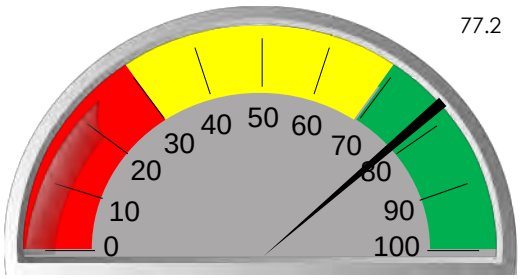
Nutrient cycling rate



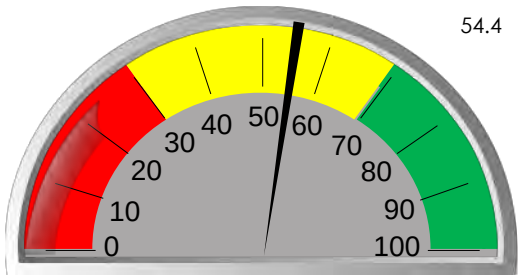
Disease resistance



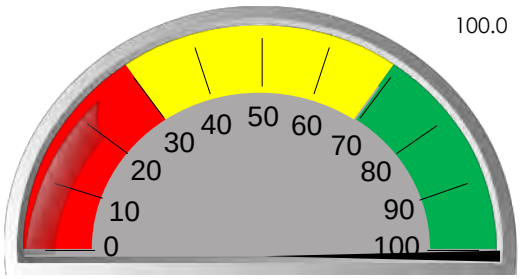
Drought resistance



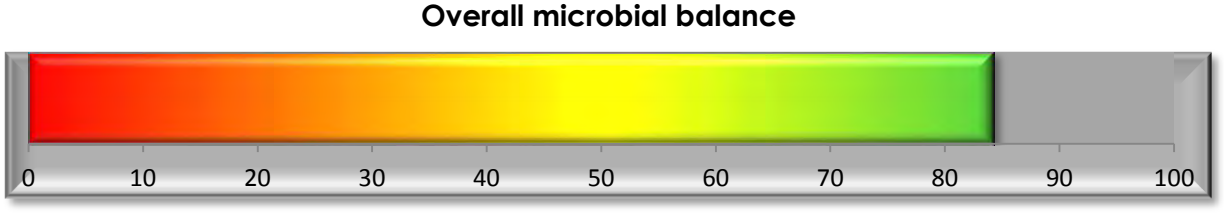
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WanboSpot 2 - 52885:9** Analysis no.: **2230-9-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**70.4**	50.0
Total bacteria	**20.8**	15.0
Total fungi	**48.7**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**41.8**	80.0
Fungi : Bacteria	**2.3**	2.3
Bacterial stress	**0.6**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.761**	1.000
Actinomycetes	**3.244**	1.000
Gram positive	**11.797**	4.000
Gram negative	**9.015**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.785**	< 0.005
Eukaryotes		
Protozoa	**0.897**	1.300
Mycorrhizal fungi (including VAM)	**5.441**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators were all good. Except for Nutrient Accessibility, which was fair. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups ranged from fair for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were fair to good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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MICROBE WISE FOR SOIL

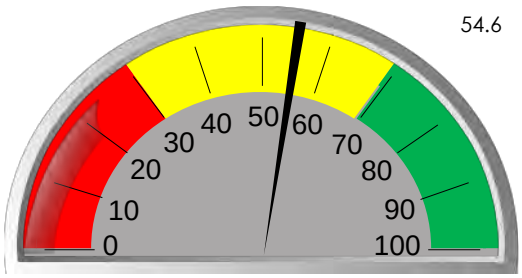
Name: **SESL Australia** Sample: **WanboSpot 3 - 52885:10** Analysis no.: **2230-10-MWSS** Date: **4/06/2019**

Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	WanboSpot 3 - 52885:10	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-10-MWSS

Microbial Soil Indicators

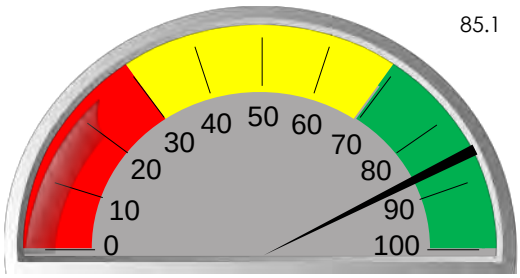
Nutrient solubilisation rate

54.6



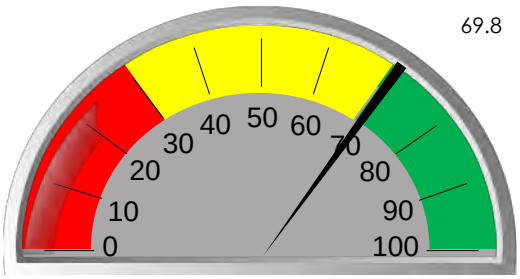
Nutrient cycling rate

85.1



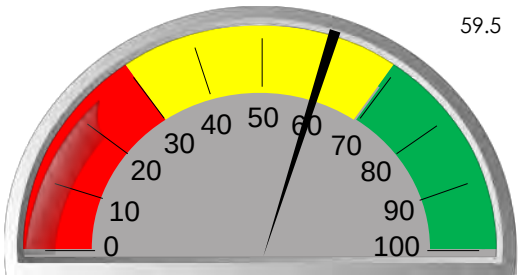
Disease resistance

69.8



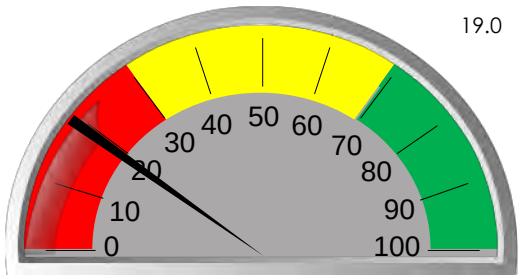
Drought resistance

59.5



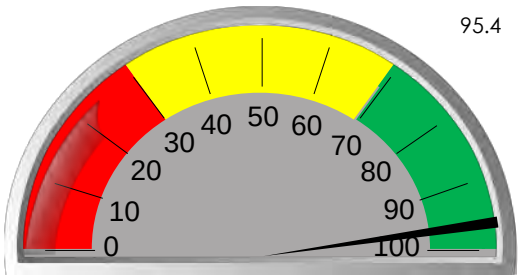
Nutrient accessibility (VAM)

19.0



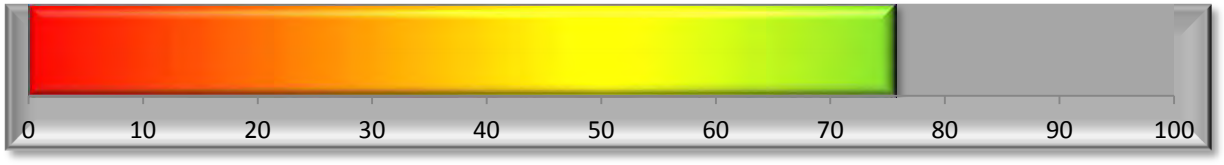
Residue breakdown rate

95.4



Overall microbial balance

75.6



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WanboSpot 3 - 52885:10** Analysis no.: **2230-10-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**45.2**	50.0
Total bacteria	**13.2**	15.0
Total fungi	**30.7**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**33.9**	80.0
Fungi : Bacteria	**2.3**	2.3
Bacterial stress	**1.0**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**0.903**	1.000
Actinomycetes	**2.132**	1.000
Gram positive	**7.741**	4.000
Gram negative	**5.469**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.339**	< 0.005
Eukaryotes		
Protozoa	**1.356**	1.300
Mycorrhizal fungi (including VAM)	**1.902**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from poor, to good. The total mass of microbes in your sample was good. Biomasses of other key desirable microbe groups ranged from poor for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good indicating a balance between both groups. However, as the levels of Mycorrhizal fungi were poor, this may indicate a possible pathogen problem. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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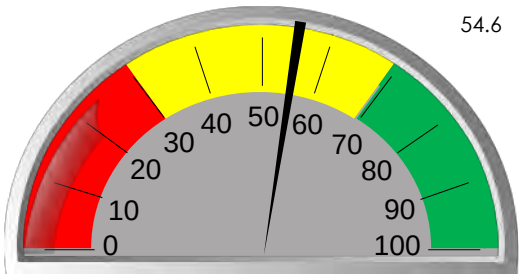
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Wantobg1 - 52885:11** Analysis no.: **2230-11-MWSS** Date: **4/06/2019**

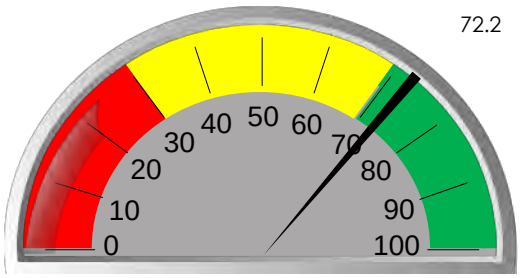
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	Wantobg1 - 52885:11	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-11-MWSS

