

Attachment 8

**Land Resource Assessment, prepared by GSS
Environmental, April 2010 and additional information
dated 13 December 2010**



FINAL

Land Resource Assessment

*Proposed Jacaranda Ponds Project near
Glossodia, Hawkesbury Region, NSW.*

April 2010

PBA01-001



GSS ENVIRONMENTAL
Environmental, Land and Project
Management Consultants

Prepared on behalf of **EG Property Group**

By:-

GSS Environmental
Environmental, Land and Project Management Consultants

Level 1, 241 Denison Street
BROADMEADOW NSW 2292

PO Box 907
HAMILTON NSW 2303

Phone: 02 4920 3000

Fax: 02 49613360

Web: www.gssenvironmental.com

Date of Issue 20th April 2010

GSSE Ref PBA01-001

ISSUE AND AMENDMENT CONTROL HISTORY

Issue	Date	Description	Author	QA/QC
1	7 th April 2010	Draft Document	John Lawrie	Rod Masters
2	20 th April 2010	Final Document	John Lawrie	Rod Masters

Distribution List

Master: GSS Environmental

Copy 1: EG Property Group

EXECUTIVE SUMMARY

Hawkesbury Council has requested that the proponent conduct soil testing at Jacaranda Ponds in order to determine the agricultural land capability at the site. After detailed soil testing GSSE has determined that the soils found at Jacaranda Ponds are generally of fair (Class 3) to poor (Class 4) agricultural quality. They are not ideally suitable for cultivation or cropping and therefore can be used for residential purposes without diminishing the LGA's agricultural land supply.

The soils on slopes, which in some areas are greater than 10%, are highly susceptible to soil erosion. These soils are dispersible throughout their profiles with highly dispersible sub-soils that exhibit poor internal drainage due to the almost impenetrable horizontally bedded shale substrate.

The site has a warm temperate climate with rainfall averaging about 900 mm per annum. The rainfall is highest during the summer months peaking in January / February when there are likely to be high intensive summer storms which could cause severe soil erosion.

These soils on the sloping ground are also acid to strongly acidic at depth which prevents abundant growth of many introduced perennial pastures and crops. Even with high application rates of lime it would be difficult to improve the acidity levels of the deeper subsoils

The soils along flats are saline at the surface and highly saline at depth. This makes it difficult for salt sensitive crops to grow well on these soils due to this subsoil constraint.

The report concludes that the entire site is not suitable for regularly cultivating soil to grow crops.

TABLE OF CONTENTS

1.0 BACKGROUND	1
1.1 LOCATION	1
1.2 TOPOGRAPHY	1
1.3 LAND MANAGEMENT UNITS	2
1.4 VEGETATION	2
1.5 SURROUNDING LAND USE	2
2.0 SOIL SURVEY METHODOLOGY	3
2.1 INTRODUCTION	3
2.2 MAPPING	3
2.3 SOIL PROFILING	3
2.4 FIELD ASSESSMENT	4
2.4.1 <i>Field Assessment Parameters</i>	4
2.5 LABORATORY TESTING	4
2.6 AGRICULTURAL SUITABILITY ASSESSMENT	6
3.0 RESULTS	8
3.1 DESKTOP REVIEW	8
3.1.1 <i>Soil Landscape Units</i>	8
3.2 SOIL RESULTS	8
3.2.1 <i>Jacaranda Field Survey Units</i>	8
3.3 EROSION POTENTIAL	13
3.4 POTENTIAL FOR ACID GENERATING MATERIAL	13
3.4.1 <i>Acid Sulphate Soils</i>	13
3.5 LAND CAPABILITY	13
3.6 AGRICULTURAL SUITABILITY	14
4.0 REFERENCES	15

TABLES

TABLE 1 – FIELD ASSESSMENT PARAMETERS	4
TABLE 2 – RURAL LAND CAPABILITY CLASSES.....	6
TABLE 3 – AGRICULTURAL SUITABILITY CLASSES.....	6
TABLE 4 – LANDSCAPE UNITS.....	8
TABLE 5 –BROWN DUPLEX LOAM PROFILE (SITE 1) <i>BROWN KUROSOL (DY3.21)</i>	10
TABLE 6 – RED DUPLEX LOAM PROFILE (SITE 3) <i>RED CHROMOSOL (DR2.21)</i>	11
TABLE 7 – BROWN ALLUVIAL LOAM PROFILE (SITE 4) <i>BROWN DERMOSOL (DB2.21)</i>	12
TABLE 8 – LAND CAPABILITY AREAS.....	13
TABLE 9 – AGRICULTURAL SUITABILITY	14

FIGURES

FIGURE 1 – LOCALITY MAP	1
FIGURE 2 – SOIL MAP	4
FIGURE 3 – LAND CAPABILITY MAP	13
FIGURE 4 – AGRICULTURAL SUITABILITY MAP	14

PLATES

PLATE 1 – BROWN DUPLEX LOAM PROFILE	10
PLATE 2 – BROWN DUPLEX LOAM LANDSCAPE	10
PLATE 3 – RED DUPLEX LOAM PROFILE.....	11
PLATE 4 – RED DUPLEX LOAM PROFILE SAND LANDSCAPE.....	11
PLATE 5– BROWN ALLUVIAL LOAM PROFILE	12
PLATE 6 – BROWN ALLUVIAL LOAM LANDSCAPE	12

APPENDICES

APPENDIX 1 – SOIL TEST RESULTS
APPENDIX 2 – SOIL CHEMICAL ANALYSES
APPENDIX 3 – GLOSSARY

1.0 BACKGROUND

GSSE Environmental (GSSE) was commissioned by Diverse Property Solutions Pty Ltd (DPSPL) to undertake an Agricultural land resource assessment at Jacaranda Ponds, which is located at Spinks Road Glossodia.

A planning proposal is being prepared which will request that the majority of the site be rezoned to a Rural Housing Zone under the Hawkesbury Local Environmental Plan 1989. Under the proposal, the existing free range egg farm will remain on site and the farm will also retain its current Mixed Agricultural Zone.

Hawkesbury Council has asked the proponent to assess the suitability of the soil found at Jacaranda Ponds for agricultural production. This request is in line with Hawkesbury Council's long standing policy of preserving prime agricultural land across the local government area. This report demonstrates, however, that the land proposed to be rezoned to a Rural Housing Zone at Jacaranda Ponds is not suitable for agricultural production and therefore the zoning change will not adversely affect the quality or quantity of agricultural land in the local region.

1.1 Location

The subject site is located in the Blue Mountains, New South Wales, south east of Spinks Road, along the southern boundary of the village of Glossodia. The township and study area is shown in **Figure 1** below. The specific study area is shown in all subsequent figures in this report.

The project is proposed to rezone a large portion of the 183.6 hectares (ha) of agricultural land (zoned "Mixed Agricultural" in the Hawkesbury LEP) to a "Rural Housing Zone" (179 lots) at Spinks Road, Glossodia.

The project site covers all or part of the following land parcels within the Hawkesbury Shire Local Government Area (LGA).

- Lot 1 – DP784300
- Lot 2 – DP784300
- Lot 3 – DP784300 & DP230943
- Lot 44 – DP214755
- Lot 50 – DP751637
- Lot 20 – DP214753
- Lot 52 – DP1104504
- Lot 75 – DP214752

Under the provisions of the *Hawkesbury Local Environmental Plan* the site currently has a Rural – Mixed Agricultural Zoning.

