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## LAND RESOURCE ASSESSMENT
## SEQ 2001 REPORT 4

# Soils and Land Suitability Albert River – Chardons Bridge to Boylands

# South East Queensland

D.T. Malcolm, J.K. Loi,
and J.V. Armbruster
Resource Sciences Centre

NATURAL RESOURCES

Department of Natural Resources,
Brisbane Queensland 1998

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QUEENSLAND GOVERNMENT

**Land Resources Bulletin Series**

# LAND RESOURCE ASSESSMENT SEQ 2001

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## SOILS AND LAND SUITABILITY

## ALBERT RIVER – CHARDONS BRIDGE TO BOYLANDS

## SOUTH EAST QUEENSLAND

**D. T. Malcolm, J. K. Loi and J. V. Armbruster**
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This publication is for limited distribution. It is intended as an aid for strategic planning by local councils in south-eastern Queensland. The information in this report is derived from 1:50 000 scale land resource mapping which is an adequate scale for planning purposes. In assessing individual applications for subdivision a detailed assessment of land resources is usually necessary. Explicit evaluation of economic factors such as the size of production units or crop viability have not been included in the suitability assessment as they are not considered relevant to the quality of the land resource (State Planning Policy 1/92). This study has been funded by treasury special funds, with additional contributions from the Beaudesert Shire Council.



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## Summary

Approximately 2570 ha of land along the Albert River from Chardons Bridge to Boylands was surveyed at a medium intensity (1:50 000) from July to August 1995. The area is located approximately 12 km north east of Beaudesert.

The soil and land characteristics of 77 sites were described in detail. These, along with other less detailed field site observations and aerial photograph interpretation, identified 63 unique map areas (UMAs).

Two broad groups of soils were identified : *soils developed on alluvial plains and terraces* and *soils developed on rises.*

Each unique map area or UMA was assessed for its suitability for 9 agricultural land uses: s*orghum, maize, sunflower, oats, wheat, barley, lucerne, crucifers,* and *rye grass*.

Based on the suitability assessments, land was grouped into agricultural land classes as per the *Planning Guidelines* (DPI/DHLGP,1993). 1270 ha was identified as **Class A** (crop land); 427 ha as **Class B** (limited crop land) and 662 ha as **Class C** (pasture land).

A soil and landform map, a land use map and a series of land suitability maps at 1:50 000 scale accompany this report.

## 1. INTRODUCTION

The SEQ 2001 was an initiative of the Regional Planning Advisory Group (1993). The initiative involved the collection of land resources of priority areas of south east Queensland at a scale of 1:50 000 providing information to address the planning and management needs required for sustainable land use.

The project aim was to provide the appropriate information in a GIS form to assist shire councils in their strategic and development control plans and tackling concerns such as:

- rapid population growth
- rezoning of rural land to rural–residential land
- conflict between agricultural and non–agricultural uses
- degradation of rural land
- the need for land uses to be ecologically and economically sustainable and
- over exploitation of natural resources

The medium intensity land resource survey at 1:50 000 scale also provided an understanding of the physical constraints on land use and the criteria by which land suitability for specific land uses is determined. Land use patterns with maximum community benefit will result when all stakeholders understand the constraints on land use. The project was funded by Treasury special with additional funding assistance from Beaudesert Shire Council.

The Chardons Bridge to Boylands area was identified by the Beaudesert Shire Council as requiring more detailed land resource information for planning purposes. The study area is located along the Albert River downstream of the proposed dam site approximately 12km northeast of Beaudesert (Figure 1). It is the fourth in a series of land resource assessment surveys being undertaken as part of the South–east Queensland (SEQ) 2001 land resource project, which was a recommendation of the Regional Planning Advisory Group (1993).

A field survey of soils, topography, vegetation and land use was conducted from July to August 1995. The results of the land resource survey and suitability assessment for nine crops are presented in the report and on the accompanying maps.

## 2. METHODOLOGY

A free survey method (Reid, 1988) of field investigation was adopted over the study area of 2571 ha after initial aerial photograph interpretation. The locations of survey sites in the area were based on predicted soil and landform variability, and site accessibility.

Land and soil characteristics of 77 sites were fully described using the terminology of McDonald *et al.*(1990). From these observations and further aerial photograph interpretation, 64 mapping units or unique map areas (UMAs) were identified.

UMAs were assessed for their suitability for nine agricultural land uses:- s*orghum, maize, sunflower, oats, wheat, barley, lucerne, crucifers (cabbages, cauliflowers)* and *rye grass*.

Assessment of land suitability followed the Guidelines for Agricultural Land Evaluation in Queensland (Land Resource Branch Staff, 1990). A soils and landform map as well as an agricultural land class map were created at 1:50 000 scale. Land suitability maps for individual crop groups at 1:50 000 scale and a current land use map are also available if required.

The current land use map was prepared using colour aerial photograph interpretation and ground truthing.

Four sites representative of the major soils in the area were sampled for detailed chemical analysis . These soil samples were analysed at the Department of Natural Resources Analytical Centre, Indooroopilly. Interpreted results are given in this report.

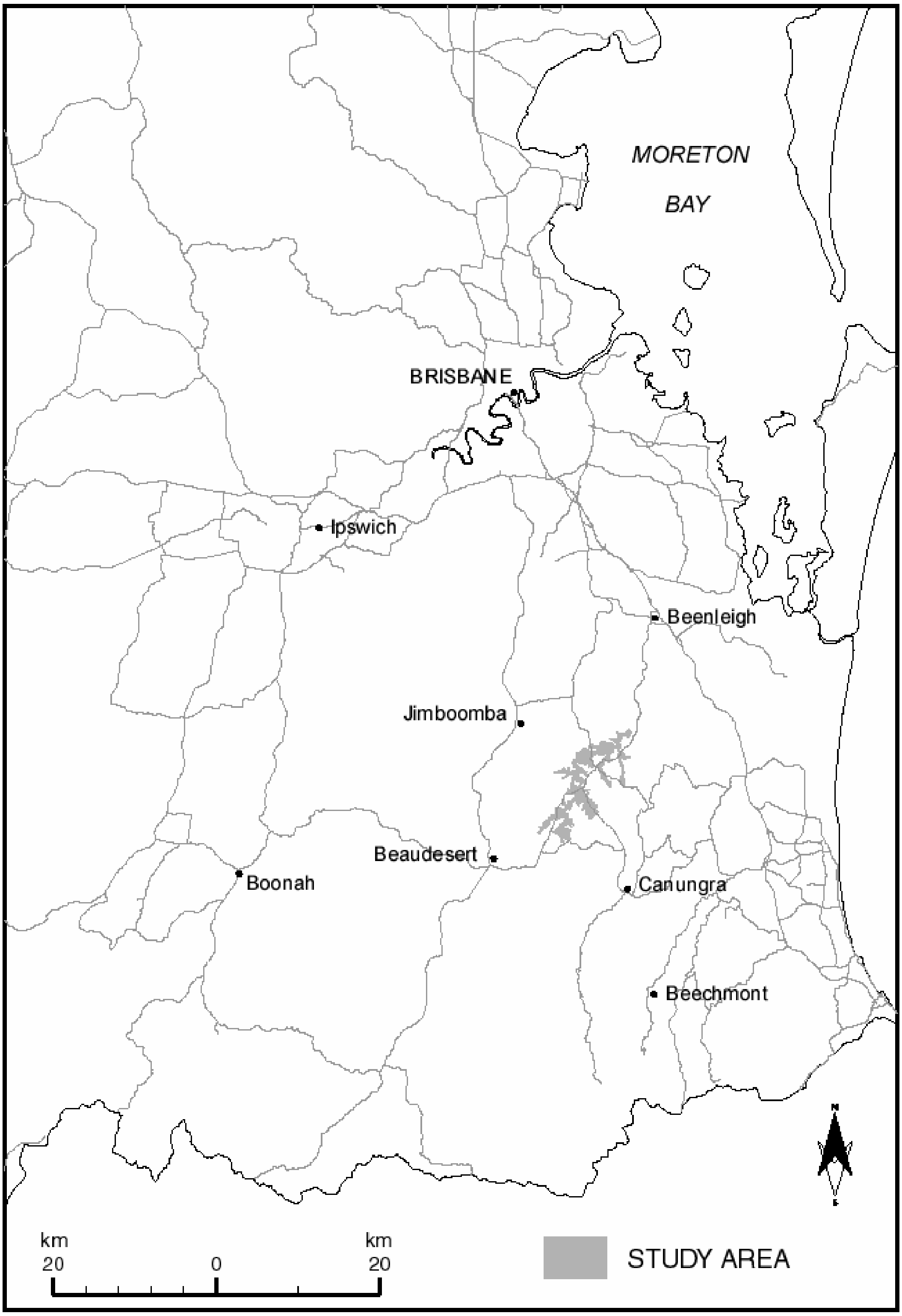


**Figure 1.** Location of Chardons Bridge to Boylands area

## 3. PHYSICAL ENVIRONMENT

### Climate

The closest long-term climatic data recording station is at Beaudesert 12 km south-west of the area. The average rainfall at Beaudesert for the period 1887 to 1993 was 926 mm per year with November to March having the highest monthly rainfall of more than 100 mm (Table 1). Lowest rainfall (of less than 50 mm per month) occurs from July to September (Bureau of Meteorology, 1994). Average annual evaporation is 1745mm.

