Our Ref 10024rh.11

Contact ROBERT HARRINGTON

14 July 2011

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Dear Andrew

**GEOTECHNICAL INVESTIGATION**
**RIVE VUE ESTATE STAGE 4**
**MURWILLUMBAH, NEW SOUTH WALES**

Please find attached a copy of our geotechnical investigation report for the above project.

If you have any queries with regards to this report, please contact the undersigned on 0404 925 428.

Yours faithfully

*ROBERT HARRINGTON*
*GEOTECHNICAL ENGINEER*
*for* **Cardno Bowler**

Cardno Bowler
Shaping the Future

# Geotechnical Investigation
# Rive Vue Estate Stage 4
# Murwillumbah, New South Wales

Job Number 10024rh.11

Prepared for Yeats Consulting

Date of Report 14 July 2011

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## Document Control

| Version | Date | Author | | Reviewer | |
|---|---|---|---|---|---|
| 1 | 14 July 2011 | Robert Harrington |  | Gary Samuels |  |

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# 1 INTRODUCTION

A geotechnical investigation was carried out for Stage 4 of Riva Vue Estate, Murwillumbah, as requested by Yeats Consulting.

We understand the proposed development consists of an 86 lot extension of an existing residential subdivision. Further, we understand that preparation works include bulk earthworks, cuts and fills of varying depths and the construction of a drainage channel along the Western and Northern boundaries of the site.

The objectives of the investigation, as outlined in our proposal Ref: E7185.11 dated 28th March 2011, were as follows:

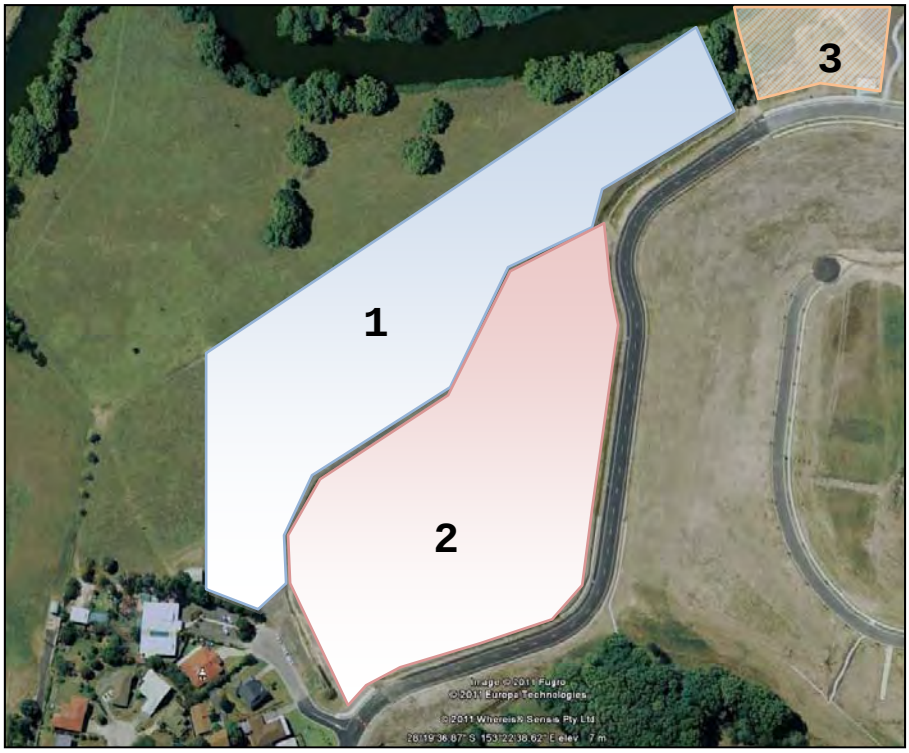
- Carry out a geotechnical investigation of the site, including drilling of boreholes across the site and testing of soils found to:
  - Sufficiently identify the site soil profile(s); and
  - Identify suitable founding material for the proposed development. Borehole logs shall include standing groundwater levels, ground surface levels and depths of each soil regime. This fee does not include any survey of ground surface levels. GPS co-ordinates and indicative surface levels will be provided only.
  - Extent of compressible soils.
- Carry out suitable laboratory testing to assist in the recommendations for foundation design and soil foundation preloading and settlement estimates, retaining wall and shoring design and earthworks conditions.
- Prepare a detailed report which shall include the borehole logs, site soil test results and laboratory testing results, and which shall advise the following:
  - Design parameters for bulk earthworks across the site.
  - Potential settlement characteristics.
  - Site excavation, shoring requirements and other relevant construction matters.
- Carry out acid sulfate soil desktop study.