1.2 Topography

The project site lies on the Cumberland Plains physiographic region and ranges in elevation between 30 - 70 metres (m) ASL of gently undulating rises and low hills with local relief to 30 m and slopes up to 5 – 10%. Crests and ridges are broad at approximately 100 – 300 m and rounded with convex (waxing) upper slopes grading into concave (waning) lower slopes and open depressions. There are slightly undulating mid and lower slopes to the south with level plains adjacent to Currency Creek which are not affected by regional flooding.



LEGEND  Study Area					FIGURE 1		Project:	Jacaranda Ponds Soils Assessment
					Locality Plan		Client:	Parsons Brinkerhoff Australia
Version	Date:	Author:	Checked:	Approved:	 GSS ENVIRONMENTAL Environmental, Land and Project Management Consultants		File:	Fg1_PBA01-001_Locality Plan_100415
1	7/04/2010	TC	JL	JL			Projection:	MGA Zone 56

1.3 Land Management Units

Although soil landscapes on the site were originally mapped as Gynea (hills) and Woodlands (flats) by (Bannerman & Hazelton, 1990), these soil landscapes better fit the descriptions of the Luddenham and South Creek soil landscapes described in the more recent Soil and Land Resources DVD of the Hawkesbury–Nepean Catchment (DECC, 2008)

Both the Luddenham & South Creek soil landscapes are found on Ashfield shale from the Middle Triassic Wianaminta Group which consists of inter-bedded and strongly laminated dark grey siltstone shales which lie conformably over the Mittagong Group of sandstones. No outcrops of shale or sandstone were observed on site. Rainfall is approximately 900 mm per annum.

1.4 Vegetation

Native vegetation found on these landscapes (DECC, 2008) consists of extensively cleared Grey Box Woodland dominated by isolated *Eucalyptus moluccana* (grey box) and *E. tereticornis* (forest red gum), with some sites having *E. crebra* (narrow-leaved ironbark) as a co-dominant species. Other species include *E. crebra* (narrow-leaved ironbark), *E. amplifolia* (cabbage gum) and *E. fibrosa* (broad-leaved ironbark). On creek lines *Casuarina glauca* (swamp oak) and *Melaleuca decora* occur. Shrubs include *Bursaria spinosa* (blackthorn), *Breynia oblongifolia* (coffee bush), *Allocasuarina torulosa* (forest oak), *Acacia implexa* (hickory wattle), *Dillwynia sieberi* and *Hardenbergia violacea* (purple coral pea).

A more detailed description and list of flora and fauna found on the site is found in a special report prepared for DPSPL by Travers et.al 2009.

1.5 Surrounding Land Use

Surrounding land use includes areas of native and introduced pastures used for cattle grazing and rural residential development. Furthermore, intensive poultry farms and horse stud farms are present.

2.0 SOIL SURVEY METHODOLOGY

2.1 Introduction

A soil and land capability survey was undertaken in March 2010 by GSSE to:

1. classify and determine the soil profile types of the study area;
2. assess the suitability of the current topsoil material for agricultural production and to;
3. identify rural land capability and agricultural suitability classifications across the site.

The survey was conducted in accordance with the methodology outlined in this section. The land resource assessment and soil testing results are presented in **Section 3** of this report.

2.2 Mapping

An initial soil map was developed using the following methodology.

1) *Aerial photographs, topographic maps and satellite images*

Aerial photographs, topographic map and satellite imagery was used as a remote sensing technique that allowed for detailed analysis of the landscape, as well as the mapping of features expected to be related to the distribution of soils within the project area.

2) *Previous soil survey results*

Previous studies, as outlined below, have comprehensively surveyed the project area for both soil attributes and agricultural land suitability. Accordingly, the soil and land resource assessment for the project area has been developed through a combination of desktop studies of the previous soil and landscape assessments that have reviewed the site, as well as additional fieldwork undertaken by GSSE. The soil and land resource information that was directly applicable to the project area was sourced from the following listed below:

- *Soil Landscapes of Penrith 1:100,000 Sheet and Report (Bannerman & Hazelton 1990); and*
- *Soil & Land Resources the Hawkesbury - Nepean Catchment 2008.*

These references were used to provide background data for carrying out the soil and land capability assessment undertaken by GSSE in March 2010.

3) *Stratified observations*

A broad soil map was developed in order to determine where to select sites to visually assess surface soil exposures, topography and vegetation. These were then used to verify potential soil units, delineate soil unit boundaries and determine preferred locations for targeted subsurface investigations.

2.3 Soil Profiling

Four (4) soil profiles were assessed at selected sites across the project area to enable soil profile descriptions to be made. Subsurface exposure was generally undertaken by backhoe excavation of test pits to 2 m deep or refusal. The test pit locations were chosen to provide representative profiles of the soil types encountered during the survey. The soil layers were generally distinguished on the basis of changes in texture, structure and colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994). Photographs of soil profile exposures and the associated landscape were also taken (refer to **Plates 1 to 6**).

Soil profiles were also observed through the use of surface exposures located in existing track cuttings, gullies and creek banks. Soil profile site locations are shown in **Figure 2**.

2.4 Field Assessment

Four (4) soil profiles within the survey area were assessed generally in accordance with the Australian Soil and Land Survey Field Handbook soil classification procedures (McDonald et al, 1998).

2.4.1 Field Assessment Parameters

Detailed soil profile descriptions recorded information that covered a variety of parameters as specified in **Table 1**. Soil profile logging was undertaken by completing soil data sheets.

Vegetation types and current land use were also recorded. Soil exposures from excavated pits were photographed during field operations as colour photography of profile sites is a useful adjunct to description of land attributes.