Average monthly evaporation for Beaudesert (recorded from 1945-1974) ranges from a low of 75 mm in July to a high of 200 mm in December and January. Water deficits are evident especially in the low rainfall months. While no information on frost is on record, anecdotal evidence suggests that an average of six frosts occur in the valley floors during periods of low temperatures in the winter months of June, July and August.

Mean summer maximum daily temperature at Beaudesert is 29-31°C and minimum temperature is 16-19°C. For winter, the mean maximum temperature is 21-22. 5°C and mean minimum temperature is 5-6. 5°C (Bureau of Meteorology, 1994). The temperature data record from 1967 to 1979 is shown in Table 1.

**Table 1.** Mean monthly rainfall and daily maximum and minimum temperatures for Beaudesert area (Recorded at 28° 0' S, 153° 0' E)

| Month | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sept | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean rainfall (mm) | 208 | 209 | 195 | 99 | 92 | 102 | 78 | 49 | 51 | 96 | 104 | 139 | 926 |
| Mean evap (mm) (1945-1974) | 200 | 175 | 175 | 125 | 100 | 77 | 75 | 120 | 133 | 175 | 190 | 200 | 1745 |
| Max temp daily $^{o}$(C) | 31 | 30 | 29 | 28 | 24 | 22 | 21 | 22 | 25 | 27 | 30 | 31 | |
| Min temp daily $^{o}$(C) | 19 | 19 | 17 | 14 | 10 | 7 | 5 | 6 | 9 | 13 | 16 | 18 | |

## Geology and terrain

There are four major geological formations in the area (Figure 2):

- Walloon Coal Measures consisting of shale, siltstone and sandstone of mid Jurassic age.
- Marburg Formation consisting of sandstone, siltstone and shale of early to mid Jurassic age.
- Woogooroo Subgroup of the Bundamba group consisting of sandstone conglomerate and siltstone of early Jurassic age.
- Quaternary alluvium.

The present landform is the result of geomorphological processes subsequent to the uplifting of the area and sea level changes in the Pleistocene (less than 2 000 000 years ago). These processes have created undulating to rolling topography of predominantly 9-30 m local relief. Slopes are generally less than 15%.

Sandstone is the major rock type in the area and the soils developed on this material have predominantly sandy topsoils. The low lying plains and terraces comprise Pleistocene to Holocene alluvial deposits (approximately 10 000 - 2 000 000 years of age) which consist of sand, silt, gravel and clay. Clay however is the dominant parent material. The extent of these deposits (shown on the 1:250 000 scale geology map by Cranfield *et al.*, 1976) have been more accurately delineated by aerial photograph interpretation and field inspection (Figure 2).

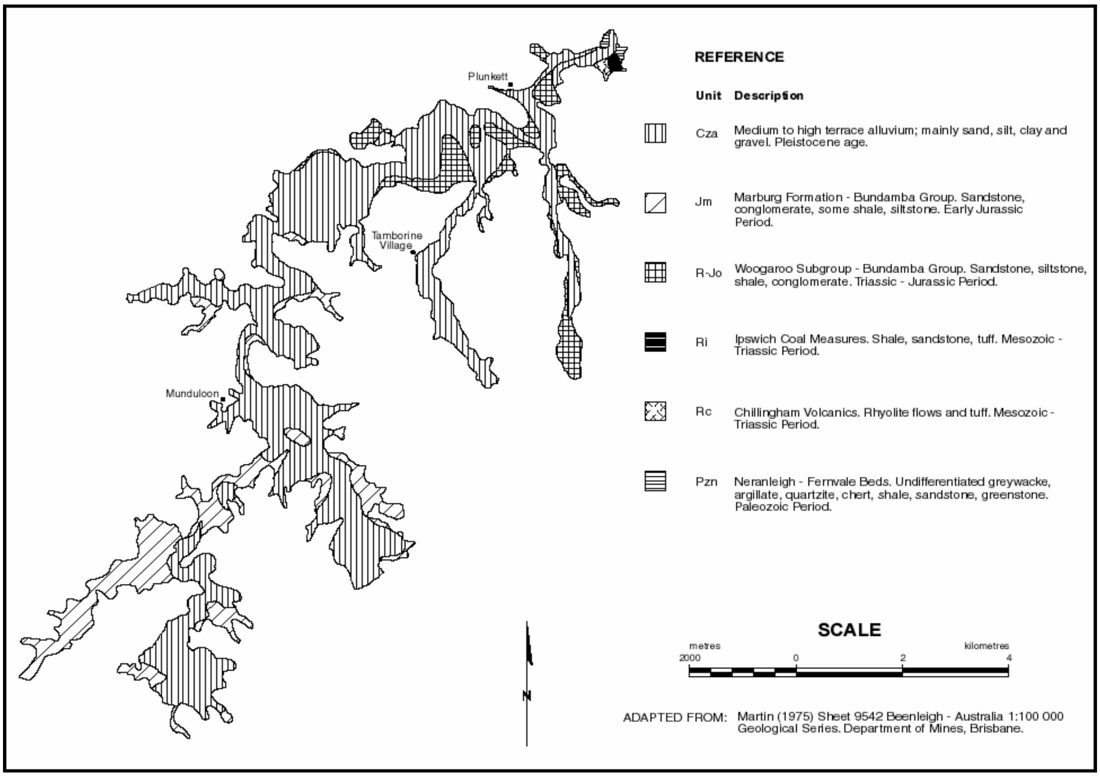


**Figure 2 :** Geology map

## Hydrology

*Surface water*

The Albert River is the largest tributary of the Logan River. A Department of Primary Industries gauging station at Bromfleet has recorded mean monthly discharges ranging from a maximum of 1621 megalitres per day to a minimum of 40 megalitres per day from 1927 to 1994 with an overall mean of 341 megalitres per day. The major water resource issue within this area is the availability and supply of surface water during dry periods. Conditional licencing is undertaken with flood harvesting and farm storage recommended. (Dale, *pers. comm*. 1995).

Quantities of irrigation water available vary considerably depending on rainfall. Water usage is restricted to domestic and stock use during dry years. Pumping is regulated by pump size and area of land to be irrigated. Current recommendations authorise a maximum output of 25 litres a second (with a preferred maximum pump size of 65 mm) on the Albert River and a maximum output of 15 litres a second on all tributaries (with preferred maximum pump size of 40 mm) (Jefferies, 1995). Further information is available from the Department of Primary Industries, Brisbane District Office.

Due to the recent dry conditions, pumping has been restricted to the upper reaches of the Albert River. Pumping from the lower reaches is currently prohibited.

Construction of Glendower dam is expected to commence on the Albert river in 2010 and should be operational by 2015. At this early stage, farmers on the Albert River are not expected to have any changes to the volumes of water available for irrigation both up and downstream of the dam (Jefferies, *pers. comm*. 1995).

*Groundwater*

There are no declared aquifers in the area and therefore there are no current restrictions on groundwater pumping (Jefferies, *pers. comm*). A groundwater investigation completed by the Queensland Water Resources Commission in 1958 indicated that water supplies are available at depths of 20 to 30 metres. Final pumping rates ranged from 10,800 to 36,000 litres per hour. Although these volumes would not be suitable for crops requiring high levels of irrigation, they would be sufficient for low volume irrigation. Water samples taken for chemical analyses on the 13th October 1992 indicated high levels in all of sodium (600 mg/L), chloride (1250 mg/L) and bicarbonate (850 mg/L). Electrical conductivity readings were also high (4850 mS/cm). Conclusions of the government chemical laboratories were :

- the water does not comply with NHMRC (1987) drinking water guidelines for chloride, hardness, manganese, sodium and dissolved solids
- the water is of marginal quality for irrigation
- the water is of marginal quality for some stock

**Land use**

The main categories of land use in the area are shown in Table 2. Most of the alluvial plains and terraces are used for beef farming, dairying and mixed cropping (maize, lucerne, sorghum, oats etc). Beef fattening occupies 864 ha or approximately 34% of the area. Dairying and mixed cropping only occupy 12% and 4. 5% respectively. On the rises horses/greyhounds, turf farming and mixed livestock (cattle and horses) are dominant, all occupying approximately 10% of the area.