Authorisation to proceed with the investigation was received by fax from Mr Scott Willis, representing Yeats Consulting, on behalf of Barnby developments Pty Ltd.

This report must be read in conjunction with our attached *'General Notes'* and the ASFE publication *'Important Information About Your Geotechnical Engineering Report'*.

# 2 SITE DESCRIPTION

The subject block, at the time of investigation could be broken into three distinct regions as represented below:




**Region 1** was accessed at the end of Joshua St and consisted of a natural level field that was well covered in thick tall grass at the time of investigation. There were also a number of drainage channels running approximately south west across the block and a grass covered road had been mowed along the West and North boundaries of the property.

**Region 2** was boarded by Rous River Way along its southern and eastern boundaries. The southwest portion of this region comprised of a well grassed level fill pad. There region rose to slight hill on the North eastern section of this area where the hill was well grassed and densely treed by large mature gums and juvenile pines perched on the flat top of the hill. There was also an open concrete lined drainage channel running between the site and Rous River Way.

**Region 3** consisted of the North-Eastern most section of the site and is separated from Region 1 by a natural creek that runs approximately North-South away from the Tweed River. The area was generally flat and well grassed at the time of investigation and was accessed off Rous River Way.

No structures existed on site at the time of investigation.

Photographs depicting typical site conditions at the time of the investigation are presented in Plates 1 to 3 following.

**Plate 1: Looking West across the site from Region 1**

**Plate 2: Looking North East across the site**

**Plate 3: Looking South West across the site**

# 3 INVESTIGATION WORK

## 3.1 Fieldwork

Fieldwork for the investigation was carried out between the 6th and 14th of June 2011 and on the 8th of July 2011 and included the drilling of 3 boreholes and 5 cone penetrometers tests at the locations shown on the attached site plan, Figure 1. The material encountered at each location is described on borehole/CPT log sheets included in Annex A.

Fieldwork was carried out in accordance with Australian Standard, AS1726-1993 *'Site Investigation Code'*.

## 3.2 Laboratory Testing

Samples of representative strata were recovered and returned to our NATA accredited soils laboratory. The following tests were carried out on selected samples;

- Moisture Content
- Particle Size Distribution
- Atterberg Limits
- Linear Shrinkage

The laboratory test results are included in Annex B. Laboratory testing was carried out in accordance with Australian Standard AS1289 *'Laboratory Testing For Engineering Purposes'*.

# 4 SUBSURFACE CONDITIONS

## 4.1 Subsurface Strata

The investigation work indicated that relatively consistent subsurface conditions existed at the investigation location.

The results of the cone penetrometer and boreholes testing indicated that the natural subsurface strata primarily comprised of stiff or better clays. Loose sands were encountered at test locations CPT-01 from 1.25 – 2.25m and CPT-04 from 2.5 – 4.6m and 8.5 - 11m. At the location of borehole 1 and CPT-03 in region 2, 5m of Silty Sandy Clay fill was encountered and 4m of Clayey Sand fill was encountered at CPT-05.

Borehole 3 drilled on the top of the hill encountered 3.5m of dense silty clayey sand underlined by very stiff silty clay to 7.3m. This was underlain by extremely weathered rock to termination depth at 8m.

The borehole/CPT logs in Annex A should be referred to for the detailed description of material encountered at each investigation location. A summary is detailed in the table below.