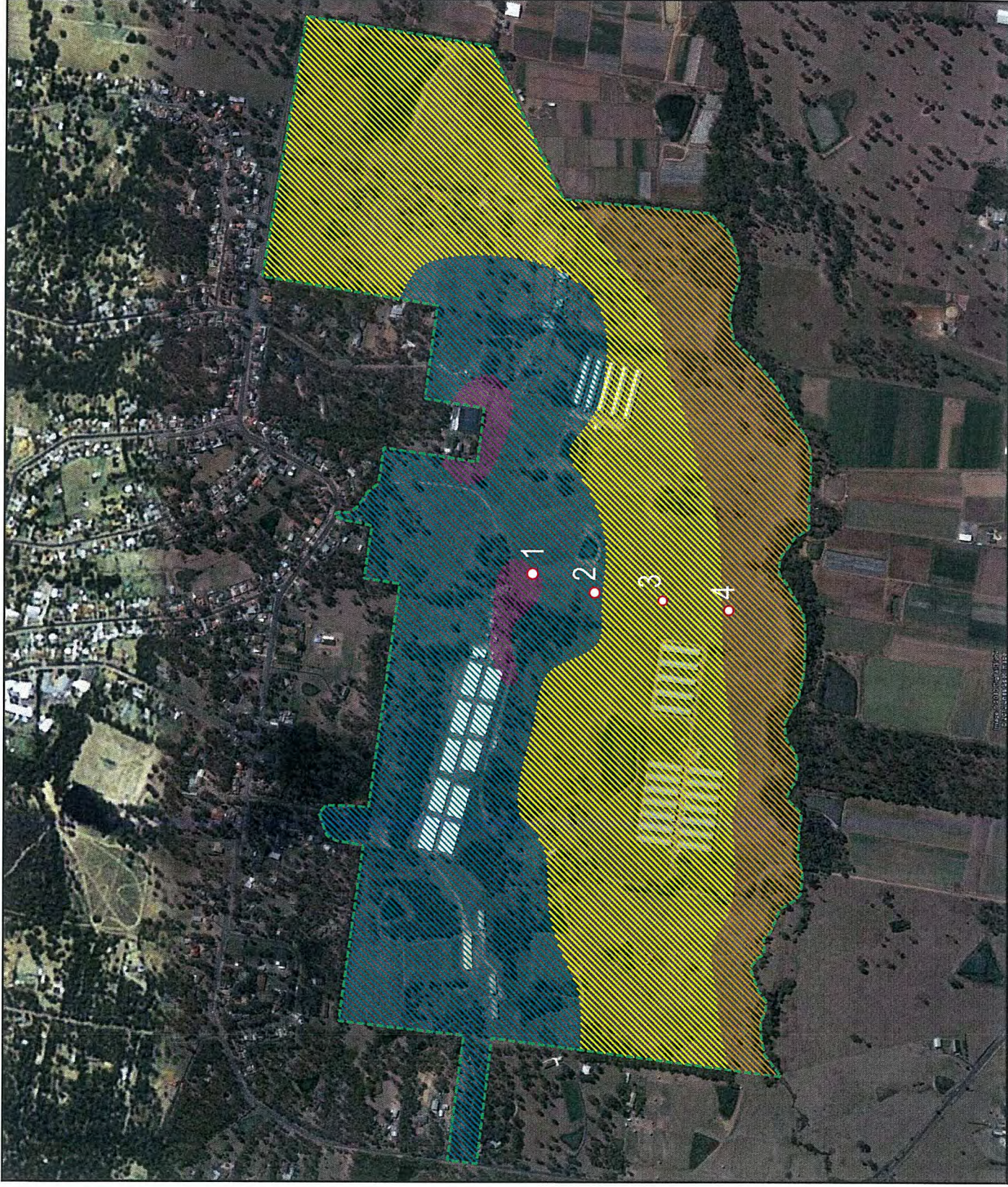
Table 1 – Field Assessment Parameters

Descriptor	Application
Physical:	
Horizon Depth	Weathering characteristics, soil development
Field Colour	Permeability, susceptibility to dispersion /erosion
Field Texture Grade	Erodibility, hydraulic conductivity, moisture retention, root penetration
Boundary Distinctness and Shape	Erosional / dispositional status, textural grade
Consistence Force	Structural stability, dispersion, ped formation
Structure Pedality Grade	Soil structure, root penetration, permeability, aeration
Pore Number and Size	Soil structure, root penetration, permeability, aeration
Structure Ped & Size	Soil structure, root penetration, permeability, aeration
Stones – Amount & Size	Water holding capacity, weathering status, erosional / depositional character
Roots – Amount & Size	Effective rooting depth, vegetative sustainability
Ants, Termites, Worms etc	Biological mixing depth

2.5 Laboratory Testing

Soil samples were collected from the exposed soil profiles and subsequently sent to the NSW Land and Property Management Authority Soil Conservation Service Laboratory at Scone, NSW for analysis. Samples were analysed to establish the suitability of surface and near-surface soil horizons as potential growth media, to identify high value soils and, conversely, soils that may have properties that are deleterious for establishing vegetation. Samples were analysed from the following sites (as shown on **Figure 2**):

- Test Pit 1 – 1/1, 1/2, & 1/3
- Test Pit 2 – 2/1, 2/2 & 2/3 (not analysed)
- Test Pit 3 – 3/1, 3/2 & 3/3
- Test Pit 4 – 4/1, 4/2 & 4/3



LEGEND

- Study Area
- Brown Dermosols (67 ha)
- Red Chromosols (82 ha)
- Brown Kurosols (31.2)
- Shallow Red Kurosols (3.4 ha)
- Total Area = 183.6 ha
- 1 Sample Location

Figure 2

Soils Assessment

Project:	Jacaranda Ponds Soils Assessment								
Client:	Parsons Brinkerhoff Australia								
File:	FgXX_PBA01-001_Soil_Units_100407								
Projection:	MGA Zone 56								
Version:	1	Date:	7/04/2010	Author:	TC	Checked:	JL	Approved:	JL

Soil horizons are signified by /1 /2 in the sample ID with the surface horizon being /1 and subsoil horizons being /2 and /3. The samples were subsequently analysed for the following parameters.

- Colour;
- Particle Size Analysis;
- Emerson Aggregate Test;
- pH;
- Electrical Conductivity;
- Cation Exchange Capacity and exchangeable cations;
- Acid Sulphate Soils Screening (SPOCAS);
- Phosphorous sorption (kg/ha);
- Available Water Capacity; and
- Bulk Density (core method)

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for recovery and use as a growth medium for rehabilitation of disturbed areas. Similarly, potentially unfavourable soil material was identified. The soil test results for the soil survey are provided in **Appendix 1** and soil chemical analyses and calculations are presented in **Appendix 2**.

The land capability assessment of the project area was conducted in accordance with DECCW's rural land capability classification system. The system consists of eight (8) classes, which classify land on the basis of an increasing soil erosion hazard and decreasing versatility of use. It recognises and assesses the following three main types of land uses:

- land suitable for cultivation;
- land suitable for grazing; and
- land not suitable for rural production.

These capability classifications identify limitations on the use of the land as a result of the interaction between the physical resources and a specific land use. The principal limitation recognised by these capability classifications is the stability of the soil mantle (Soil Conservation Service, 1986).

The method of land capability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography, and the effects of past land uses. The classification does not necessarily reflect the existing land use, rather it indicates the potential of the land for uses such as crop production, pasture improvement and grazing.

The system allows for land to be allocated into eight possible classes (with land capability decreasing progressively from Class I to Class VIII). The classes are described in **Table 2** below.

A description of land capability classification for all land within the project area is discussed further in **Section 3.5**.

Table 2 – Rural Land Capability Classes

Rural Land Capability Classification System		
Land Class	Land Suitability	Land Definition
Class I	Regular Cultivation	No erosion control requirements
Class II	Regular Cultivation	Simple requirements such as crop rotation and minor strategic works
Class III	Regular Cultivation	Intensive soil conservation measures required such contour banks and waterways
Class IV	Grazing, occasional cultivation	Simple practices such as stock control and fertiliser application
Class V	Grazing, occasional cultivation	Intensive soil conservation measures required such contour ripping and banks
Class VI	Grazing only	Managed to ensure ground cover is maintained
Class VII	Unsuitable for rural production	Green timber maintained to control erosion
Class VIII	Unsuitable for rural production	Should not be cleared, logged or grazed
U	Urban areas	Unsuitable for rural production
SF	State Forests	Unsuitable for rural production
M	Mining & quarrying areas	Unsuitable for rural production
Source: Emery (1986) .Soil Conservation Service of NSW.		

2.6 Agricultural Suitability Assessment

The agricultural suitability assessment of the survey area was conducted in accordance with DII's agricultural suitability classification system. The system consists of five (5) classes, providing a ranking of lands according to their productivity for a wide range of agricultural activities with the objective of determining the potential for crop growth within certain limits.

The classification is based upon the effects of climate, topography and soil characteristics, the cultural and physical requirements for various crops and pastures, and existing socio-economic factors including local infrastructure and geographic location. These factors combine to determine the productive potential of the land and its capacity to produce crops, pastures and support livestock. The classes are described in **Table 3** below.