**Table 2.** Land use of the Chardons Bridge to Boylands area

| **Land Use** | **Area (ha)** | **Area (%)** |
|---|---:|---:|
| Residential accommodation (>0. 6 ha) | 191.0 | 7. 4 |
| Mixed livestock (non-commercial) | 266.0 | 10.0 |
| Cattle (beef) | 863.0 | 34.0 |
| Mixed cropping and beef | 98.0 | 3.8 |
| Intensive dairy | 306.0 | 12.0 |
| Horses or greyhounds (studs or racing) | 276.0 | 11.0 |
| Horticulture (vegetables or nurseries) | 142.0 | 5.5 |
| Turf farming | 140.0 | 5.4 |
| Quarries | 16.0 | 0.6 |
| Vacant land not elsewhere classified | 4.7 | 0.2 |
| Protected area management and public open space | 55.0 | 2.1 |
| Creek reserves | 146.0 | 5.7 |
| Road reserves | 68.0 | 2.6 |
| **Total** | **2571.7** | |

## 4. SOILS

The soils in the area can be broadly differentiated into two landscape units-soils derived from Quaternary alluvial material and soils derived from sandstones and shales of the Marburg formation and Walloon Coal Measures on undulating rises. Soils of much of the study area have not been previously investigated; however where soils were found to be the same as those already identified in surveys of surrounding areas (Beckman, 1967; Paton, 1971; Christianos *et al.*, 1986 and Loi *et al*, 1995), the same soil names were used.

The main criteria used in establishing soil types were thickness and texture of A horizons, bleached or unbleached nature of A2 horizons, colour of upper B horizons, texture of B horizons and pH trend. (See Appendix 2 for details)

A total of seven soil types have been mapped in the area with six occurring on alluvial plains and terraces and the remainder on rises. Each occurrence of a mapping unit is known as a unique map area (UMA). Each UMA was given a unique number and individually described on a UMA record type in terms of soils and landform. The dominance of the major soil and the range of associated soils may vary among the UMA's of each mapping unit. The distribution and extent of soils is shown on the Soils and Landform map.

### Soils on level to undulating alluvial plains and terraces

Soils developed on the alluvial plains and terraces occupy approximately 1872 ha or 73 % of the study area and can vary over short distances from predominantly clay soils to sandy soils. This variability is a result of fluctuations in sea level which caused the river to cut through differing geologies upstream and deposit them downstream. The fluctuations in sea level were caused by melting of the polar ice caps in the Pleistocene.

Six soils have been identified: *Bell, Bridge, Logan, Maclean, Payne* and *Rockford.* The main characteristics of these soils are shown in Table 3. A brief description of each soil is given below.

*Bell (Bl).* *Bell* soils occur on low-level terraces associated with the Albert River and some of its tributaries such as Canungra Creek and Flagstone Creek. The soil profile has a 0. 15 m pedal light to light medium clay surface overlying black pedal medium clay. The subsoil has a few distinct orange mottles and the profile is imperfectly to poorly drained. The surface soil has a pH of 6. 1 but the subsoil, where calcareous nodules may be present, is strongly alkaline with a pH of 8. 5. *Bell* soils are generally greater than 1.2 m deep. They are the most extensive soils in the area covering some 1507 ha or 59% of the study area.

*Bridge (Br).* *Bridge* soils are localised and only occur in one area in conjunction with the Bell soil. The soil profile has a 0. 2m apedal sporadically bleached light clay surface overlying brown pedal medium heavy clay. *Bridge* soils are imperfectly to poorly drained. The soil pH ranges from 6 in the surface to 8. 0 in the upper subsoil. The soil depth is variable ranging from 0.6m to greater than 1.5m.

*Logan (Lg).* *Logan* soils are restricted to narrow strips (20-50 m) of gently undulating levees immediately flanking the Albert River and usually occur in association with other soils. The soil profile has a deep surface of apedal brown loamy sand to 0.75 m. This overlies mottled apedal grey or brown loamy sand to sandy clay loam. *Logan* soils are imperfectly drained and soil pH ranges from 6.5 in the surface to 6 in the upper subsoil. The soil depth is about 0.9 m.

*Maclean (Ma).* *Maclean* soils occur in one area covering 5.7 ha. The soil profile is characterised by a 0.15 m apedal bleached fine sandy clay loam surface overlying mottled pedal grey medium clay, with a pH of 6.3 throughout. *Maclean* soils are imperfectly drained and are generally in excess of 1.5 m deep.

*Payne (Pn).* These soils have been found to occur mainly in association with *Bell* and *Rockford* soils and cover 320 ha. They are characterised by a 0.2 m pedal grey-brown light clay surface overlying mottled pedal brown medium clay. The soil profile is poorly drained. The soil pH is 6.2 in the surface and 5.5 in the upper subsoil. *Payne* soils are generally greater than 1 m deep.

*Rockford (Rk).* *Rockford* soils generally occur in poorer drained areas and only cover 39 ha. The soil profile has a 0.1 m pedal grey light clay surface overlying mottled pedal grey medium clay. *Rockford* soils are imperfectly to poorly drained. The soil pH ranges from 6.5 in the surface to up to 8.5 in the subsoil. They are very deep, extending beyond 1.5 m.

**Table 3.** Main characteristics of the soils developed on the alluvial plains and terraces

| **Soil type** | **A horizon** | | **B horizon** | | **pH** | | **Soil depth (m)** |
|---|---|---|---|---|---|---|---|
| | **Depth (m)** | **Texture**** | **Colour*** | **Texture**** | **A hor** | **B hor** | |
| Bell (Bl) | 0. 15 | light-light medium clay | Dark | medium heavy clay | 6. 1 | 8. 5 | 1. 2 |
| Bridge (Br) | 0. 2 | light clay | Grey-brown | medium heavy clay | 6. 0 | 8. 0 | 1. 0 |
| Logan (Lg) | 0. 75 | loamy sand | Grey-brown | sandy clay loam | 6. 5 | 6. 0 | 0. 9 |
| Maclean (Ma) | 0. 15 | fine sandy clay loam | Grey | medium clay | 6. 3 | 6. 3 | 1. 5 |
| Payne (Pn) | 0. 2 | light clay | Brown | medium clay | 6. 2 | 5. 5 | 1. 0 |
| Rockford (Rk) | 0. 1 | light clay | Grey | medium clay | 6. 5 | 6. 7 | 1. 5 |

*Colour classes according to McDonald et al. (1990).
**Texture classes according to McDonald *et al*. (1990).

**Soils of the undulating rises formed on sandstone**

Soils on undulating rises only occupy 365 ha or 14% of the study area as the main purpose of this survey was to concentrate on the better quality alluvial soils. These soils have texture contrast profiles, with loamy sand surfaces overlying clayey subsoils (Table 4). Some soils have a bleached layer between the surface and the subsoil, indicating a strong leaching environment where most of the clay and nutrients have been removed.

*Kooruhman (Kn).* *Kooruhman* soils cover 172 ha of the upland soils in the study area. The soil profile has a 0.2 m apedal grey-brown loamy sand surface overlying apedal brown loamy sand to fine sandy loam. *Kooruhman* soils are well drained with soil pH ranging from 6.2 in the surface to 5.9 in the upper subsoil. Profiles range from 0.3 m to 0.5 m deep.

*Vale (Vl).* This soil type is the most extensive of those found on the uplands and covers approximately 189 ha. The soil profile has a 0.25 m bleached apedal sandy loam to fine sandy clay loam surface overlying pedal grey fine sandy medium clay to medium heavy clay. Vale soils are imperfectly drained with pH of 6.0 in the surface and 5.3 in the upper subsoil. Profiles range from 0.5 to 0.7 m deep.

*Wyaralong (Wg).* *Wyaralong* soils are only minor soils occurring in association with *Vale* soils. They cover 3.9 ha of the uplands. The soil profile has a 0. 3 m bleached apedal fine sandy loam to loamy sand surface overlying mottled pedal grey fine sandy light to medium clay. *Wyaralong* soils are imperfectly to poorly drained. The soil pH is 6.0 in the surface and 5.8 in the upper subsoil and the soil depth varies from 0.55 to 1.2 m.

**Table 4.** Main characteristics of the soils developed on undulating rises

| **Soil type** | **A horizon** | | **B horizon** | | **pH** | | **Soil depth (m)** |
|---|---|---|---|---|---|---|---|
| | **Depth (m)** | **Texture**** | **Colour*** | **Texture**** | **A hor** | **B hor** | |
| Kooruhman (Kn) | 0. 2 | loamy sand | Brown | fine sandy loam | 6. 2 | 5. 9 | 0. 3-0. 5 |
| Vale (Vl) | 0. 25 | sandy loam | Grey | sandy medium clay-medium heavy clay | 6. 0 | 5. 3 | 0. 5-0. 7 |
| Wyaralong (Wg) | 0. 3 | fine sandy loam | Grey | fine sandy light clay-medium clay | 6. 0 | 5. 8 | 0. 55-1. 2 |

*Colour classes according to McDonald et al. (1990).
**Texture classes according to McDonald *et al*. (1990).