**Table 1: Summary of Subsurface Strata**

| Soil Descriptions/Depth (m) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CPT/BH No** | **FILL** | | **NATURAL** | | | | **XW Rock** | **TD** |
| | **Clayey Sand** | **Sandy Clay** | **Sand/Clayey Sand** | | **Silty/Sandy Clays** | | | |
| | | | **Loose** | **Med dense or better** | **Firm** | **Stiff or better** | | |
| CPT-01 | - | - | 1.25–2.25 | 0.75–1.25<br>5.25–TD | 0.0-0.75 | 2.25–5.25 | - | 7.0 |
| CPT-02 /BH2 | - | - | - | 11.8-12.6 | - | 0.0-11.8 | 12.6-TD | 13.7 |
| CPT-03 /BH1 | - | 0.0-5.0 | - | - | - | 5.0-16.2 | - | 16.2 |
| CPT-04 | - | - | 2.5-4.6<br>8.5-11.0 | 11.0-14.1 | - | 0.0-2.5<br>4.6-8.5 | 14.1-TD | 14.7 |
| CPT-05 | 0.0-4.0 | - | - | - | - | 4.0-TD | | 7.5 |
| BH3 | - | - | - | 0.0-3.5 | - | 3.5-7.3 | 7.3-TD | 8.0 |

NOTES:

a) All depths measured in metres below ground level at the time of the investigation.
b) TD = Termination Depth

Groundwater was encountered in borehole 2 at 2.1m below ground at the time of investigation. A shallow standpipe was installed at this location.

## 4.2 Laboratory Test Results

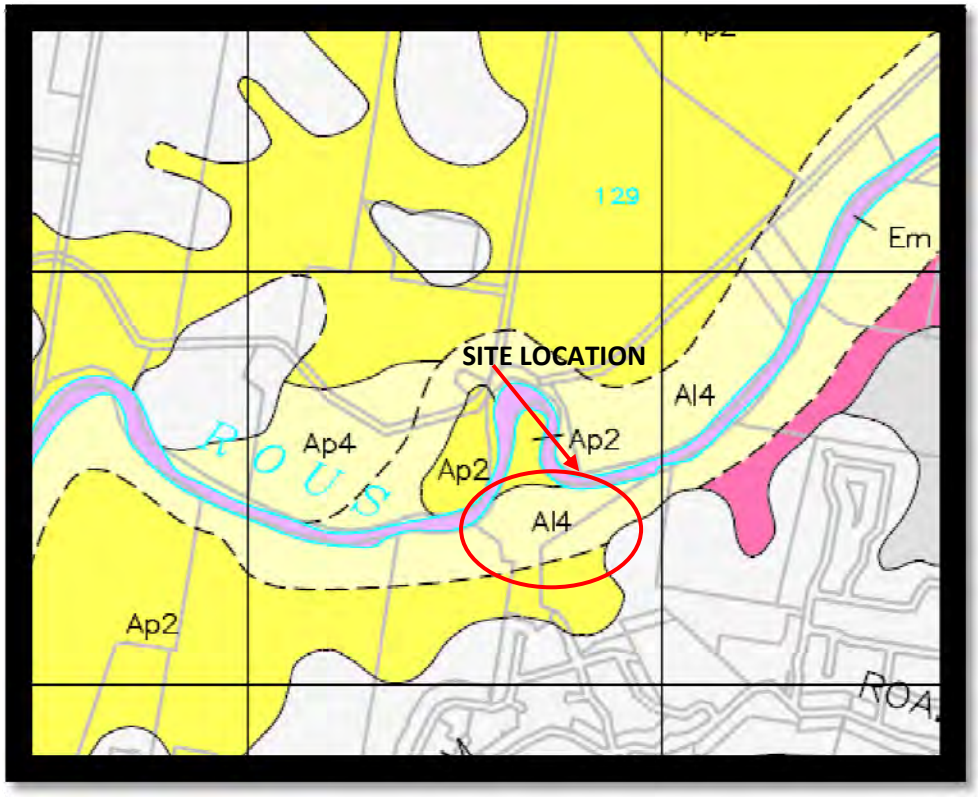
A summary of laboratory test results is provided in the Table 2 below.

**Table 2: Classification Test Results**

| Particle Size Distribution, Atterberg Limits, Linear Shrinkage and Moisture Content | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Bore No** | **Depth (m)** | **% Sand & Gravel** | **% Clay & Silt** | **Moisture Content (%)** | **Liquid Limit (%)** | **Plasticity Index (%)** | **Linear Shrinkage (%)** |
| 1 | 2.5-2.95 | 37 | 63 | 19.6 | 44 | 21 | 9.0 |
| 2 | 4.0-4.5 | 10 | 90 | 34 | 59 | 38 | 15.5 |
| 2 | 10-10.45 | 30 | 70 | ND | 47 | 31 | 12.5 |

# 5 Desktop Acid Sulfate Soils Assessment

As requested, a desktop acid sulfate soils assessment was conducted as a part of this investigation. The 1:250,000 Murwillumbah geological map classifies the site as having a regional geology of class Cza - Alluvium, mainly clay, silt, sand and gravel. The NSW department of Land and Water Conservation acid sulfate soils risk map for Murwillumbah classifies the site as part Class Al4 and part Ap2. As shown in the figure below:




Al4 is defined as being an alluvial levee with an elevation >4m.