Microbial Soil Indicators

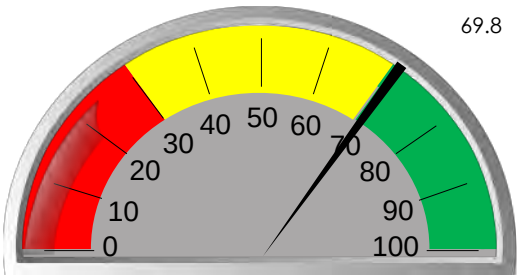
Nutrient solubilisation rate



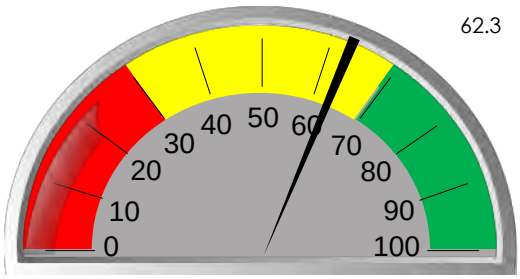
Nutrient cycling rate



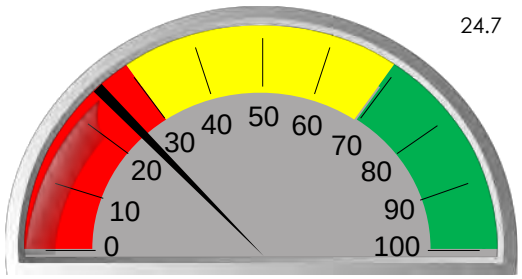
Disease resistance



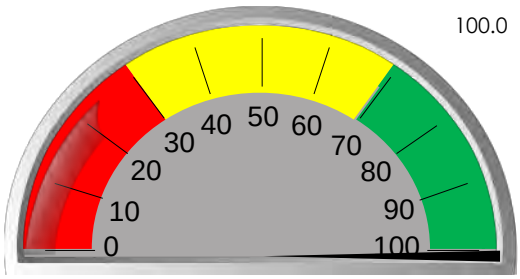
Drought resistance



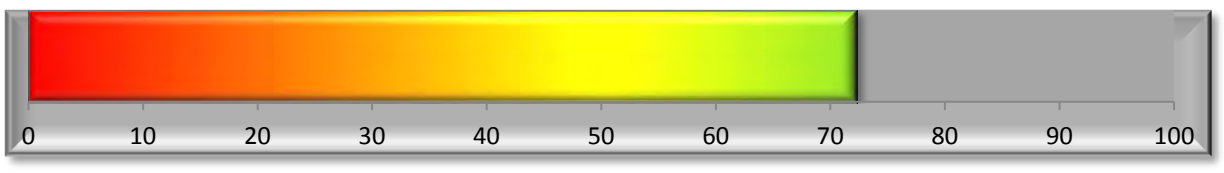
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Wantobg1 - 52885:11** Analysis no.: **2230-11-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**50.8**	50.0
Total bacteria	**15.9**	15.0
Total fungi	**34.5**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**41.2**	80.0
Fungi : Bacteria	**2.2**	2.3
Bacterial stress	**1.0**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**0.846**	1.000
Actinomycetes	**2.893**	1.000
Gram positive	**9.915**	4.000
Gram negative	**5.979**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.650**	< 0.005
Eukaryotes		
Protozoa	**0.449**	1.300
Mycorrhizal fungi (including VAM)	**2.465**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from poor, to good. The total mass of microbes in your sample was good. Biomasses of other key desirable microbe groups ranged from poor for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were poor here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good indicating a balance between both groups. However, as the levels of Mycorrhizal fungi were poor, this may indicate a possible pathogen problem. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

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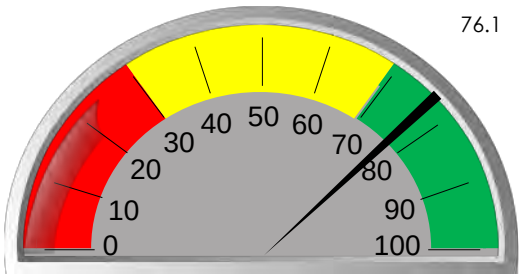
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Wantobg2 - 52885:12** Analysis no.: **2230-12-MWSS** Date: **4/06/2019**

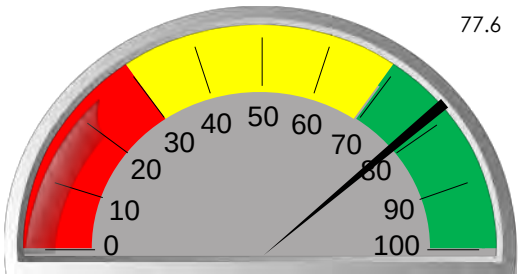
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	Wantobg2 - 52885:12	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-12-MWSS

Microbial Soil Indicators

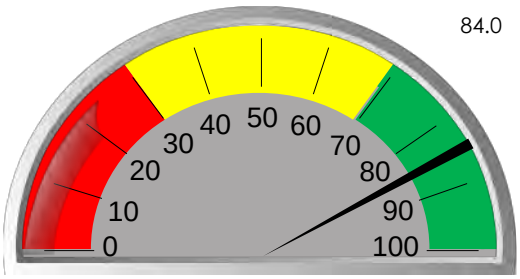
Nutrient solubilisation rate



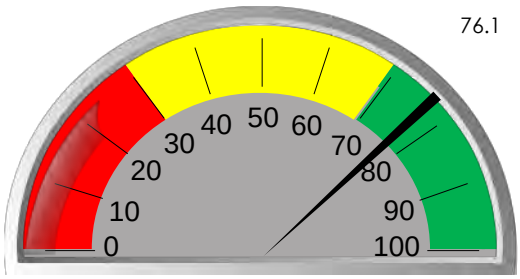
Nutrient cycling rate



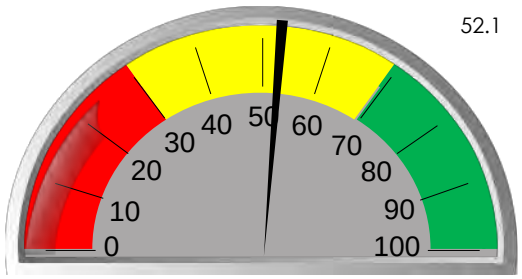
Disease resistance



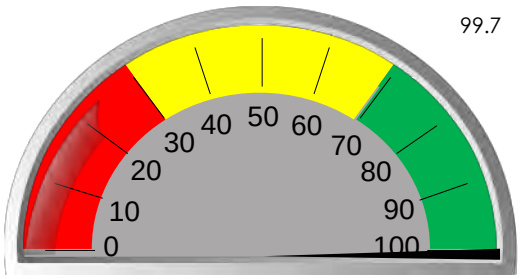
Drought resistance



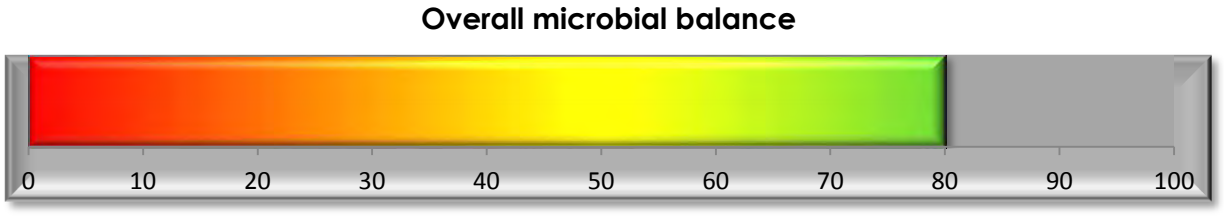
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **Wantobg2 - 52885:12** Analysis no.: **2230-12-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**51.8**	50.0
Total bacteria	**17.5**	15.0
Total fungi	**33.6**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**45.9**	80.0
Fungi : Bacteria	**1.9**	2.3
Bacterial stress	**0.8**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.183**	1.000
Actinomycetes	**3.369**	1.000
Gram positive	**10.830**	4.000
Gram negative	**6.701**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.725**	< 0.005
Eukaryotes		
Protozoa	**0.650**	1.300
Mycorrhizal fungi (including VAM)	**5.213**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators were all good. Except for Nutrient Accessibility, which was fair. The total mass of microbes in your sample was good. Biomasses of other key desirable microbe groups ranged from fair for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were fair here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was lower than the guide but it may not be of concern here. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

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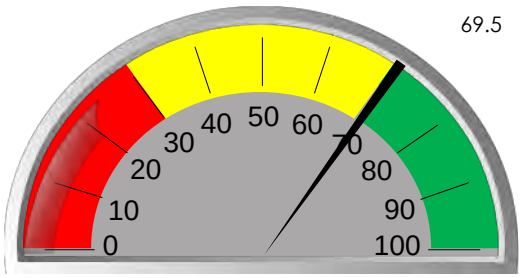
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WarkGB01 - 52885:4** Analysis no.: **2230-4-MWSS** Date: **4/06/2019**

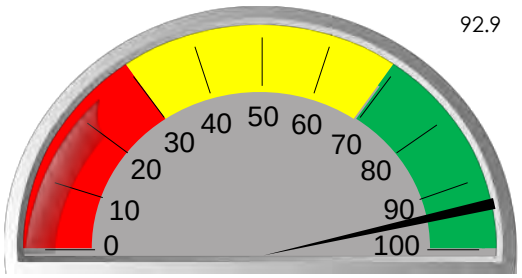
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	WarkGB01 - 52885:4	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-4-MWSS