**Soil chemical properties**

Results of chemical analysis for selected soils can be seen in Appendix 3. Analytical methods used and guidelines in data interpretation are those of Bruce and Rayment (1992), Baker (1991) and Baker and Eldershaw (1993).

Generally speaking, all soils sampled have high clay contents as expected. All have high amounts of plant available phosphorus indicating that these soils could have a major basaltic influence. This is very likely as the headwaters of the Albert River commence around the Beechmont Plateau. All major elements required by plants are present in reasonable amounts.

High subsoil pH readings of 8.5 found in the *Bell, Bridge* and *Rockford* soils sampled may induce low phosphorus availability, however the depths where this may occur are of no concern to cropping.

Basically the alluvial soils found in the study area are considered to be highly fertile with good plant rooting depth (in excess of 1 metre) and have good plant available water capacities.

*Vale*, *Wyaralong* and *Kooruhman* soils are poor quality soils that are generally unsuitable for agriculture and have not been sampled for chemical analysis. The following generalisations however have been made. The *Vale* soils have a low subsoil pH, less than 5.5 and are therefore expected to have high exchangeable aluminium and low plant available phosphorus. Both the *Vale* and the *Wyaralong* soils are also expected to have high sodium contents in their subsoils. This makes them prone to gully erosion. The surface will also set hard upon drying. The *Kooruhman* soil, due to its uniform sandy texture, has low plant available water capacity and low nutrient levels.

*Surface fertility*

Table 5 shows general fertility ratings for 0-0.1m. It can be seen that all soils sampled have medium to very high amounts of the major nutrients required for plant growth. Naturally high levels due to basaltic influence upstream combined with long term fertiliser use probably account for this. Carbon to nitrogen ratios indicate that there would be net mineralisation of nitrogen on cropping.

**Table 5.** General fertility ratings for 0–0.1m in selected alluvial soils

| **Soil** | **Acid extr. P** | **Bicarb extr. P** | **Repl. K** | **Extr. Cu** | **Extr. Zn** | **Extr. Mn** | **Total N** | **O. C** | **SO4-S** | **C:N ratio** |
|---|---|---|---|---|---|---|---|---|---|---|
| Bl (a) | v. high | v. high | high | med | med | med | high | v. high | high | 13.6 |
| Bl (b) | v. high | v. high | high | med | v. high | high | v. high | high | med | 14 |
| Br | low | high | high | med | med | high | high | high | med | 15 |
| Rk | v. high | v. high | high | med | med | med | med | high | med | 13.2 |

## 5. LAND EVALUATION

### Land suitability for agriculture

A five-class land suitability classification, with suitability decreasing progressively from class 1 to class 5, has been used in evaluating the area. The land is assessed on the basis of a specified land use which allows optimum production with minimal degradation to the land resource in the long term (Land Resource Branch Staff, 1990). The five classes are briefly defined as:

**Class 1** Suitable land with negligible limitations
**Class 2** Suitable land with minor limitations
**Class 3** Suitable land with moderate limitations
**Class 4** Marginal land, presently unsuitable due to severe limitations
**Class 5** Unsuitable land with extreme limitations that preclude its use

The area has been assessed for a range of climatically adapted crops. To determine the suitability of any parcel of land for a particular land use it is first necessary to consider the requirements of that use. Soil and land attributes which cause less than optimum conditions for a particular use are known as limitations. The main land use requirements and limitations for the selected crops are shown in Table 6.

### Limitations

The limitations of soil and land attributes were matched with the requirements of each land use to produce a suitability map showing the suitability of each mapping unit for a particular use. The critical limits of soil and land attributes used to determine subclasses for each land use are generally based on Wilson (1994) and Capelin (1987).

Each unique map area (UMA) was assessed individually in terms of the limitations (shown in Table 6). The limitations and critical limits used to determine the subclasses for each land use are detailed in Appendix 1.

**Table 6.** Land use requirements and limitations for the range of crops in the Chardons Bridge to Boylands area

| Land use requirements | Limitations |
|---|---|
| Frost free | frost (cf) |
| Adequate soil water supply | soil water availability (m) |
| Adequate nutrient supply | nutrient deficiency (nd) |
| Adequate soil depth for physical support | soil depth (d) |
| Minimum soil loss from erosion | water erosion (e) |
| Adequate soil aeration | wetness (w) |
| Absence of damaging floods | flooding (f) |
| Level land surface | microrelief (gilgai) (tm) |

## Land suitability assessment

The limitations and criteria in Appendix 1 were applied in the assessment of soils of the Chardons Bridge to Boylands area. The suitability of each unique map area (UMA) for the crops considered is shown in Table 7. Suitable and unsuitable areas are shown on the land suitability maps.

*Suitability for dryland crops*

Dryland crops assessed consisted of summer maize, sorghum and sunflower as well as winter oats, wheat and barley. Factors limiting these crops in the study area can be seen in Table 6**.** Approximately 1283 ha of land is suitable (class 2 and 3) for the summer crops with approximately 1697 ha being suitable for the winter crops.

The soils developed on the rises (*Kooruhman, Vale and Wyaralong*), have been found to be generally unsuitable for dryland cropping due to inadequate soil moisture, poor soil depth and susceptibility to erosion on slopes. Susceptibility to erosion, particularly in the *Vale* and *Wyaralong* soils is thought to be due to suspected high sodium contents in the subsoil. Irrigation is generally not available on these soils due to their distance from the river and the lack of underground water.

The soils developed on the alluvium generally are suitable for dryland cropping due to adequate plant available water holding capacities and gentle slopes.

*Suitability for irrigated crops*

Irrigated crops assessed include lucerne, crucifers and rye grass. The majority of the alluvial soils are suitable for these crops provided irrigation water is available. Some soils on the rises currently unsuitable for dryland cropping would be suitable if irrigation water was available. For irrigated lucerne and crucifers approximately 1280 ha of land is suitable. Approximately 2060 ha of land is suitable for irrigated rye grass.

The main limitations to these crops are flooding, wetness and the presence of gilgais. Figures from a Department of Primary Industries stream gauging station at Bromfleet show that flooding occurs on average once every 10 years, making this limitation only a minor concern.

Wetness is the major limiting factor on the alluvial soils as their high clay content causes poor internal drainage during wetter periods. Poor drainage in the area is indicated by the existence of gilgais which are a pattern of mounds and depressions formed by expansion of the clay when it becomes wet. Gilgais are an impediment to cultivation. In the suitability assessment, if the vertical distance from the top of the mound to the bottom of the depression is greater than 0.30 m, the UMA was classed as unsuitable for cropping.

**Table 7.** Land Suitability for crops in the Chardons Bridge to Boylands area

| UMA | SPC | sorghum | maize | oats | wheat | barley | sunflower | lucerne | crucifers | rye grass |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PN-BL | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 3 |
| 2 | PN-BL | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 3 |
| 3 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 4 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 5 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 6 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 7 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 8 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 |
| 9 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 10 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 11 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 12 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 13 | BL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 14 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 15 | RK-LG | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 3 |
| 16 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 17 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 18 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 19 | KN | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 3 |
| 20 | BL-PN | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 3 |
| 21 | MA | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 22 | BL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 4 |
| 23 | BL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 24 | RK | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 25 | BL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 4 |
| 26 | RK | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 27 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 28 | BL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 29 | PN-BL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 30 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 31 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 32 | KN | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 3 |
| 33 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 34 | BL-LG | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 3 |
| 35 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 36 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 37 | BL | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| 38 | BL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 39 | PN-RK | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 3 |
| 40 | BL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 41 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 42 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 43 | BL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 44 | BL-RK | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 45 | BL-BR | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 |
| 46 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 |
| 47 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 |
| 48 | BL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 49 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 50 | VL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 51 | WG | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| 52 | SW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 53 | SW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 54 | SW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 55 | SW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 56 | SW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 57 | SW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 58 | SW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | SW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | SW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 61 | BL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 62 | BL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 63 | BL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 4 |
| 64 | BL | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 4 |

**Agricultural land classes**

Four classes of agricultural land have been defined for Queensland (DPI/DHLGP 1993). These are shown in Table 8.

**Table 8.** Description of agricultural land classes

| Class | Description |
|---|---|
| **Class A** | **Crop land -** Land suitable for current and potential crops with limitations to production which range from none to moderate levels. |
| **Class B** | **Limited crop land -** Land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping. |
| **Class C** | **Pasture land -** Land suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment. |
| **Class D** | **Non-agricultural land -** Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage. |

The agricultural land class map shows that a large proportion of the alluvial soils (1270 ha) are considered to be Class A - Crop land, due to their favourable conditions for crop growth. They have only moderate limitations of frost, flooding and wetness. There are only several small areas of Class B - Limited crop land (427 ha). These areas are smaller, slightly poorer drained sites that could be used for cropping during drier periods. The majority of the soils formed on the rises (662 ha) are Class C - Pasture land, due to factors such as poor plant available water holding capacity, limited soil depth, steep slopes and suspected high sodicity. Several areas of alluvial soils have been classed as pasture land because of wetness problems due to poor drainage and cultivation problems due to gilgai. There are several naturally formed swamps in the study area that remain wet throughout most of the year. These have been classed as pasture land as they can be used as supplementary grazing areas during dry periods. One of these swamps is a reserve but has been kept as Class C land for consistency. Table 9 shows the agricultural land class allocated to each UMA.