Ap2 is defined as being alluvial plain with elevation of 2-4m.

The NSW department of Land and Water conservation rate these classifications as having a low probability of occurrence of acid sulfate soils.

In accordance with the key of the ASS risk map the reason for a low probability is that;

"The environment of deposition has generally not been suitable for the formation of acid sulfate soil materials. Soil materials are often Pleistocene in age. Acid sulfate soil materials, if present, are sporadic and may be buried by alluvium or windblown sediments."

The expected depth of ASS occurrence is greater 3m below ground surface for Al4 and between 1-3m in depth for Ap2.

It is generally considered that ASS could potentially occur in areas lying below 5m AHD. As parts of this site are below 5m AHD it is recommended that further investigation may be warranted, particularly for the proposed excavation of the drainage channel along the Western and Northern boundaries of the site. This is particularly relevant if it is proposed to use the material won from the excavation as structural fill.

# 6 GEOTECHNICAL ASSESSMENT

## 6.1 Earthworks

The supplied earthworks plan indicated cut depths of up to 7m for the hill on the Northeast side of the site, bordering Rous River Way. Further, there are expected cuts of 1.0-1.5m for the proposed drainage channel and wetland and a fill depth of 3m for the housing area in region 1. The fill pad in region 2 is expected to be stripped of topsoil to 0.1m.

**Site Preparation**

Where the site has not undergone and filling to date, all future site preparation work should generally be carried out in accordance with AS3798-2007 *'Guidelines on Earthworks for Commercial and Residential Developments.'*

These areas should be stripped of any topsoil from the cut and fill areas and road or drainage channel alignments, and stockpiled for later use. A stripping depth in the order of 0.1m – 0.3m is indicated from the information gathered at the investigation locations. An indicative stripping depth of 0.1m is indicated from the information gathered for the already developed fill pad adjacent to Rous River Way.

Depressions formed by the removal of vegetation, existing drainage structures, underground services etc, should have all disturbed soil cleaned out and be backfilled with compacted select fill material.

If material won from excavation onsite is to be used as structural fill, as it would generally be of a clayey nature it is recommended that it be pre-treated (i.e moisture conditioned) prior to placement as fill.

**Structural Fill Placement**

Prior to the placement of any structural fill the site should be proof rolled using a minimum 10 tonne dynamic padfoot roller. Any loose/soft areas should be removed and recompacted or replaced using a compacted select fill. Care should be taken that the dynamic roller should not be used within 30m of any existing structures; this is an issue near the end of Joshua St.

To minimise the potential for post compaction volume change due to moisture content variations, any structural clay bearing fill should be placed in loose layers not greater than 200mm thick at a moisture content in the range -2% to +3% of the standard optimum moisture content, and be compacted to a minimum dry density ratio of 95% standard compaction as per AS1289 5.1.1. Clay bearing fill should be compacted using a minimum 10 tonne vibrating padfoot roller.

Measures should be adopted to ensure that this clay bearing fill material is not allowed to dry out prior to the placement of succeeding layers of fill and final covering with building slabs and road pavements.

Any structural free draining sand fill should be placed in loose layers not greater than 200mm thick, flooded, if necessary, and compacted to a minimum density index of 65% as per AS1289 5.5.1 using a vibrating smooth roller drum not less than 10 tonne in static weight.

Compaction of fill is required for a number of reasons:-

- Fill should be compacted to the degree that significant settlement within the fill will not occur.
- Compaction of the each layer is required sufficient to provide suitable working surface for subsequent fill lifts and to enable compaction to be carried out on subsequent lifts.

It is recommended that the placement of all structural fill be inspected and tested by Cardno Bowler to a level 1 requirement during the earthworks operations to ensure that all fill is placed in a *'controlled manner'*, in accordance with AS3798-2007 *'Guidelines on Earthworks for Commercial and Residential Developments'*.