Table 3 – Agricultural Suitability Classes

Agricultural Suitability Classification System		
Land Class	Agricultural Suitability	Land Definition
Class 1	Highly productive land suited to both row and field crops	Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent
Class 2	Highly productive land suited to both row and field crops	Arable land suitable for regular cultivation for crops but not suited to continuous cultivation. It has a moderate to high suitability for agriculture but edaphic (soil factors) or environmental constraints reduce the overall level of production and may limit the cropping phase to a rotation with sown pastures.

Agricultural Suitability Classification System		
Land Class	Agricultural Suitability	Land Definition
Class 3	Moderately productive lands suited to improved pasture and to cropping within a pasture rotation	Grazing land or land suitable for pasture improvement. It may be cultivated or cropped in rotation with pasture. The overall level of production is moderate as a result of edaphic or environmental constraints. Erosion hazard or soil structural breakdown limit the frequency of ground disturbance, and conservation or drainage works may be required.
Class 4	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing	Land suitable for grazing but not for cultivation. Agriculture is based on native or improved pastures established using minimum tillage. Production may be high seasonally but the overall level of production is low as a result of a number of major constraints, both environmental and edaphic.
Class 5	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing	Land unsuitable for agriculture or at best suited only to light grazing. Agricultural production is very low or zero as a result of severe constraints, including economic factors, which preclude improvement.

Source: Emery NSW Land & Water Conservation (1988)

3.0 RESULTS

3.1 Desktop Review

3.1.1 Soil Landscape Units

One landscape unit underpins the project area. This is the Luddenham soil landscape units as delineated by the Soil Landscapes of Penrith 1:100,000 Sheet (Bannerman & Hazelton, 1990). **Table 4** describes this unit.

Table 4 – Landscape Units

Landscape Unit	Typical Landform	Vegetation	Typical Soils
Luddenham	Undulating to rolling low hills on Wianamatta shales. No local outcrop. Local relief to 40 metres (20-70m ASL) 20m ASL at the far northern boundary. Rounded hillcrests with narrow saddles and narrow valleys. Slopes range from 1-15%. Land is extensively cleared tall open-forest (wet sclerophyll forest) Land use - Development and mostly hobby farms and small rural subdivision. These include equestrian & cattle grazing apart from a couple of intensive poultry operations	Sydney Blue Gum <i>E saligna</i> and Blackbutt <i>E pilularis</i> Grey Ironbark <i>E paniculata</i> White Stringybark <i>E globoidea</i> Grey Box <i>E. mollucana</i>	Soils range from shallow to moderately deep (>100cm) Red Chromosol Soils on crests to moderately deep (70-100cm) Red & Brown Chromosol Soils on upper slopes deeper Brown Chromosols soils on lower slopes and floodplains with Yellow Chromosols in incised drainage lines in the northern extension . Limitations high soil erosion hazard, localised impermeable highly plastic subsoils, slightly reactive but not likely to be an issue with building construction

Source: Bannerman & Hazelton (1990)

3.2 Soil Results

3.2.1 Jacaranda Field Survey Units

A site inspection was undertaken in March 2010 to classify the soil profile types associated with the proposed development footprint. The objective of the field assessment was to observe soil profiles (to a maximum depth of 2 m). No shallow aquifers (i.e. < 1.5 m depth) were identified. The following soil units were identified within the project area:

- Shallow Red Duplex Loam (Red Kurosol) – 3.4 ha;
- Brown Duplex Loam (Brown Kurosol) – 31.2 ha;
- Deep Red Duplex Loam (Red Chromosol) - 82 ha and
- Brown Gradational Alluvial Loam (Brown Dermosol) - 67 ha.

The distribution of these soils is illustrated in **Figure 2**. Exposed profiles of major soil units are shown in **Plates 1, 3 & 5**. Landscape photos of areas where each soil unit was observed are shown in **Plates 2, 4 & 6**. A glossary of commonly used soils terms is presented in **Appendix 3**.

Of the four (4) profile descriptions sites, one (1) and two (2) are from hill slope sites south of Spinks Rd on Jacaranda Ponds; three (3) and four (4) are from lower lying valley floor sites further south east of the old chicken sheds. The upper slope profiles were classified as Brown & Red Kurosols and Chromosols generally with loam and fine sandy loam topsoils with a distinct increase to clayey sub-soils. The Brown Dermosol soils along the valley floor and adjacent to Currency Creek have a slightly more gradual change in texture at depth to slightly less clayey sub-soils.

The soils generally change from shallow red duplex soils (Red Kurosols) on the steepest waxing slopes to deeper brown duplex soils (Brown Kurosols) on less steep waning slopes with deeper red duplex soils (Red Chromosols) on steeper lower slopes. Gradational textured brown loams occur on the lower slopes and plains

Brown Duplex Loam Profile (Site 1) *Brown Kurosol*

Description: These Brown Duplex Loam soils have brown loams overlying a clear wavy change to mottled brown clays. These soils range from slightly acidic to neutral in the upper layers to strongly acid at depth. The soils are non saline non-sodic with moderately fertile characteristics. The soil has slow to moderately slow drainage. See (Table 2.13) Hazelton & Murphy. 2007

Location: These soils are found on the waxing upper & mid slopes.

Land-use: The land overlying these soils is currently grazed, but has not been cropped for many years and due to severe erosion in the past. There are scattered ironbark, gums and box trees with blackthorn and a good groundcover of kikuyu grass and native grass pastures.

Management: The top 0.10 m of this soil is suitable for stripping and can be reused as topdressing for landscaping purposes. The subsoil below 70 cm is not recommended for reuse in landscaping due to moderate to high dispersibility at depth. This soil requires only the standard erosion and sediment control measures if disturbed, however, if the topsoil is removed, it may lead to dispersion and erosion in wet conditions.

Table 5 –Brown Duplex Loam Profile (Site 1) *Brown Kurosol*

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.10	Brown (7.5YR 4/3), moderate consistence, fine sandy loam. Moderate pedality (0.5mm) soil with slightly acid (pH 6.5), slight to nil dispersion (EAT 8, 3(2), non saline (0.7ECe), roots abundant and >5% gravel (<20 mm). Approx sample depth 0.10 m. wavy boundary to Layer 2.
2	0.10 to 0.70	Brown (7.5YR 5/4) with yellow and red mottles, moderate consistence light-medium clay. Strong pedality, soil acidic (pH5.5) Strong angular blocky peds 5-50mm, slightly dispersible (EAT 3(2)), non saline (0.3ECe), fine roots common and 10% shale gravel & stone, gradual boundary to Layer 3.
3	0.70 to 100	Brown (10YR 5/3) with light grey mottles, moderate consistence loam. Moderate pedality (platy 15-50 mm) soils strongly acid (pH 5), moderate to high dispersion (EAT 2(1), non saline (0.9ECe), few roots 0 to 100cm with up to 40% shaly stones & gravel present.



Plate 1 – Brown Duplex Loam Profile



Plate 2 – Brown Duplex Loam Landscape

Red Duplex Loam Profile (Site 3) *Red Chromosol*

Description The Red Duplex Loam soils generally consist of dark brown fine sandy loams with a clear wavy change to strong red clays. These moderately well drained soils are strongly acidic at depth. Initial infiltration is rapid however the clayey sub-soils impede further drainage and the topsoil can become saturated.