**Table 9.** Agricultural land classes

| UMA | Soil | AGCLASS | UMA | SPC | AGCLASS |
|---|---|---|---|---|---|
| 1 | PN | B | 39 | PN | B |
| 2 | PN | B | 40 | BL | A |
| 3 | VL | C | 41 | VL | C |
| 4 | BL | A | 42 | VL | C |
| 5 | VL | C | 43 | BL | A |
| 6 | BL | A | 44 | BL | A |
| 7 | BL | A | 45 | BL | B |
| 8 | VL | C | 46 | VL | C |
| 9 | VL | C | 47 | VL | C |
| 10 | BL | A | 48 | BL | A |
| 11 | BL | A | 49 | VL | C |
| 12 | BL | A | 50 | VL | C |
| 13 | BL | A | 51 | WG | C |
| 14 | BL | A | 52 | SW | C |
| 15 | LG | B | 53 | SW | C |
| 16 | BL | A | 54 | SW | C |
| 17 | BL | A | 55 | SW | C |
| 18 | BL | A | 56 | SW | C |
| 19 | KN | C | 57 | SW | C |
| 20 | PN | B | 58 | SW | C |
| 21 | MA | C | 59 | SW | C |
| 22 | BL | C | 60 | SW | C |
| 23 | BL | A | 61 | BL | A |
| 24 | RK | C | 62 | BL | A |
| 25 | BL | C | 63 | BL | C |
| 26 | RK | C | 64 | BL | C |
| 27 | BL | A | | | |
| 28 | BL | A | | | |
| 29 | PN | C | | | |
| 30 | BL | A | | | |
| 31 | BL | A | | | |
| 32 | KN | C | | | |
| 33 | BL | A | | | |
| 34 | AL | B | | | |
| 35 | BL | A | | | |
| 36 | BL | A | | | |
| 37 | BL | A | | | |
| 38 | BL | A | | | |

## Land suitability for on-site sewage effluent disposal

In unsewered communities, adequate treatment of household sewerage effluent is necessary to avoid eutrophication of water bodies and health risks associated with contamination of the water with bacteria, viruses and nutrients.

There are five main methods used for on-site treatment and disposal of wastewater:

- septic tank with an absorption trench
- septic tank with an evapotranspiration field
- septic tank followed by aerobic sewerage treatment and surface irrigation
- septic tank followed by sand filtration and surface irrigation
- composting toilet (Eades, 1994).

The first method is the most widely used and is therefore the main method evaluated in this report. Solids and liquids are separated within the tank so that the effluent discharged from the system will have a lower level of pollutants. The breakdown of organic matter in the system relies on the action of anaerobic bacteria. Sludge and solids remaining in the tank contain high concentrations of metals, nutrients (nitrate and phosphate), grease, bacteria and viruses. This material must be periodically pumped out and disposed off-site (Eades,. 1994).

Australian Standard 1547-1994 requires the land capability of a proposed site for a septic tank be properly investigated. Effective on-site treatment and disposal requires suitable soil and landform characteristics.

Factors affecting land suitability for effluent disposal

A number of site characteristics influence the suitability for effluent disposal. They include:

- soil - permeability, texture, coherence, stoniness and depth to impermeable layer
- landform - slope, rock outcrops
- flood hazard - dependent upon landform, position and observation of flood events
- groundwater conditions - depth to watertable
- surface water conditions - proximity to streams or water storages

These factors have varying importance. The soil determines the absorption ability of a site and together with landform, determines the purification ability. The soil and landform also determine the ease of excavation for tank and drainage installation. Risk of water pollution is governed by all five characteristics with the soil being the most limiting. It determines what kind of treatment system can be used and what additional measures must be taken to avoid long term pollution (Eades, 1994).

**Table 10.** Land Suitability Rating for on-site effluent disposal using a septic tank absorption for single family dwellings (after Rowe *et al*. 1981).

| Attribute | Suitability rating | | |
|---|---|---|---|
| | **Good** | **Fair** | **Poor** |
| Slope (%) | 0-8 | 8-15 | >15 |
| Drainage | Well drained | Imperfectly drained | Poorly drained |
| Flooding | None | <1 in 100 years | >1 in 100 years |
| Depth to seasonal water table (cm) | >120 | 90-120 | <90 |
| Depth to Impermeable Layer (cm) | >150 | 100-150 | <100 |
| Gravel (%) | <20 | 20 - 40 | >40 |
| Stones (%) | <10 | 10 - 30 | >30 |
| Boulders (%) | <0. 2 | 0. 2-2 | >2 |
| Rock Outcrop (%) (of soil surface) | <0. 1 | 0. 1-1 | >1 |
| Dispersible Clays (%) | <10 | 10-16 | >16 |
| Shrink-swell potential (%) | <12 | 12-20 | >20 |

In addition to the criteria listed in Table 10, soil permeability must be within the acceptable range listed in Australian Standards AS1547-1994 of 0.05 - 0.6 m/day. Eades (1995) recommends a more conservative range of 0.05-0.3 m/day if there is a potential for groundwater contamination.

Permeability was not measured directly, an approximation was derived from texture classes using Table 11.

**Table 11.** Permeability ranges for various soil textural classes ( Hansen *et al*. 1979, as quoted in AS1547 - 1994).

| **Textural classification** | **Typical permeability (mm/day)** |
|---|---|
| Sand | 600-6000 (1200)* |
| Sandy loam | 300-1800 (600)* |
| Loam | 200-300 (300)* |
| Clay loam | 60-360 (180)* |
| Silty clay | 7-120 (60)* |
| Clay | 2. 4-24 (12)* |

*Representative values - AS1547 - 1994

**Suitability of soils for sewage effluent disposal**

The 1:50 000 scale of mapping is not adequate to assess an individual site — percolation tests and soil descriptions must be obtained at each proposed site in accordance with AS1547-1994. The scale presented in this report does however, give some indication of the suitability of each UMA for on-site effluent disposal, for planning purposes.

Soils on alluvial plains and terraces

All soils found on the alluvia : *Bell (Bl), Payne (Pn), Bridge, Rockford (Rk), Logan (Lg)* and *Maclean (Ma*) are subject to a flood frequency which is greater than 1 in 100 years. They are therefore generally unsuitable for on-site effluent disposal.

Soils on undulating rises of mainly sedimentary rocks

*Vale (Vl) and Wyaralong (Wy)* are texture contrast soils. These soils may be suitable for effluent disposal using absorption trenches subject to individual permeability tests. While the high clay content in the B horizon would greatly assist in the absorption of viruses and phosphate, the permeability may be too low in wet seasons, allowing the formation of a perched water-table in the A horizon and therefore leading to surface water contamination.

High sodium contents in the B horizon of the *Vale* and *Wyaralong* soils indicates high dispersibility. The soil pores of these soils can easily become blocked with finer soil particles further reducing permeability. The use of septic tanks followed by aerobic sewerage treatment and surface irrigation may be a more satisfactory means of disposal. This depends upon the availability of sufficient land with slope less than 10 %, as well as the regular maintenance of the treatment plants.

The permeability of the *Kooruhman (Kn)* soils is too high for on-site disposal; this is related to its uniform sandy texture profiles. The risk of ground water contamination. In addition, the shallowness of the *Kooruhman* soil would allow easy contamination of surface water during wet seasons. These soils are unsuitable for septic tanks with absorption trenches.

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# Appendix 1.

## Suitability Limitation Tables

# Appendix 1 - Suitability Limitation Tables

## 1. Climate - frosts (Cf)

**Effect:** Frosts may suppress growth, reduce yield or kill plants.
**Assessment:** Crop tolerance and the incidence and severity of frosts are used to distinguish affected areas.
**Diagnostic Land Attribute:** Topographic position.
**Limitation Class Determination:** Climatic data and local consultation.

| **Land attribute level** | sorghum, maize, sunflower | oats, rye grass, wheat, barley, crucifers | lucerne |
|---|---|---|---|
| Cf0 No Frosts | 1 | 1 | 1 |
| Cf1 Light Frosts | 1 | 1 | 2 |
| Cf2 Regular frosts | 1 | 2 | 3 |
| Cf3 Severe frosts | 2 | 3 | 4 |

- With correct management practices, summer growing crops should not be affected by frosts. Autumn and spring crops are affected by a reduced growing season.

## 2. Water Availability (M)

**Effect:** Plant yield will be decreased by periods of water stress particularly during critical growth periods. Soils with low PAWC require more frequent irrigation.
**Assessment:** Soil morphological properties together with measured PAWC.
**Diagnostic Land Attributes:** Soil texture, pedality and depth.
**Limitation Class Determination:** Based on texture and pedality and/or measured PAWC, and local consultation.