**Excavatability**

No problems should be encountered in excavating the near surface material on site. Most soils encountered on site should be within the excavation limits of a small dozer (eg Cat D6 or similar) in bulk excavations or medium size backhoe (eg Case 580 or similar) in trench excavations. Some of the material encountered during excavation of the hill on the Northeast side of the site may need to be ripped with a Cat D6 or similar prior to digging.

**Trafficability**

During this investigation, access around the natural areas of the site was quite difficult due to the soft and clayey nature of near surface soil.

If at any stage there is a need for haul roads to be developed the following construction method is recommended:

- Strip the grass and organic root zone and allow the surface to dry to promote some surface crust
- Following stripping and drying, place a minimum thickness of 500 – 600mm of granular material of a maximum particle size of 75mm over the stripped surface
- After the initial lift, subsequent lifts, preferably with granular material, can be placed and compacted in the conventional way.

## 6.2 Batter Slopes

For initial design purposes, previous experience has indicated that the following maximum unprotected batter slopes may be adopted for the cut and fill batters on the site.

**Table 3: Recommended Batter Slope Angles**

| Material Type | Short Tern (Maximum) | Long Term (Maximum) |
|---|---|---|
| Sands/Clayey Sands | 1V:2H | 1V:2.5H |
| Stiff or better Clays (cut) | 1V:1H | 1V:2H |
| Weathered Rock | 1V:1H | (ii) |
| Fill Batters(i) | 1V:2H | 1V:2H |

Notes:

(i) All fill batters should be overfilled, compacted and cut back at the maximum angles recommended above and with some form of erosion protection to minimise the potential scour effects due to weathering.

(ii) Denotes requirement for further assessment.

However, the above should be considered *'indicative'* only and may vary along the alignment depending upon the water table level and any soft/loose natural strata.

## 6.3 Settlement

For the purpose of this assessment, we understand that approximately 3m of structural fill will be used on natural areas of the site in order to raise the building platforms to the desired level. The load due to this fill is expected to be in the region of 60kPa. Single to 3 storey lightweight structures or traffic loads could be expected to induce a load in the order of 10 to 20kPa.

It is generally considered that compressible soils that have less than a 100kPa bearing capacity and would be described as being soft to firm in nature may settled under the loads described above. The results of the CPT pushed and boreholes drilled across the site would indicate that the predominant nature of the clays encountered could be regarded as being stiff in nature and therefore unlikely to settle under the expected loadings.

However, the presence of very loose sand 2m in thickness, as encountered in CPT-04, could be expected to produce immediate elastic settlements in the order of 50mm.

## 6.4 Allowable Bearing Capacity

The following allowable bearing capacities may be applied for strip/pad footing for structural design:

**Table 4: Allowable Bearing Capacities**

| Material Type | Allowable Bearing Capacity (kPa) |
|---|---|
| Controlled Fill | 100 |
| Stiff Natural Clay | 100 |
| Weathered Rock | 600 |

Provided the recommendations of this report are adopted, high level footings for residential dwellings could be expected.

# 7 CONSTRUCTION INSPECTIONS

It is recommended that placement of all structural fill and footing excavations be inspected, tested and certified where necessary, by Cardno Bowler Pty Ltd to ensure recommendations made in this report have been adhered to.

Should subsurface conditions other than those described in this report be encountered, Cardno Bowler Pty Ltd should be consulted immediately and appropriate modifications developed and implemented if necessary.

# 8 CONCLUSIONS AND RECOMMENDATIONS

The following is a summary of the conclusions and recommendations in regard to the geotechnical investigation the development of Stage 4 of Riva Vue Estate, Murwillumbah.

However, the preceding sections of this report should be read for a full description of the conclusions and recommendations.

1. The subsurface conditions at the site generally consisted of natural stiff or better clays with some loose sand layers in the low lying areas.

2. The site preparation work should generally be carried out in accordance with AS3798-2007 *'Guidelines on Earthworks for Commercial and Residential Developments'*. All soils encountered whilst onsite should be within the excavation limits of a small dozer (eg Cat D6 or similar) in bulk excavations or medium size backhoe (eg Case 580 or similar) in trench excavations.