The soils are generally non saline with poor fertility characteristics. These soils will respond well to added fertilizer and may need molybdenum fortified superphosphate. The soil also responds well to lime applications to reduce acidity but it is difficult to effectively improve the acidity of the subsoil. Sub-soils are not sodic.

Volume expansion is low in topsoils and moderate in subsoil.

Location: These soils are found on the lower slopes.

Land-use: The land overlying these soils is currently grazed, but has been cropped in the past. There is some gum tree re-growth with black thorn, paspalum and native perennial pastures.

Management: The top 0.32m of this soil is suitable for stripping and can be reused as a top dressing for landscaping. The subsoil below 32 cm is not recommended for reuse in landscaping due to the limiting factors of dispersion. This soil requires only the standard erosion and sediment control measures if disturbed. The topsoil is suitable for stripping and reused as a top-dressing in rehabilitation. This soil requires only the standard erosion and sediment control measures if disturbed.

Table 6 – Red Duplex Loam Profile (Site 3) *Red Chromosol*

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.32	Brown (10YR4/3), moderate consistence fine sandy loam. Moderate crumb structure 2-5mm that is slightly acid (pH5.9), slight to nil dispersion (EAT 8/3(1) non saline (0.6ECe), roots abundant and only minor gravel (<20 mm). Approx sample depth 0.10m, wavy boundary to Layer 2.
2	032 to 125	Yellowish Red (5YR4/6) with yellow mottles, moderate consistence light medium clay. Smooth moderate angular blocky peds 5-20mm soil that is moderately acid (pH 5.4), slight dispersion (EAT 5), non saline (0.7ECe), fine roots common and little gravel Gradual boundary to Layer 3
3	125 to 1.90	Brown (7.5YR4/4), with grey mottles weak consistence (wet) heavy clay. Smooth, strong angular blocky structure soil that is strongly acid (pH5), no dispersion (EAT 6), non saline (1.17ECe), many fine roots and very little gravel overlying deeper subsoil



Plate 3 – Red Duplex Loam Profile



Plate 4 – Red Duplex Loam Profile Sand Landscape

Brown Gradational Alluvial Loam Profile (Site 4) *Brown Dermosol*

Description: These moderately slow to moderately slowly drained soils are weakly acidic in the upper layers and moderately acidic at depth. The soils are moderately saline at the surface and highly saline in the subsurface layers but otherwise have fair fertility characteristics throughout. The soil is not sodic.

Location: These soils are found on the lower slope, flats and flood plain of the higher quality grazing and only marginally suited to annual cropping with salt tolerant species due to their highly saline subsurface soil horizons.

Land-use: The land overlying these soils is used for grazing and in the past they were used for cropping activities. The vegetation includes improved and native pastures. There are occasional gum and stringy bark with paspalum and perennial native grass pastures.

Management: The top 0.30 m of loamy soil is suitable for stripping and reused as topdressing for landscaping. Other factors limiting the subsoil include salinity, and acidity. This soil requires only the standard erosion and sediment control measures if disturbed, however given the salinity at depth, perennial native and introduced saline resistant pasture species should be encouraged.

Table 7 – Brown Alluvial Loam Profile (Site 4) *Brown Dermosol*

LAYER	DEPTH (m)	DESCRIPTION
1	0.02 to 0.30	Brown (10YR5/3), weak consistence light sandy clay loams. Moderate sub angular blocky (5-50 mm) soil with slightly acid (pH 6.1), stable to moderate dispersion (EAT 8,3/3), moderately saline (4.1ECe), roots abundant. Clear and wavy boundary to Layer 2.
2	0.30 to 1.70	Yellowish Brown (10YR6/4), weak consistence (moist) silty clay. Strong smooth angular blocky peds (>5-20mm) slightly acidic (pH 6), no-dispersion (EAT 6), non sodic (ESP 0.8), highly saline 14.3ECe), many fine roots <1% gravel. Clear even boundary to Layer 3.
3	1.7 to 1.9	Brownish yellow (10YR6/6) with 20% red mottles, weak consistence (wet), sandy clay loam. Pedal rough sub angular blocky peds (10-30mm) strongly acid (pH 5), moderately dispersive (EAT 2/1) non sodic (ESP 0.82), highly saline (13.3ECe) fine roots common.

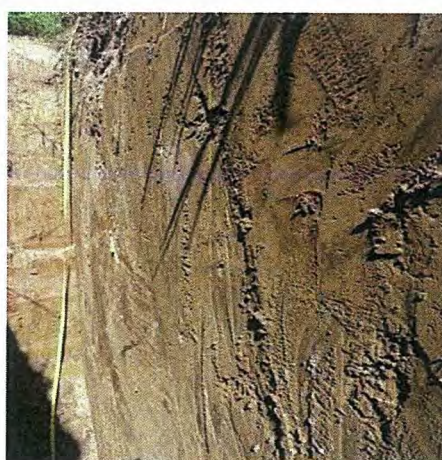


Plate 5 – Brown Alluvial Loam Profile



Plate 6 – Brown Alluvial Loam Landscape

3.3 Erosion Potential

All soil samples were laboratory tested for dispersion, using the Emerson Aggregate Test (EAT) and sodicity, using the Exchangeable Sodium Percentage (ESP). These tests indicate the susceptibility of a soil to losing its structure and binding capacity when wet, and therefore the erosion potential of the soil. The results showed a similar pattern within the Grey Brown Gradational Loams, Light Brown Duplex Loams and Brown Gradational Clay of the upper layers being non dispersive and non sodic whilst the sub-soils tended to moderate to high dispersion and high sodicity with depth.

The appropriate erosion and sediment control measures should be in place prior to surface disturbance of these soils during urban development, as the risk of erosion is high once the subsoil is exposed. Appropriate measures are outlined in **Section 4.1** of this report. These sub-soils should also be placed in the overburden dumps in areas where they are unlikely to be exposed to the rainfall or drainage for long periods of time. The topsoils of the Duplex soils were non dispersive and non saline throughout the profile however the Brown Alluvial Loams have a saline profile and their topsoils may be may be dispersive thus reducing their land capability.

3.4 Potential for Acid Generating Material

3.4.1 Acid Sulphate Soils

Acid Sulfate Soils (ASS), which are the main cause of acid generation within the soil mantle, are commonly found less than 5 m above sea level, particularly in low-lying coastal areas such as mangroves, salt marshes, floodplains, swamps, wetlands, estuaries, and brackish or tidal lakes. However they are also known to occur in Currency Creek further downstream where it turns into a chain of ponds but there was no visual evidence of acid sulphate in this well drained landscape. The laboratory analyses, Appendix 4 confirm that none of the soils sampled were acid sulfate soils.

3.5 Land Capability

The rural land capability classification of the study area, in accordance with Department of Environment, Climate Change & Water (DECCW) mapping is shown in **Figure 3**.

Figure 3 illustrates the existing rural land capability classification and **Table 8** quantifies the area of each class. The project area encompasses classes IV suitable for grazing and occasional cultivation (e.g. 2 or 3 crops in 10 to 12 years) due its potential salinity hazard to as long as simple best management practices are followed and VI lands which are suitable only for grazing and managed to ensure that sufficient ground cover is maintained.

The southern and north eastern portions of the project area contain 149 ha of Class IV land. Class IV land comprises the better classes of grazing land is not suitable for cultivation on a regular basis due to significant potential salinity hazards. In addition, there is a small portion of Class VI (34.6 ha) land in the northern half of the project area which comprises lands where cultivation is unsuitable.