Microbial Soil Indicators

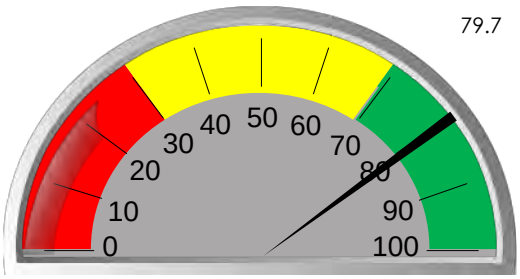
Nutrient solubilisation rate



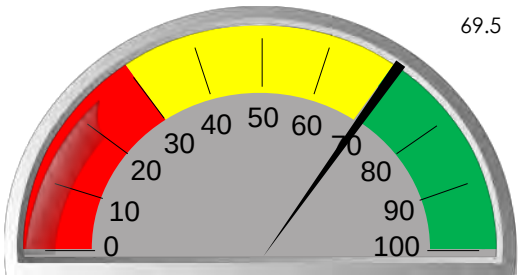
Nutrient cycling rate



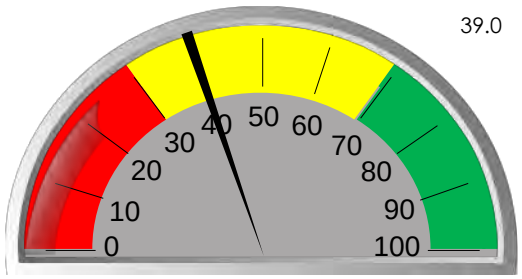
Disease resistance



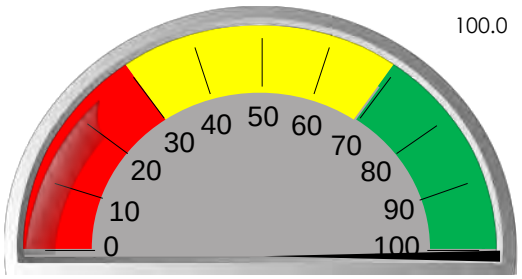
Drought resistance



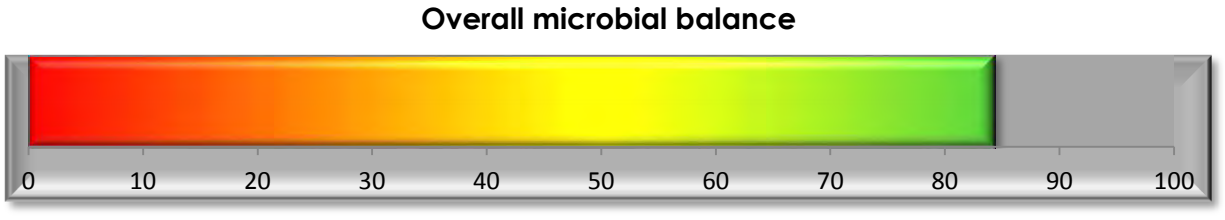
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WarkGB01 - 52885:4** Analysis no.: **2230-4-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**71.7**	50.0
Total bacteria	**17.4**	15.0
Total fungi	**50.4**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**38.1**	80.0
Fungi : Bacteria	**2.9**	2.3
Bacterial stress	**0.8**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.353**	1.000
Actinomycetes	**1.681**	1.000
Gram positive	**9.555**	4.000
Gram negative	**7.873**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.705**	< 0.005
Eukaryotes		
Protozoa	**3.950**	1.300
Mycorrhizal fungi (including VAM)	**3.896**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from fair, to good. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups ranged from fair for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were fair to good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good indicating a balance between both groups. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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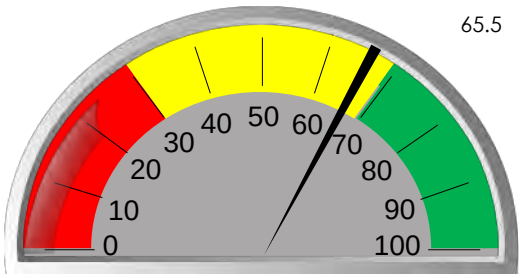
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WarkGB02 - 52885:5** Analysis no.: **2230-5-MWSS** Date: **4/06/2019**

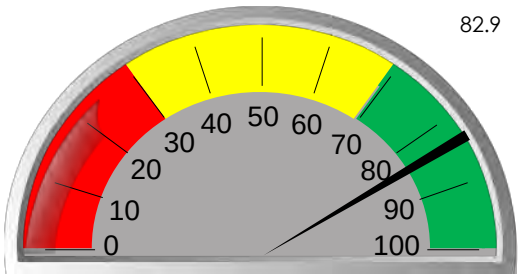
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	WarkGB02 - 52885:5	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-5-MWSS

Microbial Soil Indicators

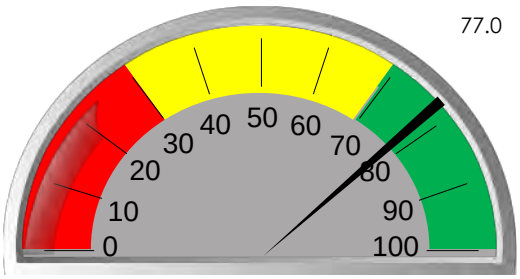
Nutrient solubilisation rate



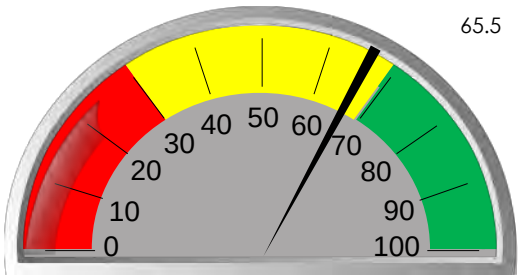
Nutrient cycling rate



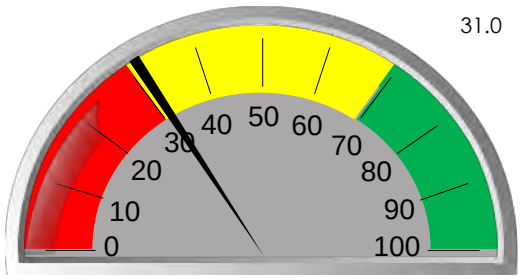
Disease resistance



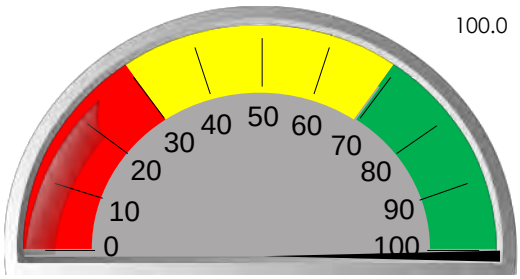
Drought resistance



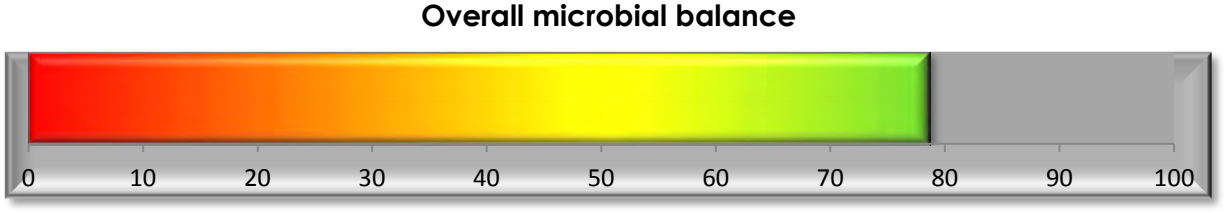
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WarkGB02 - 52885:5** Analysis no.: **2230-5-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**61.6**	50.0
Total bacteria	**17.8**	15.0
Total fungi	**43.0**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**35.5**	80.0
Fungi : Bacteria	**2.4**	2.3
Bacterial stress	**0.9**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.273**	1.000
Actinomycetes	**3.011**	1.000
Gram positive	**10.659**	4.000
Gram negative	**7.093**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.459**	< 0.005
Eukaryotes		
Protozoa	**0.872**	1.300
Mycorrhizal fungi (including VAM)	**3.098**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from fair to poor, to good. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups ranged from fair to poor for Mycorrhizal fungi, to good for Pseudomonas, Actinomycetes, etc. Protozoa, which were fair to fair to good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good indicating a balance between both groups. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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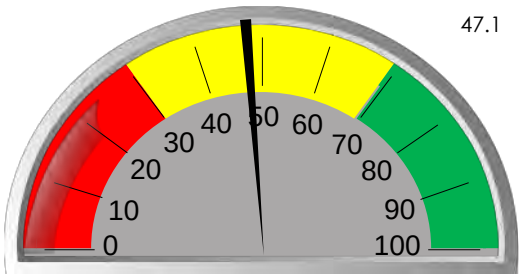
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WarkGB03 - 52885:6** Analysis no.: **2230-6-MWSS** Date: **4/06/2019**

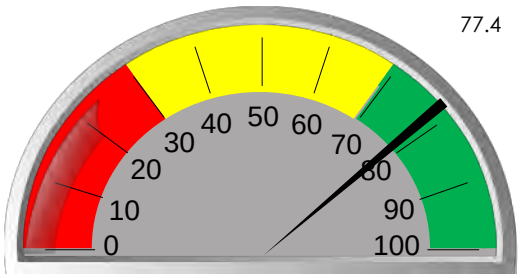
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	WarkGB03 - 52885:6	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-6-MWSS