3. Long term consolidation settlement is not expected to occur in the clays encountered onsite.

4. Conventional footings could be expected provided the recommendations in this report are adhered to.

Yours faithfully

*ROBERT HARRINGTON*
*GEOTECHNICAL ENGINEER*

*GARY SAMUELS*
*PRINCIPAL*


Key:

- Approximate Borehole Location

▲ - Approximate CPT location

NOT TO SCALE

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Investigation Location Plan

Riva Vue Estate, Murwillambah

Yeats Consulting

**JOB NO.:**

**10,024**

FIGURE 1

# GENERAL NOTES

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April 2005

## GENERAL

This report comprises the results of an investigation carried out for a specific purpose and client as defined in the introduction section(s) of the document. The report should not be used by other parties or for other purposes as it may not contain adequate or appropriate information.

## TEST HOLE LOGGING

The information on the Test Hole Logs (Boreholes, Backhoe Pits, Exposures etc.) has been based on a visual and tactile assessment except at the discrete locations where test information is available (field and/or laboratory results).

Reference should be made to our standard sheets for the definition of our logging procedures (Soil and Rock Descriptions).

## GROUNDWATER

Unless otherwise indicated the water levels given on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level depending on material permeabilities. Further variations of this level could occur with time due to such effects as seasonal and tidal fluctuations or construction activities. Final confirmation of levels can only be made by appropriate instrumentation techniques and programmes.

## INTERPRETATION OF RESULTS

The discussion and recommendations contained within this report are normally based on a site evaluation from discrete test hole data. Generalised or idealised subsurface conditions (including any cross-sections contained in the report) have been assumed or prepared by interpolation/extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

## CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions used for this report can occur, particularly between discrete test hole locations. Furthermore, certain design or construction procedures may have been assumed in assessing the soil structure interaction behaviour of the site.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed in this report should be referred to this firm for appropriate assessment and comment.

## FOUNDATION DEPTH

Where referred to in the report, the recommended depth of any foundation (piles, caissons, footings, etc.) is an engineering estimate of the depth to which they should be constructed. The estimate is influenced and perhaps limited by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The depth remains, however, an estimate and therefore liable to variation. Footing drawings, designs and specifications based upon this report should provide for variations in the final depth depending upon the ground conditions at each point of support.

## REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in this report for the inclusion in the contract documents or engineering specification of the subject development, such reproduction should include at least all the relevant test hole and test data, together with the appropriate standard description sheets and remarks made in the written report of a factual or descriptive nature.

# IMPORTANT INFORMATION
## ABOUT YOUR
# GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions that any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE / The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays cost-overruns and other costly headaches that can occur during a construction project.

### A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, *your geotechnical engineering report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

*Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.*

### MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent testing are extrapolated by geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predications. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimise their impact.* For this reason, *most experienced owners retain their geotechnical consultants through the construction stage*, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

### SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional test are necessary.

### GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

## A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

## BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use*. Those who do not provide such access may proceed under the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

## READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

## OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE has developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by The Institution of Engineers Australia, National Headquarters, Canberra, 1987.

*Published by*

ASFE
**THE ASSOCIATION OF ENGINEERING FIRMS PRACTICING IN THE GEOSCIENCES**

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Annex A

# Fieldwork Results

*September, 2001*

# SOIL DESCRIPTION

This procedure involves the description of a soil in terms of its visual and tactile properties, and relates to both laboratory samples and field exposures as applicable. A detailed soil profile description, in association with local geology and experience, will facilitate the initial (and often complete) site assessment for engineering purposes.

The method involves an evaluation of each of the items listed below and is in general agreement with the Site Investigation Code AS1726-1993.

**SOIL TYPE**
The soil is described on the basis of the grain size composition of the constituent particles, and the plasticity of the fraction of material passing the 425μm sieve.

Furthermore, as most natural soils are part combinations of various constituents, the primary soil is described and modified by minor components. In brief, the system is as follows;

| SILT OR CLAY AS MINOR COMPONENT | | GRAVEL OR SAND AS MINOR COMPONENT | |
|---|---|---|---|
| **% Fines** | **Modifier** | **% Coarse** | **Modifier** |
| ≤5<br>>5 ≤12<br>>12 | omit, or use "trace"<br>describe as "with clay/silt" as applicable<br>prefix soil as "silty/clayey" as applicable | ≤15<br>>15 ≤30<br>>30 | omit, or use "trace"<br>describe as "with sand/gravel" as applicable<br>prefix soil as "sandy/gravelly' as applicable |

Note: For soils containing both sand and gravel the minor coarse fraction is omitted if less than 15%, or described as "with sand/gravel" as applicable when greater than 15%.