Table 8 – Land Capability Areas

Land Capability Class	(ha)	% Area
I	0	0%
II	0	0%
III	0	0%
IV	149	81%
V	0	%



LEGEND

Study Area

Land Capability Class IV (149 ha)

Land Capability Class VI (34.6 ha)

Total Area = 183.6 ha

Sample Location

1

Figure 3

Land Capability

Project:

Jacaranda Ponds Soils Assessment

Client:

Parsons Brinkerhoff Australia

File:

FgXX_PBA01-001_Land Cap_100407

Projection:

MGA Zone 56

Version:

1

Date:

7/04/2010

Author:

TC

Checked:

JL

Approved:

JL



GSS ENVIRONMENTAL
Environmental Land and Project
Management Consultants

Land Capability Class	(ha)	% Area
VI	34.6	19%
VII	0	0%
VIII	0	0%
Totals	183.6	100%

3.6 Agricultural Suitability

The agricultural land suitability classification of the project area was carried out in accordance with DII and is shown in **Figure 4** and **Table 9**.

The majority of the project area has a land suitability of Class 3 (149 ha) which indicates only moderately productive lands.

The soils along flats are saline at the surface and highly saline at depth. This makes it difficult to grow salt sensitive crops. Perennial native and introduced saline resistant pasture species should be encouraged to prevent the increase in salinity levels in the lower lying soils.

The remaining area Class 4 (34.6 ha) situated on hill-slopes and along minor drainage lines is not suitable for cultivation. Production may be high seasonally but the overall level of production is low as a result of a number of major constraints, both environmental and edaphic.

Therefore this site overall is poor agricultural land and is only suitable for occasional cropping. The quantity of cropping land in the Hawkesbury LGA will not be significantly reduced if this site is rezoned to a Rural Housing Zone.

Table 9 – Agricultural Suitability

Agricultural Suitability Class	Area (ha)	% Area
1	0	0%
2	0	%
3	149	81%
4	34.6	19%
5	0	0%
Totals	183.6	100%



LEGEND

Study Area

Agricultural Suitability Class 3
(149 ha)

Agricultural Suitability Class 4
(34.6 ha)

Total Area = 183.6 ha

1 Sample Location

Figure 4

Agricultural Suitability

Project:

Jacaranda Ponds Soils Assessment

Client:

Parsons Brinkerhoff Australia

File:

FgXX_PBA01-001_Ag_Suit_100407

Projection:

MGA Zone 56

Version:

1

Date:

7/04/2010

Author:

TC

Checked:

JL

Approved:

JL



GSS ENVIRONMENTAL
Environmental, Land and Project
Management Consultants

4.0 REFERENCES

Bannerman S M & Hamilton P A (1990) Soil Landscapes of Penrith 1:100,000 Sheet

Department of Natural Resources, (2005). Land Capability Spatial Data. Resource Information Unit, Hawkesbury Region

DECCW (2008) Soil & Land Resources of the Hawkesbury –Nepean Catchment

Elliot.G.L. and Veness, R.A. (1981). Selection of Topdressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley, J. Soil Cons. NSW 37 37-40.

Kovac M. & Lawrie J.L. 1991 Soil landscapes of the Singleton 1:250,000 Sheet Soil Conservation Service of NSW, Sydney.

Emery, K.A. (1986). Rural Land Capability Mapping, Soil Conservation Service of NSW. Sydney, NSW.

Hazelton P.A. & Murphy B.W. (2007) Interpreting Soil Test Results, CSIRO Publication

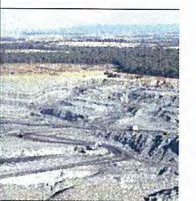
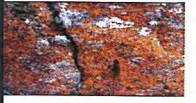
Macbeth, (1994). Munsell Soil Colour Charts. Revised Edition.

McDonald R.C, et al, (1998) Australian Soil & Land Survey Field Handbook, Inkata Press.

NSW Agriculture & Fisheries (1990). Agricultural Suitability Maps – Uses and Limitations. Agfact AC.9 Second Edition.

Travers et.al. (2009).Flora and Fauna Constraints Assessment – Jacaranda Ponds Glossodia Ref 9064

SOIL TEST RESULTS



APPENDIX 1



Soil Conservation Service

SOIL TEST REPORT

Page 1 of 3

Scone Research Centre

REPORT NO: SCO10/080R1

REPORT TO: John Lawrie
GSS Environmental
PO Box 907
Hamilton NSW 2303

REPORT ON: Nine soil samples

REPORT STATUS: Preliminary

DATE REPORTED: 7 April 2010

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

A handwritten signature in cursive script that reads "SR Young".

SR Young
(Laboratory Manager)

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Page 2 of 3

Report No: SCO10/080R1 (Preliminary 2)
Client Reference: John Lawrie
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method Sample Id	C1A/4	C2A/3	C5A/3 CEC & exchangeable cations (me/100g)							C8B/1	
		EC (dS/m)	pH	CEC	Na	K	Ca	Mg	Al	P sorp (mg/kg)	P sorp index	
1	PBA Pit 1, 1 0-10cm	0.05	6.2	13.9	0.3	1.1	7.7	2.6	<0.1	148	1.5	
2	PBA Pit 1, 2 60-70cm	0.04	5.9	23.9	0.9	0.5	11.2	5.9	0.1	373	2.8	
3	PBA Pit 1, 3 90-100cm	0.09	5.0	16.0	1.9	0.5	2.3	3.4	4.8	389	2.9	
4	PBA Pit 3, 1 0-10cm	0.04	5.9	12.2	0.8	0.5	5.5	2.3	0.1	287	2.4	
5	PBA Pit 3, 2 40-60cm	0.08	5.4	15.7	1.6	0.2	2.8	5.0	1.2	574	3.8	
6	PBA Pit 3, 3 170-190cm	0.29	5.0	22.3	3.9	0.4	0.7	9.3	2.9	729	4.6	
7	PBA Pit 4, 1 0-10cm	0.29	6.1	12.7	1.9	0.2	2.9	4.6	<0.1	271	2.3	
8	PBA Pit 4, 2 40-60cm	1.66	6.0	17.9	4.8	0.2	1.6	8.3	<0.1	281	2.4	
9	PBA Pit 4, 3 170-200cm	1.40	5.0	13.9	4.1	0.3	0.4	5.7	0.2	314	2.5	

SR Young

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Page 3 of 3

Report No: SCO10/080R1 (Preliminary 2)
Client Reference: John Lawrie
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method Sample Id	P7B/2 Particle Size Analysis (%)				P9B/2 EAT	P14B/1 BD (Mg/m ³)	P18B/1 AWC		Colour	
		clay	silt	f sand	c sand	gravel		0.3bar (%)	1.5 bar (%)	Dry	Moist
1	PBA Pit 1, 1 0-10cm	17	27	36	18	2	1.58	25.5	11.4	7.5YR5/3	7.5YR4/3
2	PBA Pit 1, 2 60-70cm	43	18	22	6	11	1.67	30.6	16.9	7.5YR6/4	7.5YR5/4
3	PBA Pit 1, 3 90-100cm	26	17	20	13	24	1.82	23.8	12.9	10YR6/3	10YR5/3
4	PBA Pit 3, 1 0-10cm	11	32	43	14	<1	1.32	27.3	10.1	10YR4/3	10YR3/3
5	PBA Pit 3, 2 40-60cm	39	18	36	7	<1	1.83	27.6	14.9	7.5YR6/6	7.5YR5/8
6	PBA Pit 3, 3 170-190cm	57	21	20	2	<1	1.60	33.0	19.5	7.5YR5/4	7.5YR4/4
7	PBA Pit 4, 1 0-10cm	18	32	41	9	<1	1.53	24.8	8.6	10YR6/3	10YR5/3
8	PBA Pit 4, 2 40-60cm	35	38	23	4	<1	1.73	23.6	13.0	10YR6/4	10YR5/4
9	PBA Pit 4, 3 170-200cm	28	17	53	2	0	1.70	24.7	11.8	10YR6/6	10YR4/6