Microbial Soil Indicators

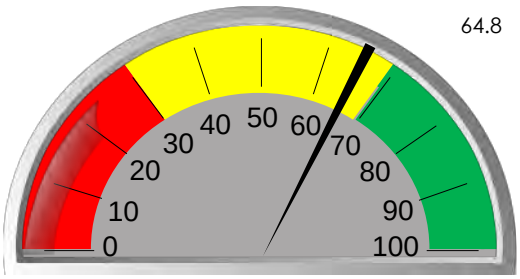
Nutrient solubilisation rate



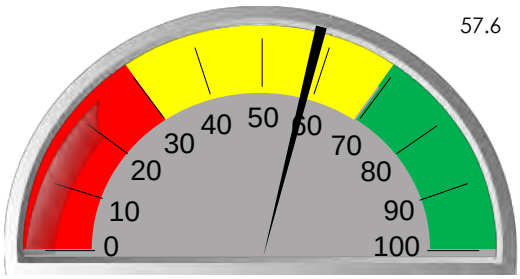
Nutrient cycling rate



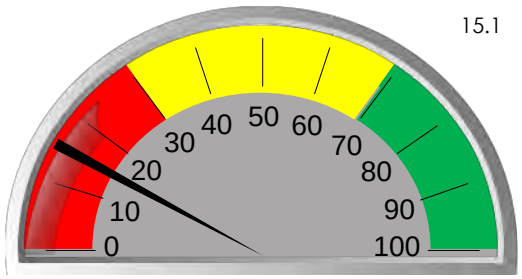
Disease resistance



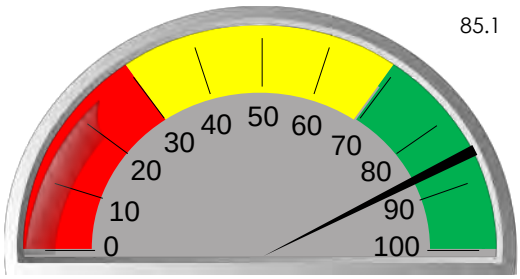
Drought resistance



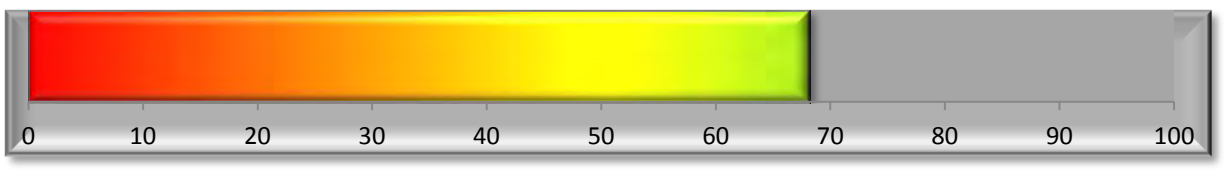
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WarkGB03 - 52885:6** Analysis no.: **2230-6-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**35.2**	50.0
Total bacteria	**10.1**	15.0
Total fungi	**23.7**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**33.1**	80.0
Fungi : Bacteria	**2.3**	2.3
Bacterial stress	**0.9**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**0.791**	1.000
Actinomycetes	**1.615**	1.000
Gram positive	**5.768**	4.000
Gram negative	**4.354**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.287**	< 0.005
Eukaryotes		
Protozoa	**1.372**	1.300
Mycorrhizal fungi (including VAM)	**1.515**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from poor, to good. The total mass of microbes in your sample was fair to good. Biomasses of other key desirable microbe groups ranged from poor for Mycorrhizal fungi, to good for Actinomycetes, etc. Protozoa, which were good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good, however the levels of Mycorrhizal fungi were poor indicating a possible problem with pathogens. These results suggest that management practices should initially focus on building general microbial biomass but mainly Mycorrhizal fungi and Gram negative bacteria. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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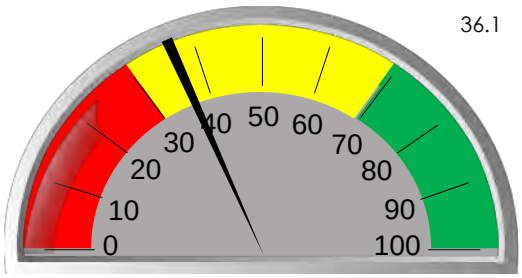
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WarkGB04 - 52885:7** Analysis no.: **2230-7-MWSS** Date: **4/06/2019**

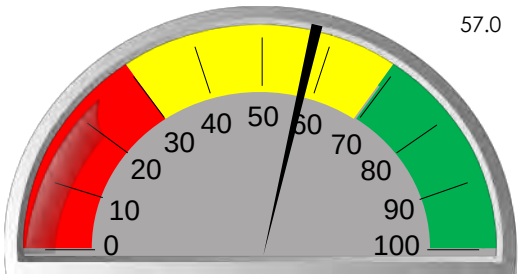
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	WarkGB04 - 52885:7	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-7-MWSS

Microbial Soil Indicators

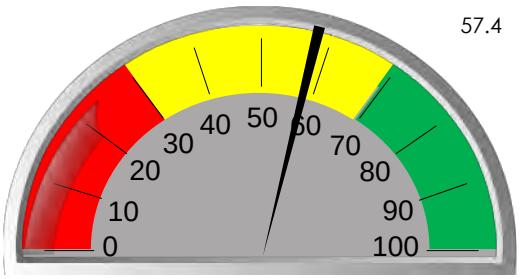
Nutrient solubilisation rate



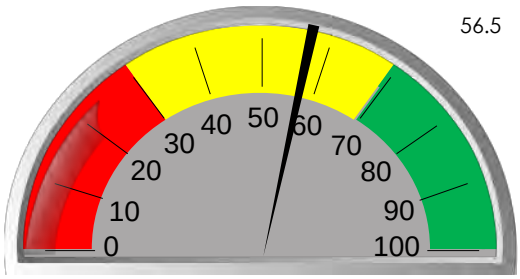
Nutrient cycling rate



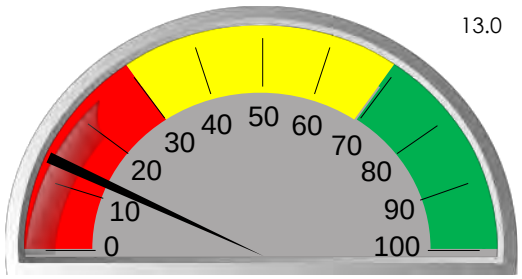
Disease resistance



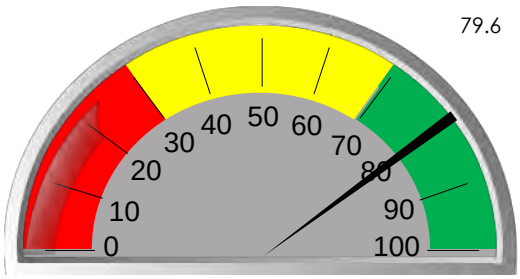
Drought resistance



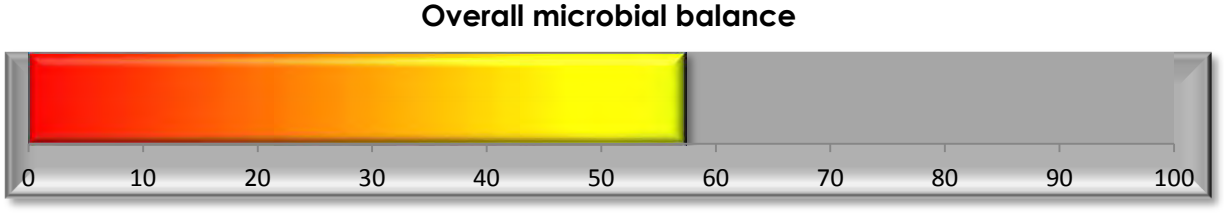
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **WarkGB04 - 52885:7** Analysis no.: **2230-7-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**31.0**	50.0
Total bacteria	**10.5**	15.0
Total fungi	**20.0**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**36.3**	80.0
Fungi : Bacteria	**1.9**	2.3
Bacterial stress	**1.0**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**0.591**	1.000
Actinomycetes	**1.849**	1.000
Gram positive	**6.306**	4.000
Gram negative	**4.237**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.450**	< 0.005
Eukaryotes		
Protozoa	**0.391**	1.300
Mycorrhizal fungi (including VAM)	**1.305**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from poor, to good. The total mass of microbes in your sample was fair to good. Biomasses of other key desirable microbe groups ranged from poor for Mycorrhizal fungi, to good for Actinomycetes, etc. Protozoa, which were poor here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was slightly lower than the guide but it may not be of concern here. These results suggest that management practices should initially focus on building general microbial biomass. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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MICROBE WISE FOR SOIL

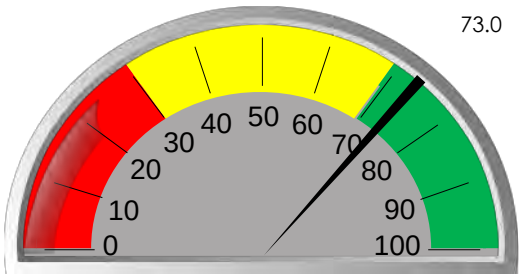
Name: **SESL Australia** Sample: **MTWNPN200901 - 52885:13** Analysis no.: **2230-13-MWSS** Date: **4/06/2019**

Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	MTWNPN200901 - 52885:13	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-13-MWSS

Microbial Soil Indicators

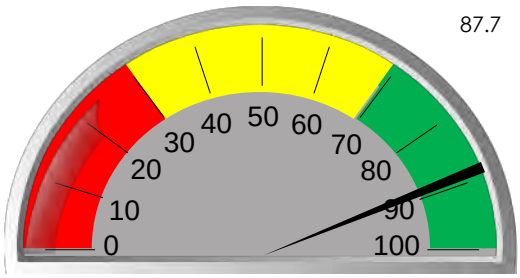
Nutrient solubilisation rate

73.0



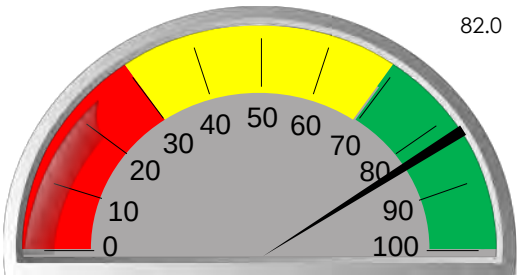
Nutrient cycling rate

87.7



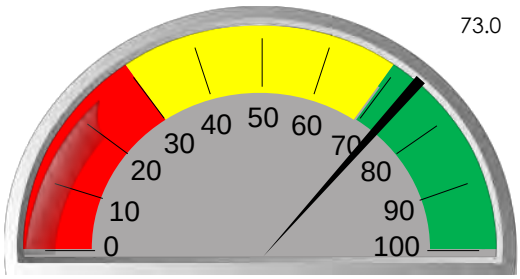
Disease resistance

82.0



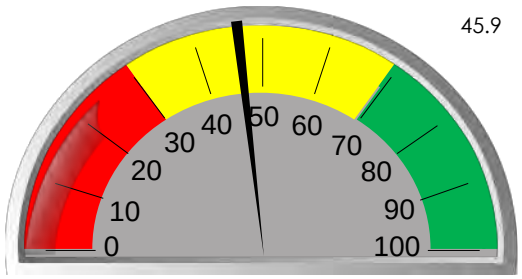
Drought resistance

73.0



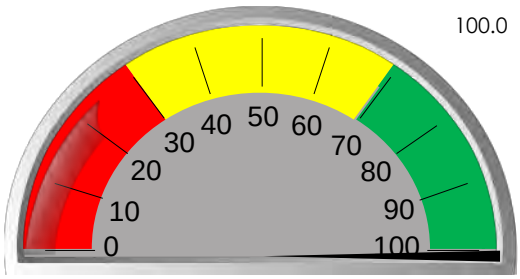
Nutrient accessibility (VAM)