The appropriate classification group symbol for soil classification is also given before the soil type description in accordance with AS1726-1993, Table A1.

For granular soils, an assessment of grading (well, uniform, gap or poor), particle size (fine, medium etc), angularity, shape and particle composition may also be given.

**COLOUR**
Colour is important for correlation of data between test holes and for subsequent excavation operations. The prominent colour is noted, followed by (spotted, mottled, streaked etc.) secondary colours as applicable. Colour should be described in the "moist" condition, though both wet and dry colours may also be appropriate.

**MOISTURE**
The moisture condition of the soil is described by the appearance and feel of the soil using one of the following terms:
Dry cohesive soils - hard, friable or powdery; granular soils - cohesionless, free funning.
Moist soil cool, darkened colour: cohesive soils - can be moulded; granular soils - tend to cohere.
Wet soil cool, darkened colour: cohesive soils - usually weakened, free water on hands when handling; granular soils - tend to cohere.

In addition, the presence of any seepage or free water is noted on all test hole logs.

**CONSISTENCY/RELATIVE DENSITY**
Granular soils are generally described in terms of relative density (density index) as listed in Table A5 AS1726. These soils are inherently difficult to assess and normally a penetration test procedure (SPT, DCP or CPT) is used in conjunction with published correlation tables. Alternatively, insitu density tests can be conducted in association with minimum and maximum densities performed in the laboratory.

Cohesive soils can be assessed by direct measurement (shear vane), or estimated approximately by tactile means and/or the aid of a geological pick as given on the following table. It is emphasised that a "design shear strength" must take cognisance of the insitu moisture content and the possible variations of moisture with time.

| Term | Tactile Properties | Undrained Shear Strength (kPa) |
|---|---|---|
| Very Soft | Exudes between the fingers when squeezed in the hand. | ≤12 |
| Soft | Easily penetrated by thumb about 30-40mm. Pick head can be pushed in up to shaft. Moulded by light finger pressure. | >12 ≤25 |
| Firm | Penetrated by thumb 20-30mm with moderate effort. Sharp end of pick pushed in some 30-40m. Moulded by strong finger pressure. | >25 ≤50 |
| Stiff | Indented by thumb about 4mm with moderate effort. Pick pushed in up to 10mm. Cannot be moulded in fingers. | >50 ≤100 |
| Very Stiff | Readily indented by thumb nail. Slight indentation produced by pushing pick into soil. | >100 ≤200 |
| Hard | Difficult to indent with thumb nail. Requires power tools for excavation. | >200 |

**STRUCTURE/OTHER FEATURES**
The structure of the soil may be described with reference to: zoning, where soils consist of separate zones differing in colour, grain size or other properties; defects, including fissures, cracks, root-holes and the like; cementing, with the strength (weakly to strongly), and nature of the cementing agent; additional observations including geological origin, odour and the like. In addition, the presence of other features (ferricrete nodules, organic inclusions) should also be noted as applicable.

# BOREHOLE LOG SHEET

| | | | |
|---|---|---|---|
| **Client:** Yeats Consulting<br>**Project:** Riva Vue Estate, Murwillumbah<br>**Location:** Riva Vue Estate, Murwillumbah | | | **Hole No: BH1** |
| | | **Job No: 10024** | **Sheet: 1 of 2** |
| **Position: REFER SITE SKETCH FIGURE 1** | | **Angle from Horizontal: 90°** | **Surface Elevation:** |
| **Rig Type: Edson MRA260** | | **Bit: TC BIT** | **Driller: LB** |
| **Casing Diameter: 100 mm** | | **Contractor: Cardno Bowler** | |
| **Date Started : 14/6/11** | **Date Completed: 14/6/11** | **Logged By: LB** | **Date Logged: 14/6/11** |