SR Young

END OF TEST REPORT

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

SCO10/080R1

John Lawrie

GSS Environmental

PO Box 907

Hamilton NSW 2303

Report No:

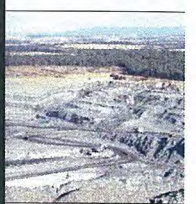
Client Reference:

Lab No	Method Sample Id	SPOCAS					
		pH _{KCl}	TAA (H ₂ SO ₄ kg/t)	pH _{ox}	TPA (H ₂ SO ₄ kg/t)	S _{KCl} (H ₂ SO ₄ kg/t)	S _p (H ₂ SO ₄ kg/t)
1	PBA Pit 1, 1 0-10cm	5.7	0.9	6.7	0.0	<0.1	0.5
2	PBA Pit 1, 2 60-70cm	4.7	1.1	4.4	1.4	<0.1	0.1
3	PBA Pit 1, 3 90-100cm	4.1	3.3	4.0	3.7	<0.1	0.4
4	PBA Pit 3, 1 0-10cm	5.3	0.5	5.7	<0.1	<0.1	0.5
5	PBA Pit 3, 2 40-60cm	4.4	1.6	4.5	1.9	0.3	0.3
6	PBA Pit 3, 3 170-190cm	4.1	2.8	4.7	3.5	0.1	0.6
7	PBA Pit 4, 1 0-10cm	5.1	0.7	5.2	<0.1	0.1	0.3
8	PBA Pit 4, 2 40-60cm	5.6	0.3	5.8	<0.1	<0.1	0.3
9	PBA Pit 4, 3 170-200cm	5.1	0.4	4.8	0.8	0.1	0.4



END OF TEST REPORT

SOIL CHEMICAL ANALYSES



APPENDIX 2

Lab No	Sample Id	MGA 94 Z 56 E292837 N 6286492	depth	C1A/4	Ece	C2A/3	C5A/3 CEC & exchangeable cations (me/100g)							ESP	AI	C8B/1 P sorp (mg/kg)	Storage capacity P P kg/ha	P14B/1 BD (Mg/m ³)	Table 8 Permeability category	PTB/2		P9B/2	Dispersi oness	P18B/1 AWC			
							CEC	Na	K	Ca	Mg	Al	AI							clay	silt			0.3bar (%)	15 bar (%)	AWC	
1	PBA Pit 1, 0-10cm		65	0.05	0.7	6.2	13.9	0.3	1.1	7.7	2.6	<0.1	0.05	N/A	148	1.5	234	1.58	FSL/ZC	3a rapid	17	27	8/3(1)	stable to slight	25.5	11.4	14.1
2	PBA Pit 1, 60-70cm			0.04	0.3	5.9	23.9	0.9	0.5	11.2	5.9	0.1	0.15	0.004	373	2.8	3737	1.67	LMC/C	5a slow	43	18	3(2)	slight	30.6	16.9	13.7
3	PBA Pit 1, 90-100cm			0.09	0.8	5	16	1.9	0.5	2.3	3.4	4.8	0.38	0.300	389	2.9	2124	1.82	L/L	3a rapid	26	17	2(1)	mod to high	23.8	12.9	10.9
																total	6095										
4	PBA Pit 3, 10-10cm	E292837 N 6286210	>190 cm	0.04	0.6	5.9	12.2	0.8	0.5	5.5	2.3	0.1	0.14	0.008	287	2.4	379	1.32	FSL/ZL	3a rapid	11	32	8/3(1)	stable to slight	27.3	10.1	17.2
5	PBA Pit 3, 40-60cm			0.08	0.7	5.4	15.7	1.6	0.2	2.8	5	1.2	0.30	0.076	574	3.8	2101	1.83	LC/C	5b moderate	39	18	5	slight	27.6	14.9	12.7
6	PBA Pit 3, 170-190cm			0.29	1.7	5	22.3	3.9	0.4	0.7	9.3	2.9	0.78	0.130	729	4.6	15163	1.6	HC/C	6b very slow	57	21	6	stable	33	19.5	13.5
																total	17643										
7	PBA Pit 4, 0-10cm	E292817 N 6286066	>200 cm	0.29	4.1	6.1	12.7	1.9	0.2	2.9	4.6	<0.1	0.31	N/A	271	2.3	1244	1.53	LSC/ZL	3a rapid	18	32	8/3(3)	stable to mod	24.8	8.6	16.2
8	PBA Pit 4, 40-60cm			1.66	14.3	6	17.9	4.8	0.2	1.6	8.3	<0.1	0.80	N/A	281	2.4	6806	1.73	ZC/ZCL	5b moderate	35	38	6	stable	23.6	13	10.6
9	PBA Pit 4, 170-200cm			1.4	13.3	5	13.9	4.1	0.3	0.4	5.7	0.2	0.82	0.014	314	2.5	1601	1.7	SC/LCL	3a rapid	28	17	2(1)	mod to high	24.7	11.8	12.9
																total	9651										

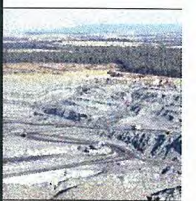
Pit 2

E292855

51

128 cm

N6284357



APPENDIX 3

GLOSSARY

A Horizon

The original top layer of mineral soil divided into A1 (typically from 5 to 30 cm thick; generally referred to as topsoil).

Alluvial Soils

Soils developed from recently deposited alluvium, normally characterise little or no modification of the deposited material by soil forming processes, particularly with respect to soil horizon development.

Available Water Holding Capacity (AWC)

The amount of moisture in the soil that is available for plants to grow.

B Horizon

Is the layer of soil below the A horizon. It is usually finer in texture, denser and stronger in colour.

Bulk Density

The mass of dry soil per unit bulk volume.

Chromosols

Duplex soils which are not strongly acidic at depth.

Consistence

Comprises the attributes of the soil material that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation or rupture.

Dermosols

Soils with structured b horizons and lacking a strong texture contrast between the A and B horizons.

Duplex Soils

Soils which have a sharp increase in texture between the A horizon and the B horizon.

Electrical Conductivity Soil (ECe)

The property of the conduction of electricity through water extract of soil.
Used to determine the soluble salts in the extract, and hence soil stability.
(Soil Landscapes of Singleton Kovac & Lawrie, 1991)

Emmerson's Aggregate Test (EAT)

A classification of soil based on soil aggregate coherence when immersed water. Classifies soils into eight classes and assists in identifying whether soils will slake, swell or disperse
(Soil Landscapes of Singleton, Kovac & Lawrie 1991).

Gravel

The >2 mm materials that occur on the surface and in the A1 horizon and include hard, coarse fragments.

Kurosols

Duplex soils with strongly acidic B horizons.

Loam

A medium, textured soil of approximate composition 10 - 25% clay, 25 - 50% silt and <50% sand.