M1 - PAWC > 150mm
M2 - PAWC 120-150mm
M3 - PAWC 100-120mm
M4 - PAWC 75-100mm
M5 - PAWC <75mm

| **Land attribute level** | **Dryland** | **Irrigated** |
|---|---|---|
| | sorghum, maize, sunflower oat, wheat, barley | rye grass, lucerne, crucifers |
| M1 | 1 | 1 |
| M2 | 2 | 1 |
| M3 | 3 | 2 |
| M4 | 4 | 3 |
| M5 | 4 | 3 |

### 3. Wetness (W)

**Effect**: Waterlogged soils reduce plant growth and delay effective machinery operations.

**Assessment**: Internal and external drainage are assessed.

**Diagnostic Land Attributes:** Colour, pedality, mottles, segregations, impermeable layers, topographic position.

**Limitation Class Determination:** Consultation, crop tolerance information and the effects of delays in machinery operation.

<u>Permeability</u>
s = slowly permeable
m = moderately permeable
h = highly permeable

<u>Drainage class</u>
1. = very poorly drained
2. = poorly drained
3. = imperfectly drained
4. = moderately well drained
5. = well drained
6. = rapidly drained

| **Land attribute level** | lucerne | rye grass | maize, sunflower, sorghum | wheat, barley, oats | crucifers |
|---|---|---|---|---|---|
| W6h | 1 | 1 | 1 | 1 | 1 |
| W6m | 1 | 1 | 1 | 1 | 1 |
| | | | | | |
| W5h | 1 | 1 | 1 | 1 | 1 |
| W5m | 2 | 1 | 1 | 1 | 1 |
| | | | | | |
| W4h | 2 | 1 | 1 | 1 | 1 |
| W4m | 3 | 1 | 2 | 1 | 2 |
| W4s | 3 | 2 | 3 | 2 | 3 |
| | | | | | |
| W3h | 3 | 1 | 2 | 2 | 2 |
| W3m | 3 | 2 | 3 | 2 | 3 |
| W3s | 4 | 2 | 4 | 2 | 4 |
| | | | | | |
| W2h | 4 | 3 | 4 | 3 | 5 |
| W2m | 4 | 3 | 4 | 3 | 5 |
| W2s | 4 | 3 | 4 | 4 | 5 |
| | | | | | |
| W1h | 5 | 4 | 5 | 4 | 5 |
| W1m | 5 | 4 | 5 | 5 | 5 |
| W1s | 5 | 4 | 5 | 5 | 5 |

## 4. Soil Depth (D)

**Effect:** Shallow soils limit root proliferation and anchorage.
**Assessment:** Effective soils depth, depth to decomposing rock or impermeable layer.
**Diagnostic Land Attribute:** Soil depth.
**Limitation Class Determination:** Consultation.

| Land attribute level | effective soil depth | rye grass | other crops |
|---|---|---|---|
| D1 | >1m | 1 | 1 |
| D2 | 0.6-1m | 1 | 2 |
| D3 | 0.4-0.6m | 2 | 3 |
| D4 | 0.3-0.4m | 3 | 4 |
| D5 | <0.3m | 4 | 5 |

## 5. Micro Relief (G)

**Effect:** Uneven crop productivity due to uneven water distribution, for example water ponding in depressions.

**Assessment:** Levelling of uneven surface is required for effective irrigation and surface drainage. The vertical interval of gilgai dictates the amount of levelling required.

**Diagnostic Land Attribute:** Vertical interval from top of mound to bottom of depression.

**Limitation Class Determination:** Local opinion and consultation.

| Land attribute level | vertical interval | all crops |
|---|---|---|
| G1 | <0.1m | 1 |
| G2 | 0.1-0. 3m | 3 |
| G3 | 0.3-0.6m | 4 |

## 6. Nutrient Deficiency (N)

**Effect:** Low pH can cause restricted availability of nutrients.
**Assessment:** Based on the top 60 cm of soil profile, the rooting depth of most crops.
**Diagnostic Land Attribute:** Field pH measurement.
**Limitation Class Determination:** Documented data on low pH relating to element toxicity and nutrient availability.

| Land attribute level | pH | all crops |
|---|---|---|
| N 1 | <5.5 | 3 |
| N 2 | 5.5-7.5 | 1 |
| N 3 | >7.5 | 2 |

## 7. Flooding (F)

**Effect:** Yield reduction or plant death caused by anaerobic conditions and or silt deposition during inundation as well as physical removal or damage by flowing water. Flowing water can also cause erosion.
**Assessment:** Assessing the effects of flooding on an individual UMA is difficult. Flooding frequency has been used to distinguish between suitable and unsuitable land only in extreme flooding situations or for intolerant crops.
**Diagnostic Land Attribute:** Topographic position.
**Limitation Class Determination:** Local consultation.

| **Land attribute level** | flood frequency | sorghum, oats, maize, sunflower, wheat, barley, lucerne | crucifers | rye grass |
|---|---|---|---|---|
| F0 | No flooding | 1 | 1 | 1 |
| F1 | Frequency <1 in 10 years | 1 | 1 | 1 |
| F2 | Frequency 1 in 2 to 1 in 10 years | 1 | 1 | 1 |
| F3 | Frequency approaches annual occurrence | 4 | 2 | 1 |

## 8. Water Erosion (E)

**Effect:** Land degradation and long-term productivity decline will occur on unprotected arable land due to excessive soil erosion.
**Assessment**. Soil loss will depend on soil erodibility and land slope for a particular crop and surface management system. For each soil type there is a maximum slope above which soil loss cannot be reduced to acceptable levels by erosion control
measures or surface management practices.
**Diagnostic Land Attributes:** Soil type, slope.
**Limitation Class Determination:** Slope limitations are determined in consultation with soil conservation, extension and research personnel.

| **Land attribute level** | slope | rye grass | maize, sorghum, wheat, oats, crucifers, lucerne, barley, sunflower |
|---|---|---|---|
| **Sodic Texture Contrast soils** | | | |
| E1d | 0-1% | 1 | 1 |
| E2d | 1-3% | 1 | 2 |
| E3d | 3-5% | 2 | 3 |
| E4d | 5-8% | 3 | 4 |
| E5d | 8-12% | 4 | 5 |
| E6d | >12% | 5 | 5 |
| **Other soils** | | | |
| E1c | 0-2% | 1 | 1 |
| E2c | 2-5% | 1 | 2 |
| E3c | 5-8% | 1 | 3 |
| E4c | 8-12% | 3 | 4 |
| E5c | 12-15% | 4 | 5 |
| E6c | 15-20% | 4 | 5 |
| E7c | >20% | 5 | 5 |

# Appendix 2.

## Glossary

## Appendix 2 - Glossary

The following are definitions of terms used throughout the report especially in the soil descriptions. All other terms used in the report and that are not described below, are taken from McDonald *et al.* (1990).

**1. Depth of solum (taken from Isbell, 1993)**

Shallow : 0.25-<0.5 m
Moderately deep : 0.5-<1.0 m
Deep : 1.0-<1.5 m
Very deep : 1.5-5.0m

**2. Soil Reaction Trend (taken from Northcote, 1977)**

Acid reaction trend (A horizon pH <7.0, B horizon pH <6.5)
Neutral reaction trend (A horizon pH 5.0-8.0, B horizon pH 6.0 -8.0)
Alkaline reaction trend (A horizon pH >5.0, B horizon pH >8.0)

**3. Soil Structure**

pedal - breaks into individual units of uniform size and shape
apedal - soil structure is not evident or only weakly evident

**4. Profile texture trend (taken from Northcote, 1979)**

| | |
|---|---|
| Uniform | : little, if any change in texture with increasing depth |
| Gradational | : clay content gradually increases with depth |
| Duplex | :clay content increases abruptly between the surface and lower horizons |

**5. Horizonation (soil layers)**

| | |
|---|---|
| A1 | :horizon at or near the soil surface with some accumulation of organic matter |
| A2 | :horizon having, either alone or in combination, less organic matter, sesquioxides or silicate clay than the adjacent horizons. It is usually differentiated by its paler colour. |
| A3 | :transitional horizon between A and B, that is dominated by properties characteristic of the overlying A horizon |
| B1 | :transitional horizon between A and B that is dominated by properties characteristic of the underlying B horizon |
| B2 | :horizon showing one or more of the following: maximum colour development, concentration of silicate clay, sesquioxides, or organic matter; structure and/or consistence unlike the A horizons immediately above or below. |
| B3 | :transitional horizon between B and C that is dominated by the properties characteristic of the above B horizon |
| C | :usually consolidated or unconsolidated, partially weathered parent material or sedimentary laminae |