45.9



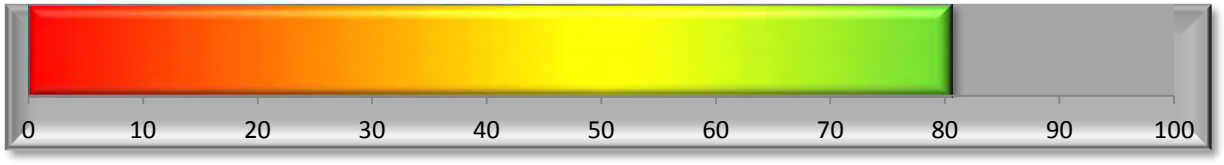
Residue breakdown rate

100.0



Overall microbial balance

80.5



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **MTWNPN200901 - 52885:13** Analysis no.: **2230-13-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**84.7**	50.0
Total bacteria	**12.5**	15.0
Total fungi	**69.6**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**35.8**	80.0
Fungi : Bacteria	**5.6**	2.3
Bacterial stress	**0.5**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.077**	1.000
Actinomycetes	**1.832**	1.000
Gram positive	**6.894**	4.000
Gram negative	**5.596**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.472**	< 0.005
Eukaryotes		
Protozoa	**2.634**	1.300
Mycorrhizal fungi (including VAM)	**4.591**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators were all good. Except for Nutrient Accessibility, which was fair due to intermediate levels of Mycorrhizal fungi. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups ranged from fair, to good. Protozoa, which were good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was highly elevated, and needs to be balanced as Mycorrhizal fungi were fair. These results suggest that management practices should initially focus on building bacteria and Mycorrhizal fungi biomasses. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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MICROBE WISE FOR SOIL

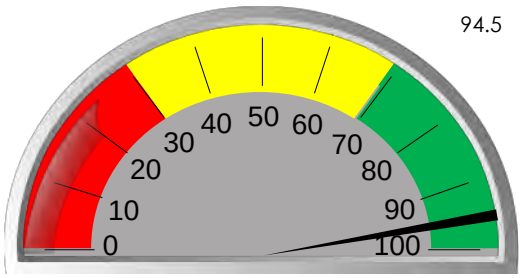
Name: **SESL Australia** Sample: **MTWNPN201101 - 52885:14** Analysis no.: **2230-14-MWSS** Date: **4/06/2019**

Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	MTWNPN201101 - 52885:14	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-14-MWSS

Microbial Soil Indicators

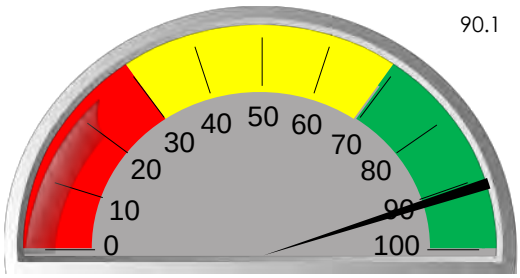
Nutrient solubilisation rate

94.5



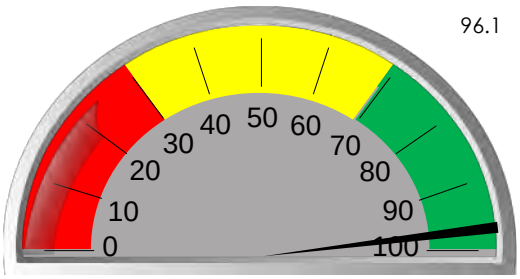
Nutrient cycling rate

90.1



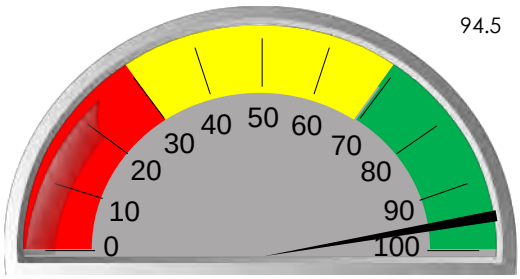
Disease resistance

96.1



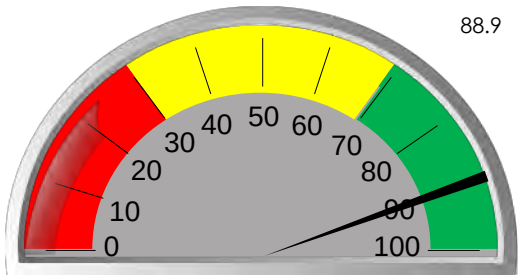
Drought resistance

94.5



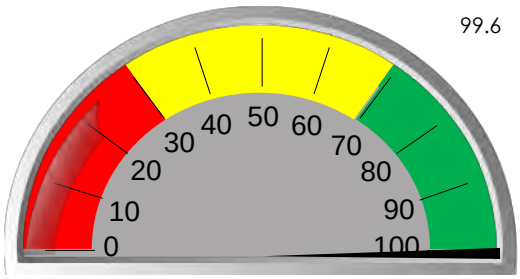
Nutrient accessibility (VAM)

88.9



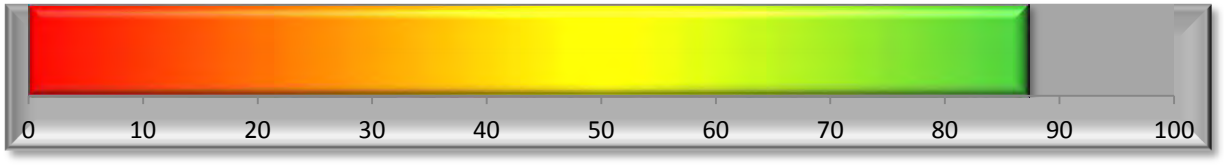
Residue breakdown rate

99.6



Overall microbial balance

87.2



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **MTWNPN201101 - 52885:14** Analysis no.: **2230-14-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**72.8**	50.0
Total bacteria	**13.0**	15.0
Total fungi	**56.8**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**39.2**	80.0
Fungi : Bacteria	**4.4**	2.3
Bacterial stress	**0.2**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.671**	1.000
Actinomycetes	**0.992**	1.000
Gram positive	**6.276**	4.000
Gram negative	**6.706**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.604**	< 0.005
Eukaryotes		
Protozoa	**3.046**	1.300
Mycorrhizal fungi (including VAM)	**8.892**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators were all good. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups were also good. Except for Gram negative bacteria. Protozoa, which were good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was highly elevated due to much higher levels of fungi compared to bacteria and needs to be balanced. These results suggest that management practices should initially focus on building Gram positive bacteria biomass. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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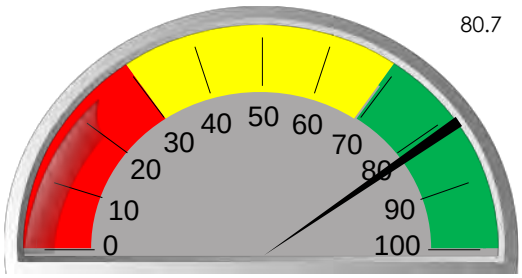
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **NPN 201301 - 52885:26** Analysis no.: **2230-26-MWSS** Date: **4/06/2019**

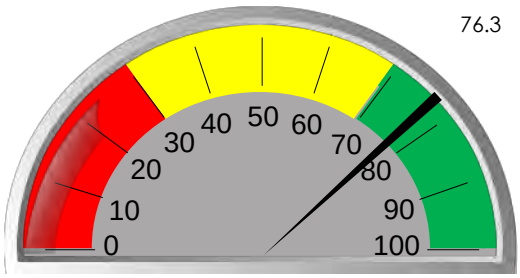
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	NPN 201301 - 52885:26	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-26-MWSS

Microbial Soil Indicators

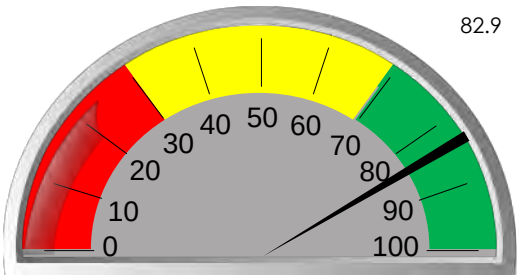
Nutrient solubilisation rate



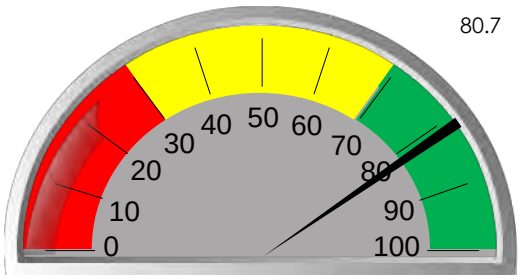
Nutrient cycling rate



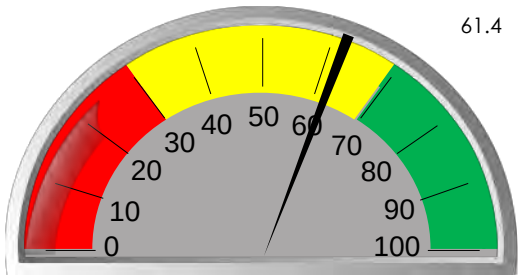
Disease resistance



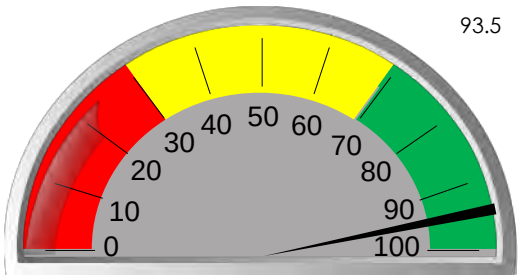
Drought resistance



Nutrient accessibility (VAM)