Mottling

The presence of more than one soil colour in the same soil horizon, not including different nodule or cutan colours.

Particle Size Analysis (PSA)

The determination of the amount of the different size fractions in a soil sample such as clay, silt, fine sand, coarse sand and gravel. (Soil Landscapes of Singleton 1991).

Pedality

Refers to the relative proportion of peds in the soil (as strongly pedal, weakly pedal or non-pedal).

Permeability

Is the characteristic of a soil material which governs the rate at which water can move through that it. See E&HP Guidelines, Table 8.1a is very rapid and 6c is very slow.

pH

A measure of the acidity or alkalinity of a soil.

P Storage Capacity (kg/ha)

Amount of P that a soil profile can absorb on one hectare of land.

Saline Soil

A soil which contains sufficient soluble salts to adversely affect plant growth or land use. Generally a saturation extract in excess of E_{Ce} of 4ds/m is regarded as saline

Podzolics

Podzolic soils are acidic throughout and have a clear boundary between the topsoil and subsoil. The topsoils are loams with a brownish grey colour. The lower part of the topsoil has a pale light colour and may be bleached with a nearly white, light grey colour.

Ped

An individual, natural soil aggregate. (Soil Landscapes of Singleton. Kovac & Lawrie 1991)

Sodicity

A measure of exchangeable sodium in the soil. High levels adversely affect soil stability, plant growth and/or land use. Soils with an exchangeable sodium percentage (ESP) of 6 or greater are considered to be sodic.

Managing Director:
ROD MASTERS
M Sc, Dip App Sci, (Agric) Dip Geo

General Manager:
ANDREW HUTTON
B Nat Res, M.Bus Env Man.



GSS ENVIRONMENTAL
Environmental, Land and Project
Management Consultants

Senior Project Managers:

CRAIG BAGNALL
B E (Env) (Hons)

CHAD STOCKHAM
B E (Env) (Hons)

NICOLE ARMIT
B.E (Env) (Hons), M.Env.Law

REF NO (PBA01- 001)

13th December 2010

Jeremy Spinak
Executive Officer
EG Property Group
Level 14 | 345 George St
Sydney NSW 2000

Dear Jeremy

RE: Soil Sampling Technique used for the Jacaranda Ponds Project Report

As requested, please see below a detailed explanation of the methods and techniques used to map soil types for the Jacaranda Ponds Project.

The identification of the four sites for testing as well as the production of the soil type and land classification maps followed Australian Standards and best practice. The survey included comprehensive soil testing of the 3 main soil types, in order to determine whether the project area is considered prime or poor agricultural land. The following soil laboratory tests were carried out:

- Particle Size Analysis (PSA);
- Colour;
- Electrical Conductivity (EC);
- pH;
- Cation Exchange Capacity (CEC);
- Exchangeable Cations;
- Emerson's Aggregate Test (EAT);
- SPOCAS test for Acid Sulphate soils;
- Phosphorus Sorption;
- Available Water Holding Capacity; and
- Bulk Density.

The soil map and laboratory results were used to classify land capability and suitability classes within the project area. The survey was carried out in accordance with standards set by the Australian Soil & Land Survey Handbook Guidelines for Conducting Surveys" edited by Gunn RH et al. 1988 and using McKenzie N., Grundy M.J., Webster R. & Ringrose-Voase AJ (2008) Guidelines for Surveying Soil and Land Resources: second edition (CSIRO Australia).

The area of the survey was approximately 183 ha and the scale of the survey was moderately detailed at a scale of approximately 1:25,000.

Windaf Pty Limited ABN 47 059 448 323 trading as GSS Environmental

Head Office: PO Box 907, HAMILTON NSW 2303
Central Coast Office: PO Box 3214, WAMBERAL NSW 2260

Ph: (02) 4920 3000 Fax: (02) 4961 3360
Ph: (02) 4385 7899 Fax: (02) 4385 8028

www.gssenvironmental.com

The number of areas in which soil sampling took place was based upon rigorous research and analysis. The following background work went into determining the four sample locations and assisted in the production of the final land classification map. Initially, a land reconnaissance survey was carried out in order to prepare a base soil map using the following 3 methods:

1. **Use of previous soil surveys** which have comprehensively surveyed the project area for both soil attributes and agricultural land suitability. Accordingly, the soil and land resource assessment for the project area has been developed through a combination of desktop studies of the previous soil and landscape assessments that have reviewed the site. The soil and land resource information that was directly applicable to the project area was sourced from the following reports listed below:

- *Soil Landscapes of Penrith 1:100,000 Sheet and Report (Bannerman & Hazelton 1990);*
- *Soil & Land Resources the Hawkesbury - Nepean Catchment 2008.*

The most recent report prepared by (DECC, 2008) indicated that there are 2 soil landscapes in the survey area. These are the Luddenham & South Creek soil landscapes both found on Ashfield shale which consists of inter-bedded and strongly laminated dark grey siltstone shales.

2. **Using aerial photographs, topographic maps and satellite images** as a remote sensing technique which allowed for more detailed analysis of the landscape, as well as the mapping of features expected to be related to the distribution of soils within the project area.
3. **Using stratified observations** a broad scale soil map was prepared in order to determine where to select sites to visually assess surface soil exposures, topography and vegetation. These were then used to verify potential soil units, delineate soil unit boundaries and determine preferred locations for targeted subsurface investigations. In addition, vegetation information was used from a special report prepared for DPSPL by Travers et.al 2009 to help determine the main types of soil found in the survey area.

These references were used to provide background data for carrying out the soil and land capability assessment undertaken by GSSE in March 2010.

Several soil profiles were observed during the site induction and initial field inspection of surface exposures which were found along tracks, cuttings, gullies, dams, and other disturbed areas of land.

Four (4) main soil units were identified including the shallow Red Kurosol unit which was confined to a small area (3.4ha) of steeper hill slopes. Four (4) soil pits were then dug by backhoe to at least 1 metre deep and up to 1.9 metres at selected sites located near the centre of the survey area and detailed soil descriptions were recorded. These test pit locations were chosen to provide representative profiles of the soil types in the survey area. The soil layers were distinguished on the basis of changes in texture, structure and colour.

These 4 sites were selected near the top, middle and bottom of the catenary sequence respectively on hill slopes, convex mid slopes and concave lower slope sites. Nine (9) samples were then collected for laboratory analyses from 3 pits which represented the main 3 soil types. These 3 soil types were those that were most likely to have higher agricultural suitability classes.

The Australian Soil & Land Survey Handbook "Guidelines for Conducting Surveys" by Gunn R H et al. recommend at this scale of soil survey that at least one soil profile is described from each soil type: except when it is only practical to collect one sample from the more important soil profile classes when time and laboratory resources are limited.

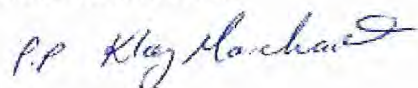
Using these descriptions and by analysing the soil laboratory results, two land capability classes and two land suitability classes were then identified and mapped.

I believe that sufficient observations, soil pit descriptions and soil profile laboratory analyses were carried out to accurately map the agricultural suitability of the land for this project.

Please do not hesitate to contact me on (0428) 998959 should you wish to discuss any aspect of the information outlined above.

Yours sincerely,

GSS Environmental



John Lawrie

Manager - Land Systems & Catchment Management

Certified Soil Scientist (CP grade 3)