**4. Horizon boundary**

| | |
|---|---|
| “over” | :sharp, abrupt or clear boundary (<5-50 mm) |
| “grading” | :gradual or diffuse (>50 mm) |

**6. Great Soil Group is derived from Stace *et al.* (1968)**

**7. NSG - indicates "No Suitable Group"**

**8. Australian Classification is derived from Isbell (1993). Only Suborder, and Order are indicated.**

**9. Landform element terminology is derived from McDonald *et al.* (1990).**

# Appendix 3 –

## Soil Chemical Analysis Results
**(Laboratory Batch Reference SO195/536)**

## Appendix 3

SOIL TYPE: Bell
SITE NO: 393
A.M.G. REFERENCE: 511 532 mE 6 911 743 mN ZONE 56
GREAT SOIL GROUP: Black earth
PRINCIPAL PROFILE FORM: Ug5.16
SOIL TAXONOMY UNIT:
FAO UNESCO UNIT:
TYPE OF MICRORELIEF: normal gilgai
VERTICAL INTERVAL: .35 m
HORIZONTAL INTERVAL: 3 m

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:
SLOPE: 0.5 %
LANDFORM ELEMENT TYPE: terrace plain
LANDFORM PATTERN TYPE: level plain <9m <1%
VEGETATION
STRUCTURAL FORM: Mid-high woodland
DOMINANT SPECIES: Eucalyptus tereticornis
CONDITION OF SURFACE SOIL WHEN DRY: periodic cracking

PROFILE MORPHOLOGY:

| HORIZON | DEPTH | DESCRIPTION |
|---|---|---|
| A1 | 0 to .10 m | Very dark grey (10YR3/1); medium clay; moderate 2-5mm granular. |
| B21 | .10 to 1.00 m | Black (10YR2/1); medium heavy clay; moderate 5-10mm subangular blocky parting to moderate 2-5mm subangular blocky. |
| B22 | 1.00 to 1.40 m | Black (10YR2/1); few fine distinct orange mottles; medium heavy clay; moderate 10-20mm lenticular parting to moderate 5-10mm subangular blocky; few medium ferromanganiferous nodules. |
| B23 | 1.40 to 1.70 m | Dark yellowish brown (10YR4/4); many coarse distinct orange mottles; medium clay; moderate 2-5mm subangular blocky; few coarse ferromanganiferous nodules. |

| Depth metres | 1:5 Soil/Water pH @ 40°C | EC dS/m @ 40°C | Cl % @105°C | Particle Size CS % @ 105°C | FS | S | C | Exch. Cations CEC m.eq/100g @ 105°C | Ca | Mg | Na | K | Total Elements P % | K | S | Moistures ADM % @ 105°C | 33* | 1500* | Disp.Ratio R1 @ 40°C | R2 | Exch Al m.eq/100g @ 105°C | Exch Acid | ECEC | pH CaCl2 @40°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B0-.10 | 6.0 | .16 | .010 | | | | | | | | | | | | | | | | | | | | | 5.2 |
| 0-.10 | 6.3 | .11 | .005 | 5 | 12 | 30 | 54 | 62 | 17 | 18 | 1.3 | .48 | .179 | .729 | .051 | 5.90 | | 28 | | . | | | | 5.3 |
| .20-.30 | 6.9 | .09 | .006 | 3 | 15 | 35 | 48 | 58 | 20 | 18 | 1.6 | .24 | .184 | .784 | .022 | 6.90 | | 27 | | . | | | | 5.8 |
| .50-.60 | 7.7 | .19 | .021 | 3 | 9 | 24 | 64 | 65 | 28 | 26 | 3.3 | .16 | .074 | .549 | .014 | 8.00 | | 33 | | . | | | | 6.8 |
| .80-.90 | 7.8 | .29 | .031 | 3 | 10 | 28 | 60 | 64 | 28 | 24 | 4.2 | .14 | .121 | .640 | .012 | 8.50 | | 31 | | . | | | | 6.9 |
| 1.10-1.20 | 8.2 | .34 | .040 | 2 | 16 | 30 | 52 | 61 | 26 | 24 | 4.9 | .13 | .122 | .705 | .009 | 8.40 | | | | . | | | | 7.3 |
| 1.40-1.50 | 8.2 | .38 | .048 | | | | | | | | | | | | | | | | | | | | | 7.4 |

| Depth metres | Org.C (W&B) % @105°C | Tot.N % @105°C | Extr. P Acid mg/kg @ 105°C | Bicarb. | HCl K meq% @ 105°C | CaCl2 Extr K mg/kg @ 105°C | P | DTPA-extr. Fe mg/kg @ 105°C | Mn | Cu | Zn | B | Extractable SO4S mg/kg @ 105°C | NO3N | NH4N | P Buff Cap @ 40°C | Equil ug/L | Alternative Cations CEC m.eq/100g @ 105°C | Ca | Mg | Na | K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B0-0.10 | 5.6 | .41 | 318 | 379 | .85 | | | 367 | 17 | 2.0 | 2.6 | | 34 | | | | | | | | | |

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.

SOIL TYPE: Bell
SITE NO: 383
A.M.G. REFERENCE: 510 500 mE 6 914 500 mN ZONE 56
GREAT SOIL GROUP: Black earth
PRINCIPAL PROFILE FORM: Ug5.
SOIL TAXONOMY UNIT:
FAO UNESCO UNIT:
TYPE OF MICRORELIEF: normal gilgai
VERTICAL INTERVAL: .25 m
HORIZONTAL INTERVAL: 3 m

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:
SLOPE: 0.5 %
LANDFORM ELEMENT TYPE: terrace plain
LANDFORM PATTERN TYPE: terrace
VEGETATION
STRUCTURAL FORM: Mid-high woodland
DOMINANT SPECIES: Eucalyptus tereticornis

CONDITION OF SURFACE SOIL WHEN DRY: firm

PROFILE MORPHOLOGY:

| HORIZON | DEPTH | DESCRIPTION |
|---|---|---|
| A1 | 0 to .10 m | Very dark grey (10YR3/1); medium clay; moderate 2-5mm granular. |
| B21 | .10 to .90 m | Black (10YR2/1); medium heavy clay; moderate 5-10mm subangular blocky parting to moderate 5-10mm lenticular. |
| B22 | .90 to 1.40 m | Very dark greyish brown (10YR3/2); medium heavy clay; moderate 10-20mm lenticular parting to moderate 5-10mm subangular blocky; few coarse calcareous nodules. |
| B3/d | 1.40 to 1.55 m | Yellowish brown (10YR5/6); few medium ferromanganiferous nodules. |



| Depth metres | 1:5 Soil/Water pH @ 40°C | EC dS/m @105°C | Cl % @105°C | Particle Size CS % @ 105°C | FS | S | C | Exch. Cations CEC m.eq/100g @ 105°C | Ca | Mg | Na | K | Total Elements P % | K | S | Moistures ADM % @ 105°C | 33* | 1500* | Disp.Ratio R1 @ 40°C | R2 | Exch Al m.eq/100g @ 105°C | Exch Acid | ECEC | pH CaCl2 @40°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B0-.10 | 5.8 | .13 | .009 | | | | | | | | | | | | | | | | | | | | | 5.1 |
| 0-.10 | 6.2 | .08 | .004 | 6 | 12 | 35 | 44 | 62 | 14 | 16 | .75 | .84 | .231 | .889 | .075 | 8.30 | | 30 | | . | | | | 5.4 |
| .20-.30 | 7.5 | .06 | .001 | 4 | 11 | 32 | 52 | 55 | 17 | 22 | 1.9 | .26 | .158 | .825 | .030 | 6.30 | | 26 | | . | | | | 6.2 |
| .50-.60 | 8.3 | .19 | .020 | 5 | 11 | 31 | 54 | 54 | 16 | 26 | 3.9 | .18 | .095 | .728 | .025 | 7.10 | | 26 | | . | | | | 7.3 |
| .80-.90 | 8.7 | .61 | .081 | 9 | 12 | 25 | 54 | 50 | 12 | 28 | 5.6 | .16 | .072 | .631 | .018 | 6.30 | | 28 | .67 | . | | | | 7.9 |
| 1.10-1.20 | 9.0 | .76 | .085 | 24 | 17 | 16 | 43 | 44 | 8.4 | 26 | 5.8 | .11 | .094 | .567 | .011 | 6.70 | | | | . | | | | 8.1 |

| Depth metres | Org.C (W&B) % @105°C | Tot.N % 105°C | Extr. P Acid mg/kg @ 105°C | Bicarb. | HCl K meq% @ 105°C | CaCl2 Extr K mg/kg @ 105°C | P | DTPA-extr. Fe mg/kg @ 105°C | Mn | Cu | Zn | B | Extractable SO4S mg/kg @ 105°C | NO3N | NH4N | P Buff Cap @ 40°C | Equil ug/L | Alternative Cations CEC m.eq/100g @ 105°C | Ca | Mg | Na | K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B0-0.10 | 5.6 | .41 | 318 | 379 | .85 | | | 367 | 17 | 2.0 | 2.6 | | 34 | | | | | | | | | |

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.