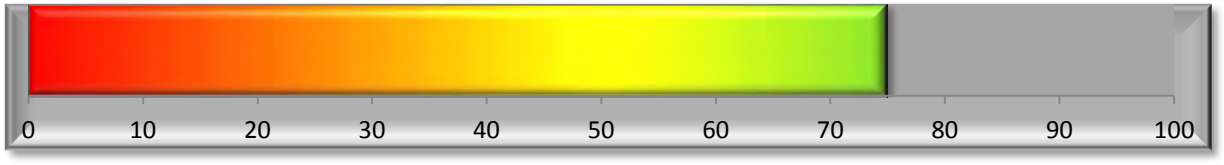


Residue breakdown rate



Overall microbial balance

74.8



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **NPN 201301 - 52885:26** Analysis no.: **2230-26-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**43.6**	50.0
Total bacteria	**8.9**	15.0
Total fungi	**33.7**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**38.1**	80.0
Fungi : Bacteria	**3.8**	2.3
Bacterial stress	**0.3**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.140**	1.000
Actinomycetes	**0.873**	1.000
Gram positive	**4.892**	4.000
Gram negative	**3.983**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.277**	< 0.005
Eukaryotes		
Protozoa	**1.063**	1.300
Mycorrhizal fungi (including VAM)	**6.137**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from fair, to good. The total mass of microbes in your sample was fair to good. Biomasses of other key desirable microbe groups ranged from poor for Gram negative bacteria, to Good for Pseudomonas, Actinomycetes, etc. Protozoa, which were good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was highly elevated due to much higher levels of fungi compared to bacteria and needs to be belanced. These results suggest that management practices should initially focus on building bacteria biomass. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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MICROBE WISE FOR SOIL

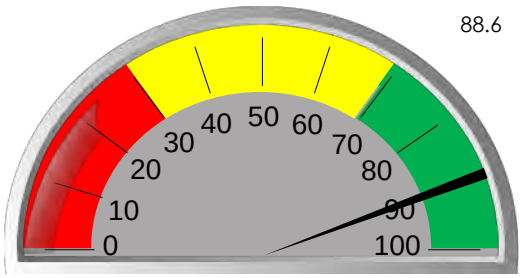
Name: **SESL Australia** Sample: **MTWCDD201101 - 52885:16** Analysis no.: **2230-16-MWSS** Date: **4/06/2019**

Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	MTWCDD201101 - 52885:16	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-16-MWSS

Microbial Soil Indicators

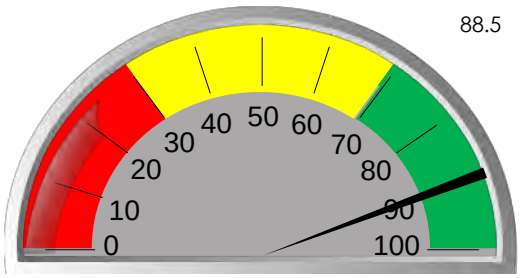
Nutrient solubilisation rate

88.6



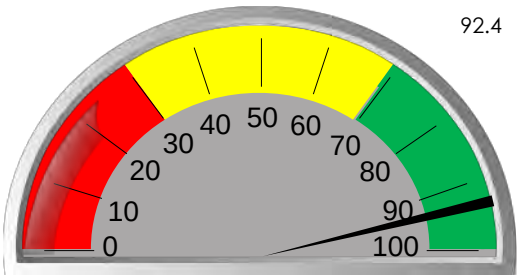
Nutrient cycling rate

88.5



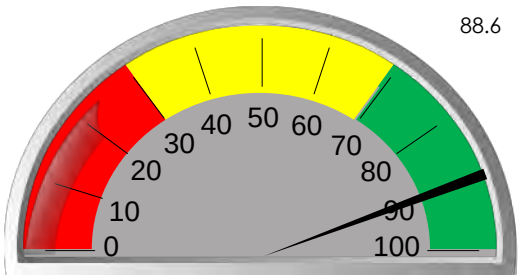
Disease resistance

92.4



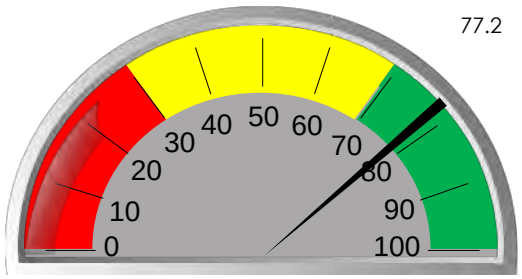
Drought resistance

88.6



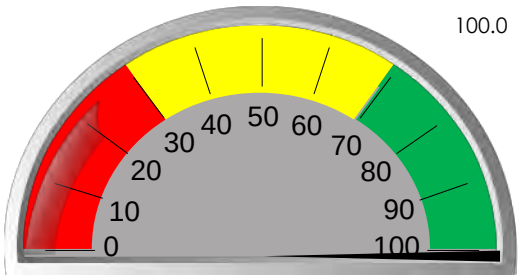
Nutrient accessibility (VAM)

77.2



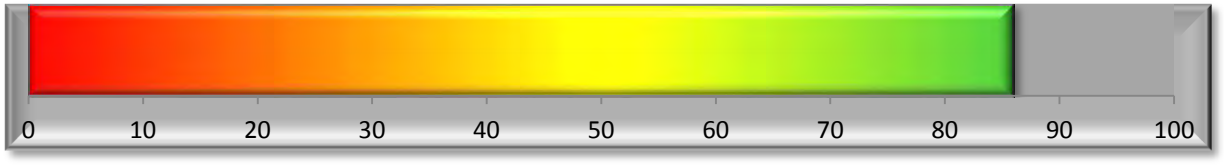
Residue breakdown rate

100.0



Overall microbial balance

85.9



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **MTWCDD201101 - 52885:16** Analysis no.: **2230-16-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**68.0**	50.0
Total bacteria	**13.1**	15.0
Total fungi	**51.2**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**43.8**	80.0
Fungi : Bacteria	**3.9**	2.3
Bacterial stress	**0.4**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.237**	1.000
Actinomycetes	**2.198**	1.000
Gram positive	**7.133**	4.000
Gram negative	**5.955**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.579**	< 0.005
Eukaryotes		
Protozoa	**3.726**	1.300
Mycorrhizal fungi (including VAM)	**7.718**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators were all good. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups were also good. Except for Gram negative bacteria, which were fair. However, with these microbial levels, Nitrogen needs to be monitored as high amounts of this nutrient may be kept by the microbes thus competing with the plant. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was highly elevated due to higher levels of fungi compared to bacteria and needs to be balanced. These results suggest that management practices should initially focus on building Gram negative bacteria biomass and microbial diversity. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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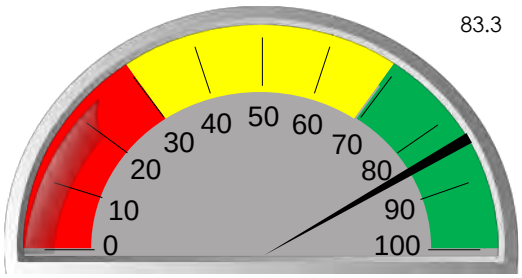
MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **MTWCDD201501 - 52885:17** Analysis no.: **2230-17-MWSS** Date: **4/06/2019**

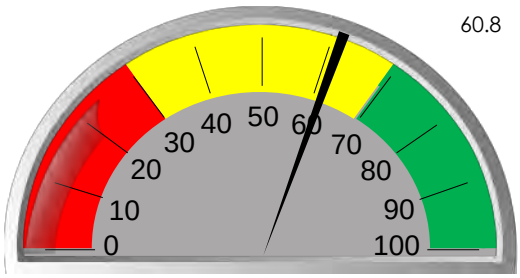
Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	MTWCDD201501 - 52885:17	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-17-MWSS

Microbial Soil Indicators

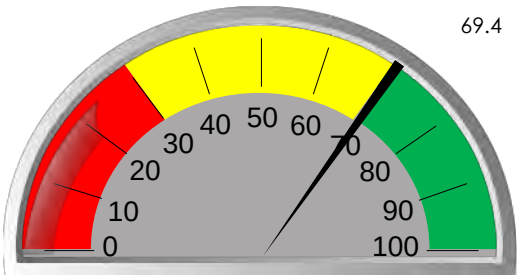
Nutrient solubilisation rate



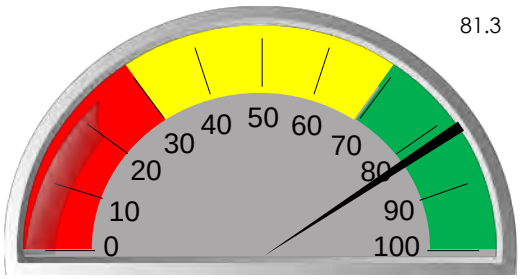
Nutrient cycling rate



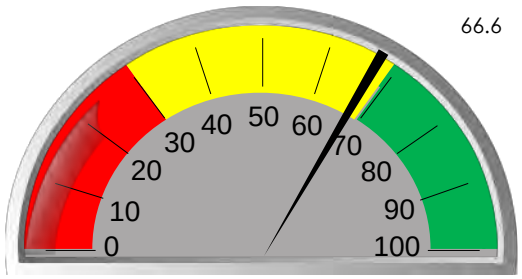
Disease resistance



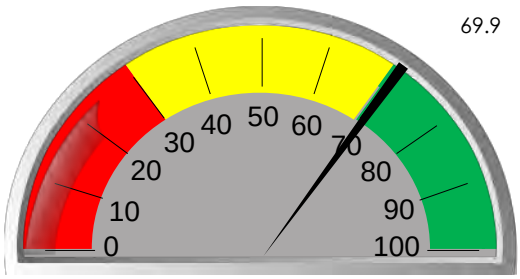
Drought resistance



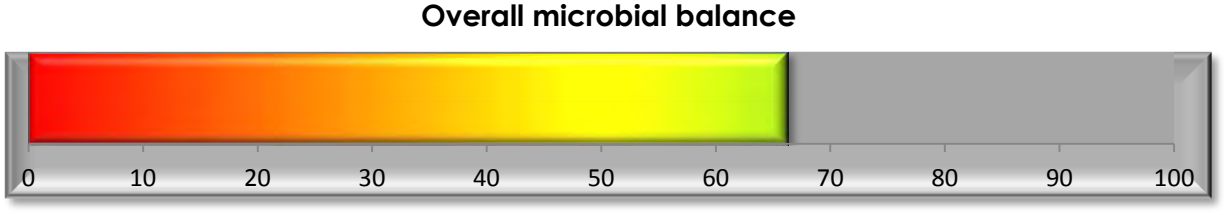
Nutrient accessibility (VAM)



Residue breakdown rate



Overall microbial balance



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **MTWCDD201501 - 52885:17** Analysis no.: **2230-17-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**41.4**	50.0
Total bacteria	**7.2**	15.0
Total fungi	**33.3**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**33.5**	80.0
Fungi : Bacteria	**4.6**	2.3
Bacterial stress	**0.3**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**1.014**	1.000
Actinomycetes	**0.415**	1.000
Gram positive	**3.840**	4.000
Gram negative	**3.338**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.081**	< 0.005
True anaerobes	**0.268**	< 0.005
Eukaryotes		
Protozoa	**0.949**	1.300
Mycorrhizal fungi (including VAM)	**6.663**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from fair to good. The total mass of microbes in your sample was fair to good. Biomasses of other key desirable microbe groups ranged from fair to poor for Gram negative bacteria, to good for Pseudomonas, etc. Protozoa, which were fair to fair to good here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was highly elevated due to much higher levels of fungi compared to bacteria and needs to be balanced. These results suggest that management practices should initially focus on building general microbial biomass but mainly bacteria. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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MICROBE WISE FOR SOIL

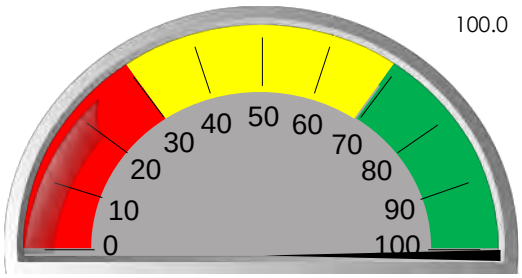
Name: **SESL Australia** Sample: **MTW SPN201401 11/04/19 - 52885:21** Analysis no.: **2230-21-MWSS** Date: **4/06/2019**

Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	MTW SPN201401 11/04/19 - 52885:21	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-21-MWSS

Microbial Soil Indicators

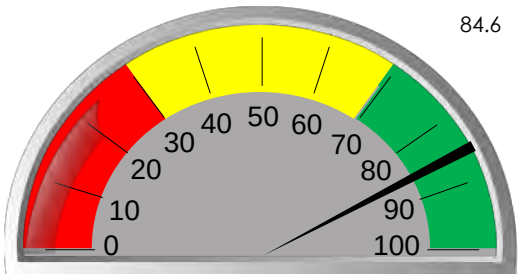
Nutrient solubilisation rate

100.0



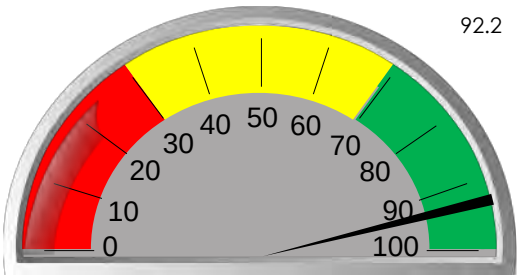
Nutrient cycling rate

84.6



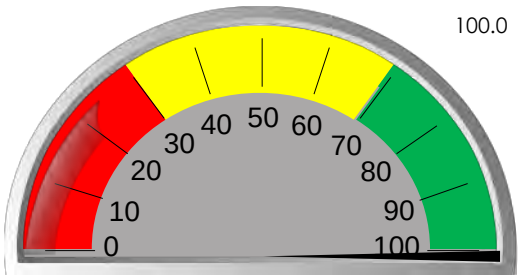
Disease resistance

92.2



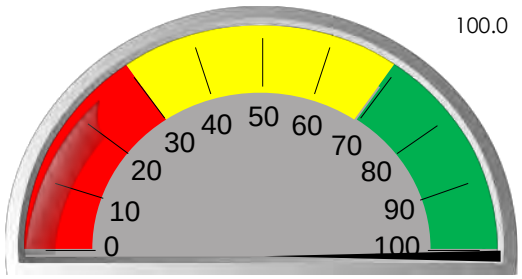
Drought resistance

100.0



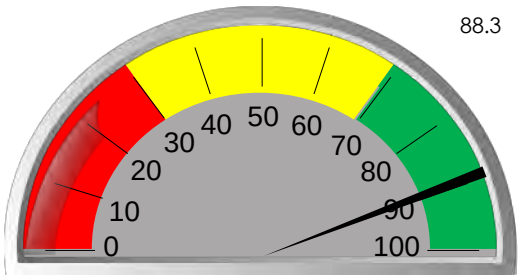
Nutrient accessibility (VAM)

100.0



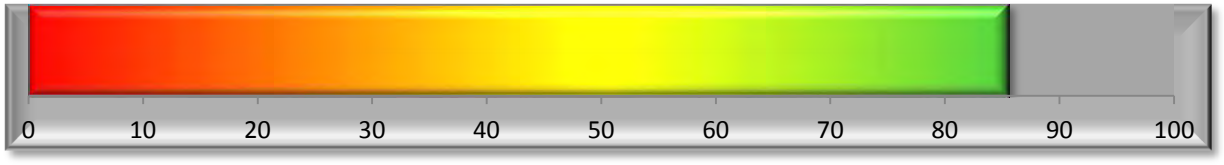
Residue breakdown rate

88.3



Overall microbial balance

85.5



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **MTW SPN201401 11/04/19 - 52885:21** Analysis no.: **2230-21-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**89.9**	50.0
Total bacteria	**13.1**	15.0
Total fungi	**72.2**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**35.2**	80.0
Fungi : Bacteria	**5.5**	2.3
Bacterial stress	**0.3**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**2.007**	1.000
Actinomycetes	**0.766**	1.000
Gram positive	**6.279**	4.000
Gram negative	**6.789**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.000**	< 0.005
True anaerobes	**0.647**	< 0.005
Eukaryotes		
Protozoa	**4.628**	1.300
Mycorrhizal fungi (including VAM)	**13.827**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators were all good. The total mass of microbes in your sample was very good. Biomasses of other key desirable microbe groups were also good. Except for Gram negative bacteria, which was fair to good. However, with these microbial levels Nitrogen needs to be monitored as high amounts of this nutrient may be kept by the microbes thus competing with the plant. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair and needs to be improved. The fungi to bacteria ratio was highly elevated, and needs to be balanced. These results suggest that management practices should initially focus on building bacteria biomass to balance the fungi to bacteria ratio. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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MICROBE WISE FOR SOIL

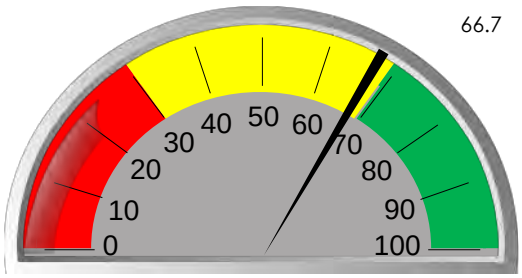
Name: **SESL Australia** Sample: **MTW TDI201501 - 52885:24** Analysis no.: **2230-24-MWSS** Date: **4/06/2019**

Customer name	SESL Australia	**Date received**	4/06/2019
Client name	Harrison Leake	**Agent**	SESL Australia
Sample name	MTW TDI201501 - 52885:24	**Advisor**	Harrison Leake
Crop		**Authorised by**	Dr Maria Manjarrez
Date sampled	31/05/2019	**Analysis no.**	2230-24-MWSS

Microbial Soil Indicators

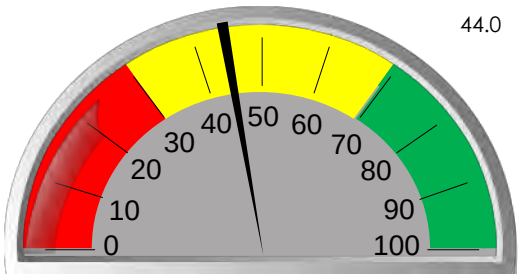
Nutrient solubilisation rate

66.7



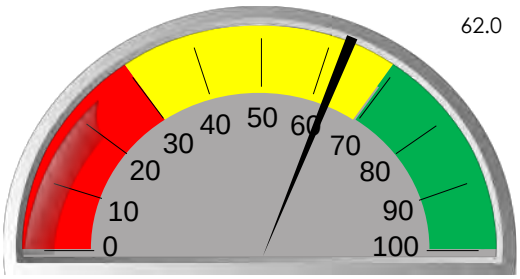
Nutrient cycling rate

44.0



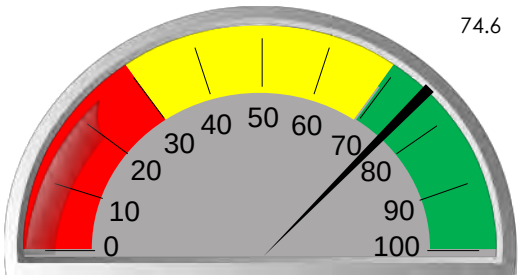
Disease resistance

62.0



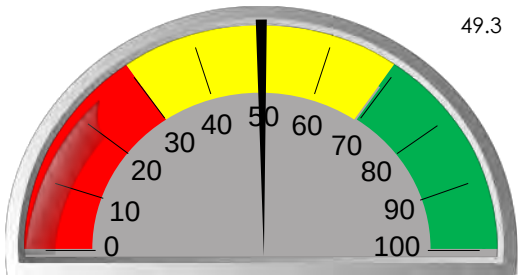
Drought resistance

74.6



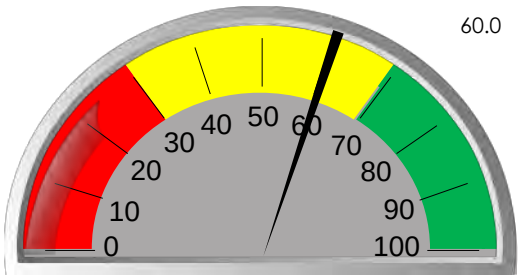
Nutrient accessibility (VAM)