SOIL TYPE : Bridge
SITE NO: 395
A.M.G. REFERENCE: 511 100 mE  6 916 600 mN  ZONE 56
GREAT SOIL GROUP: Brown clay
PRINCIPAL PROFILE FORM: Ug5.35
SOIL TAXONOMY UNIT:
FAO UNESCO UNIT:
TYPE OF MICRORELIEF: normal gilgai
VERTICAL INTERVAL: .15 m
HORIZONTAL INTERVAL: 8 m
COMPONENT OF MICRORELIEF SAMPLED: mound
SURFACE COARSE FRAGMENTS: No coarse fragments

CONFIDENCE SUBSTRATE IS PARENT MATERIAL:
SLOPE: 2 %
LANDFORM ELEMENT TYPE: terrace plain
LANDFORM PATTERN TYPE: gently undulating plains <9m  1-3%
VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES:

CONDITION OF SURFACE SOIL WHEN DRY: periodic cracking

PROFILE MORPHOLOGY:

| HORIZON | DEPTH | DESCRIPTION |
|---|---|---|
| A | 0 to .05 m | Very dark greyish brown (10YR3/2); medium clay;,; weak; moist; clear to |
| B21 | .05 to .55 m | Brown (10YR4/3); medium heavy clay; strong lenticular. gradual to- |
| B22 | .55 to .85 m | Dark grey (10YR4/1); very few medium distinct orange mottles; medium clay; strong lenticular; common medium manganiferous nodules. clear to- |
| B23 | .85 to 1.75 m | Dark grey (10YR4/1); common medium distinct orange mottles; medium clay; strong lenticular; few coarse calcareous nodules. clear to- |

| Depth (metres) | 1:5 Soil/Water pH @ 40°C | EC dS/m @ 40°C | Cl % @105°C | Particle Size CS % @ 105°C | FS | S | C | Exch. Cations CEC m.eq/100g @ 105°C | Ca | Mg | Na | K | Total Elements P % | K | S | Moistures ADM % @ 105°C | 33* | 1500* | Disp.Ratio R1 @ 40°C | R2 | Exch Al m.eq/100g @ 105°C | Exch Acid | ECEC | pH CaCl2 @40°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B0-.10 | 6.2 | .09 | .005 | | | | | | | | | | | | | | | | | | | | | 5.2 |
| 0-.10 | 6.2 | .04 | .002 | 8 | 13 | 23 | 54 | 40 | 9.2 | 8.7 | .65 | .89 | .055 | .541 | .047 | 6.50 | | 23 | .40 | . | | | | 4.9 |
| .20-.30 | 6.2 | .07 | .005 | 3 | 8 | 16 | 72 | 51 | 14 | 15 | 2.0 | .42 | .028 | .419 | .024 | 6.80 | | 28 | | . | | | | 4.8 |
| .50-.60 | 6.8 | .43 | .064 | 3 | 8 | BQ | 71 | 51 | 16 | 20 | 4.3 | .17 | .021 | .466 | .020 | 9.10 | | 29 | .67 | . | | | | 6.0 |
| .80-.90 | 8.0 | .60 | .082 | 9 | 22 | 16 | 52 | 40 | 14 | 17 | 4.6 | .10 | .019 | .555 | .016 | 5.00 | | 21 | .91 | . | | | | 7.2 |
| 1.10-1.20 | 8.3 | .69 | .087 | 17 | 18 | 14 | 50 | 36 | 13 | 16 | 4.8 | .14 | .017 | .523 | .012 | 4.60 | | | | . | | | | 7.6 |
| 1.40-1.50 | 8.4 | .70 | .093 | | | | | | | | | | | | | | | | | | | | | 7.3 |

| Depth (metres) | Org.C (W&B) % @105°C | Tot.N % @105°C | Extr. P Acid mg/kg @ 105°C | Bicarb. | HCl K meq% @ 105°C | CaCl2 Extr K mg/kg @ 105°C | P | DTPA-extr. Fe mg/kg @ 105°C | Mn | Cu | Zn | B | Extractable SO4S mg/kg @ 105°C | NO3N | NH4N | P Buff Cap @ 40°C | Equil ug/L | Alternative Cations CEC m.eq/100g @ 105°C | Ca | Mg | Na | K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B0-0.10 | 5.6 | .41 | 318 | 379 | .85 | | | 367 | 17 | 2.0 | 2.6 | | 34 | | | | | | | | | |

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.

SOIL TYPE: Rockford
SITE NO: 402
A.M.G. REFERENCE: 507 785 mE 6 910 029 mN ZONE 56
GREAT SOIL GROUP: Grey clay
PRINCIPAL PROFILE FORM: Ug5.28
SOIL TAXONOMY UNIT:
FAO UNESCO UNIT:

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:
SLOPE: 0.5 %
LANDFORM ELEMENT TYPE:
LANDFORM PATTERN TYPE:
VEGETATION
STRUCTURAL FORM: Mid-high woodland
DOMINANT SPECIES: Eucalyptus tereticornis, Eucalyptus moluccana
CONDITION OF SURFACE SOIL WHEN DRY: firm

PROFILE MORPHOLOGY:

| HORIZON | DEPTH | DESCRIPTION |
|---|---|---|
| A11 | 0 to .10 m | Very dark grey (10YR3/1); light medium clay; moderate 2-5mm granular; moderately moist; weak. |
| A12 | .10 to .25 m | Very dark greyish brown (10YR3/2); light medium clay; moderate 2-5mm granular; moderately moist; moderately weak. |
| B21 | .25 to .80 m | Dark greyish brown (2.5Y4/2); medium heavy clay; moderate 10-20mm lenticular parting to moderate 2-5mm subangular blocky; moderately moist; moderately firm. |
| B22 | .80 to 1.20 m | Dark grey (2.5Y4/1); medium heavy clay; moderate 5-10mm lenticular parting to moderate 2-5mm subangular blocky; moderately moist; moderately firm. |
| B23 | 1.20 to 1.80 m | Grey (2.5Y5/1); common medium distinct orange mottles; medium heavy clay; moderate 5-10mm subangular blocky parting to moderate 2-5mm subangular blocky. |

| Depth metres | 1:5 Soil/Water pH @ 40°C | EC dS/m | Cl % @105°C | Particle Size % @ 105°C CS | FS | S | C | Exch. Cations m.eq/100g @ 105°C CEC | Ca | Mg | Na | K | Total Elements % P | K | S | Moistures % @ 105°C ADM | 33* | 1500* | Disp.Ratio @ 40°C R1 | R2 | Exch Al m.eq/100g @ 105°C | Exch Acid | ECEC | pH CaCl2 @40°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B0-.10 | 5.9 | .14 | .005 | | | | | | | | | | | | | | | | | | | | | 5.2 |
| 0-.10 | 6.1 | .08 | .002 | 3 | 23 | 35 | 40 | 53 | 14 | 13 | .43 | .61 | .230 | .963 | .045 | 5.40 | | 23 | .50 | . | | | | 5.2 |
| .20-.30 | 7.0 | .05 | .001 | 2 | 20 | 33 | 49 | 58 | 18 | 19 | 1.1 | .25 | .166 | .825 | .026 | 7.30 | | 29 | .60 | . | | | | 5.8 |
| .50-.60 | 7.7 | .08 | .001 | 1 | 20 | 30 | 52 | 61 | 19 | 26 | 2.1 | .21 | .121 | .780 | .018 | 8.10 | | 29 | | . | | | | 6.4 |
| .80-.90 | 8.5 | .14 | .003 | 1 | 23 | 30 | 52 | 63 | 20 | 29 | 3.4 | .13 | .103 | .747 | .014 | 11.0 | | 29 | .81 | . | | | | 7.3 |
| 1.10-1.20 | 8.8 | .17 | .010 | 1 | 22 | 30 | 49 | 59 | 17 | 30 | 3.9 | .10 | .101 | .768 | .012 | 11.0 | | | | . | | | | 7.6 |
| 1.40-1.50 | 8.8 | .23 | .020 | | | | | | | | | | | | | | | | | | | | | 7.7 |

| Depth metres | Org.C (W&B) % @105°C | Tot.N % @105°C | Extr. P mg/kg @ 105°C Acid | Bicarb | HCl K meq% @ 105°C | CaCl2 Extr mg/kg @ 105°C K | P | DTPA-extr. mg/kg @ 105°C Fe | Mn | Cu | Zn | B | Extractable mg/kg @ 105°C SO4S | NO3N | NH4N | P @ 40°C Buff Cap | Equil ug/L | Alternative Cations m.eq/100g @ 105°C CEC | Ca | Mg | Na | K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B0-0.10 | 5.6 | .41 | 318 | 379 | .85 | | | 367 | 17 | 2.0 | 2.6 | | 34 | | | | | | | | | |

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.