49.3



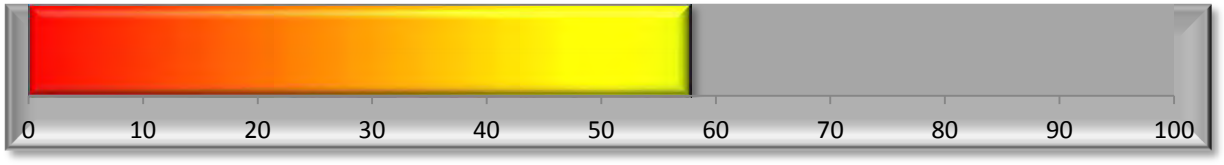
Residue breakdown rate

60.0



Overall microbial balance

57.7



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MICROBE WISE FOR SOIL

Name: **SESL Australia** Sample: **MTW TDI201501 - 52885:24** Analysis no.: **2230-24-MWSS** Date: **4/06/2019**

Key Microbe Groups

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	**32.4**	50.0
Total bacteria	**9.4**	15.0
Total fungi	**22.7**	33.8

Microbial indicators	Yours	Guide
Microbial diversity	**37.8**	80.0
Fungi : Bacteria	**2.4**	2.3
Bacterial stress	**0.4**	< 0.5

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	**0.841**	1.000
Actinomycetes	**0.528**	1.000
Gram positive	**5.796**	4.000
Gram negative	**3.650**	11.000
Methane oxidisers	**0.000**	0.500
Sulphur reducers	**0.149**	< 0.005
True anaerobes	**0.502**	< 0.005
Eukaryotes		
Protozoa	**0.298**	1.300
Mycorrhizal fungi (including VAM)	**4.927**	10.000

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor **Fair** **Good**

Comments

The soil indicators ranged from fair, to good. The total mass of microbes in your sample was fair to good. Biomasses of other key desirable microbe groups ranged from poor for Gram negative bacteria, to Good for Pseudomonas. Protozoa, which were poor here, are important for nutrient transfer and cycling between soil trophic levels, and can be sensitive to agrochemicals, particularly herbicides. True anaerobes were elevated, which indicates that this soil was recently waterlogged, or compacted. Microbial diversity was fair. The fungi to bacteria ratio was good indicating a balance between both groups. These results suggest that management practices should initially focus on building general microbial biomass. Re-test periodically, and once biomass has improved concentrate on minimising True anaerobes, building microbial diversity and biomasses of any key desirable groups that remain low.

Explanations

Microbe Wise for Soil measures the living biomass of key microbial groups important for soil health and productivity directly from your sample. It uses molecular ('DNA type') technology to analyse the unique cell membrane 'fingerprint' of each microbe group to identify and quantify well-known microbial groups essential to important soil processes. The Microbe Wise method allows for some unique features, such as a measure of microbial diversity, a valuable indicator of soil system resilience. Results are presented in a way that allows you to easily assess the microbial health of your soil in detail and indicates what that means in practice. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit **www.microbelabs.com.au** for more information.

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PO Box 230
MELROSE PARK DC, SA 5039
Lab: 1/7, Adelaide Tce
ST MARYS, SA 5042
T +61 (0)8 7127 8982
F +61 (0)8 8277 1548
E info@microbelabs.com.au
www.microbelabs.com.au
ABN 66 145 073 481

How to Interpret Microbe Wise Reports

Does this look like you after your receive your Microbe Wise report?! Read on and we'll explain everything.

Background information

- **Plant roots** exude different amounts of photosynthetically fixed carbon (from 5% to 20%) to the rhizosphere; by doing so, plants are regulating soil microbial communities.
- **Plant root** exudates and all other carbon sources in the soil are the main drivers for soil microbial communities.
- **Extracted fatty acids** (FAMEs, the method used in Microbe Wise) from microbial communities differ among different soil characteristics and agronomic practices: e.g., rhizosphere soil vs non-rhizosphere soil, crop types, soil pH, carbon amendments, crop rotations and cultivation practices.
- **Soil indicators** in Microbe Wise reports are unitless as they are based on the relative abundance of different microbial groups (Table 1).
- **Microbial diversity** is a calculation that describes the variability and relative abundance of microbe groups. The Microbial Diversity Indicator is calculated using the ecological statistic 'True Diversity', which is the exponential of Shannon's Diversity Index.
- **Fungi to bacteria ratio** is based on the relative abundance of each group when compared to total microbial biomass. It may indicate how available soil organic matter is to microbes.
- **Use Table 1** to get an easy understanding of what your results mean in the field.
- **Use Table 2** to learn what the microbial groups in your soil do, and how you can manage them to improve the bio-fertility of your soil.

Interpreting Soil Indicators (page 1 of the report)

Table 1. Microbial groups used in the calculation of Soil Indicators.

Soil Indicator	Microbe groups involved
Nutrient solubilisation	Pseudomonas VAM (Mycorrhizal fungi)
Nutrient Cycling	Total fungi Actinomycetes Gram negative bacteria Protozoa
Disease resistance	Pseudomonas Actinomycetes VAM (Mycorrhizal fungi)
Drought resistance	Gram Positive bacteria VAM
Nutrient accessibility	VAM
Residue breakdown	Total fungi Actinomycetes
Overall microbial balance	All microbial groups Microbial diversity

Interpreting Results and Comments (page 2 of the report)

Table 2. Roles and management options for microbial groups and indicators in Microbe Wise.

Microbe group or Indicator	Role and how to manage
Total Microorganisms	Indicates the overall living microbial biomass. If low: Check for any particular microbe groups that are low (see separate entries for each group). If the biomasses of all microbe groups are generally low: Supply a diverse range of carbon compounds to build Total Bacteria, Total Fungi and Protozoa (see separate entries for these groups).
Total bacteria	Indicates the overall living bacterial biomass. If low: Supply simple and semi-complex carbon compounds, such as sugars, starches, proteins (fish and blood meal), compost tea and legume residues.
Total fungi	Indicates the overall living fungal biomass. If low: Increase carbon in a resistant form, such as organic residues that contain cellulose and lignin (e.g., broadacre crop residues, woody residues, matured compost, compost juice, humic acids).
Pseudomonas	Pseudomonas are Gram negative (see separate entry, below). If low (under aerobic conditions): Supply simple carbohydrates, such as sugars.
Actinomycetes	Actinomycetes are Gram positive (see separate entry, below). If low: Increase semi-complex carbohydrates and compounds, such as starches, proteins (fish and blood meal), composted animal manure, and other organic residues.
Gram positive bacteria	This group includes numerous well-known plant growth-promoting rhizobacteria (PGPR), such as *Bacillus subtilis*. If low: Supply semi-complex carbohydrates and compounds, such as starches, proteins (fish and blood meal) and composted animal manure.
Gram negative bacteria	This group includes some well-known plant growth promoting Rhizobacteria (PGPR), such as *Pseudomonas fluorescens*, free-living nitrogen fixing bacteria (FLNFB), such as *Azotobacter vinelandii*, and nitrifying bacteria, such as *Nitrosomonas* spp. If low: Supply simple carbohydrates, such as sugars, or apply compost tea.
True anaerobes	These multiply when there is a lack of oxygen in the soil and are undesirable. If high: Identify the cause (e.g., waterlogging or compaction) and implement physical solutions where practicable, such as better irrigation management, drainage works or deep ripping.
Sulphur reducers	Sulphur reducers are Anaerobic and Gram negative, and are undesirable. If high: Implement physical solutions where practicable, such as better irrigation management, drainage works or deep ripping.

Microbe group or Indicator	Role and how to manage
Protozoa	Protozoa are neither bacteria nor fungi, but rather like 'micro animals. If low: Increase Total bacteria biomass (see separate entry) if that is low; minimise agrochemical inputs, particularly herbicides; apply a straw tea (search the internet using the terms "straw brew protozoa" for more information).
Mycorrhizal fungi (including VAM)	Mycorrhizal fungi (including VAM) are a key indicator of soil microbial health. If low: Use crop rotations with mycorrhizal host crops such as legumes, supply matured compost, inoculate with a multi-species mycorrhizal fungi inoculum, avoid high P and N fertilizer applications.
Microbial diversity	Indicates the number and abundance of different types of microbes present in the soil. If low: Determine if any particular desirable microbial groups are low, and if so increase them. Otherwise supply a mixture of carbon compounds; simple carbohydrates (e.g., sugars); semi-complex carbon compounds (e.g., molasses, starches, fish and blood meal); complex carbon compounds (e.g. matured compost) and resistant carbon compounds (e.g. crop residues).
Fungi to Bacteria ratio	The Fungi to Bacteria ratio should be considered in conjunction with the biomasses of Total fungi and Total bacteria. If the Fungi to Bacteria ratio is HIGH, and: + Total bacteria biomass is very good: The ratio is probably indicative of the type of agricultural system + Total bacteria biomass is less than very good: Increase bacterial biomass (see separate entry for Total Bacteria) If the Fungi to bacteria ratio is LOW, and: + Total fungi biomass is very good: The ratio is probably indicative of the type of agricultural system or recent soil management practices, such as fertiliser application. + Total fungi biomass is less than very good: Increase fungal biomass (see separate entry for Total Fungi)
Bacterial stress	Under conditions of stress, bacteria change some components of their cell membranes, which can be measured using Microbe Wise. If high: Determine the cause of the stress and take actions to reduce it.

[end of document]