| Depth (m) | Drilling: Auger 'V' Bit | Drilling: Auger 'TC' Bit | Drilling: Washbore | Drilling: Casing | Drilling: Coring | Groundwater (m) | Sample or Field Test | Recovered | DCP | RL (m AHD) | Graphic Log | USCS Symbol | Description (SYMBOL, SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | | | CH | SANDY SILTY CLAY/SILTY SANDY CLAY, low plasticity, fine to medium sand, dark brown, with fine gravel, moist to wet, FILL (100mm ROOT ZONE) |
| | | | | | | | | | | | | CH | SANDY SILTY CLAY/SILTY SANDY CLAY, low plasticity, fine to medium sand, dark brown, with fine gravel, moist, FILL |
| 0.5 | | | | | | | | | | | | | SILTY SANDY CLAY, intermediate plasticity, fine to coarse sand, orange, trace fine to medium gravel, moist, FILL |
| 1.0 | | | | | | | D 1.00 - 1.45 m<br>SPT<br>4,4,3 N=7 | | | | | | |
| 1.5 | | | | | | | | | | | | | |
| 2.0 | | | | | | | | | | | | CI | |
| 2.5 | | | | | | | D 2.50 - 2.95 m<br>SPT<br>4,5,7 N=12 | | | | | | |
| 3.0 | | | | | | | | | | | | | |
| 3.5 | | | | | | | | | | | | | |

See Standard Sheets for details of abbreviations & basis of descriptions

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# BOREHOLE LOG SHEET

| | | | |
|---|---|---|---|
| **Client:** Yeats Consulting<br>**Project:** Riva Vue Estate, Murwillumbah<br>**Location:** Riva Vue Estate, Murwillumbah | | **Job No: 10024** | **Hole No: BH1**<br>**Sheet: 2 of 2** |
| **Position: REFER SITE SKETCH FIGURE 1** | | **Angle from Horizontal: 90°** | **Surface Elevation:** |
| **Rig Type: Edson MRA260** | | **Bit: TC BIT** | **Driller: LB** |
| **Casing Diameter: 100 mm** | | **Contractor: Cardno Bowler** | |
| **Date Started : 14/6/11** | **Date Completed: 14/6/11** | **Logged By: LB** | **Date Logged: 14/6/11** |

| Depth (m) | Drilling: Auger 'V' Bit | Drilling: Auger 'TC' Bit | Drilling: Washbore | Drilling: Casing | Drilling: Coring | Groundwater (m) | Sample or Field Test | Recovered | DCP | RL (m AHD) | Graphic Log | USCS Symbol | Description (SYMBOL, SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | D 4.00 - 4.45 m<br>SPT<br>3,4,4 N=8 | | | | | | SILTY SANDY CLAY, intermediate plasticity, fine to coarse sand, orange, trace fine to medium gravel, moist, FILL |
| 4.5 | | | | | | | | | | | | CI | |
| 5.0 | | | | | | | | | | | | | SANDY SILTY CLAY/SILTY SANDY CLAY, intermediate plasticity, fine to medium sand, grey, moist to wet, stiff, NATURAL |
| 5.5 | | | | | | | D 5.50 - 5.95 m<br>SPT<br>2,3,5 N=8 | | | | | | |
| 6.0 | | | | | | | | | | | | CI | |
| 6.5 | | | | | | | | | | | | | |
| 7.0 | | | | | | | D 7.00 m<br>TUBE | | | | | | BOREHOLE TERMINATED AT 7.00 m |
| 7.5 | | | | | | | | | | | | | |

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# BOREHOLE LOG SHEET

**Client:** Yeats Consulting
**Project:** Riva Vue Estate, Murwillumbah
**Location:** Riva Vue Estate, Murwillumbah

## Hole No: BH2

**Job No:** 10024 **Sheet:** 1 of 4

**Position:** REFER SITE SKETCH FIGURE 1 **Angle from Horizontal:** 90° **Surface Elevation:**
**Rig Type:** Edson MRA260 **Bit:** TC BIT **Driller:** LB
**Casing Diameter:** 100 mm **Contractor:** Cardno Bowler
**Date Started :** 14/6/11 **Date Completed:** 14/6/11 **Logged By:** LB **Date Logged:** 14/6/11

| Depth (m) | Drilling: Auger 'V' Bit | Drilling: Auger 'TC' Bit | Drilling: Washbore | Drilling: Casing | Drilling: Coring | Groundwater (m) | Sample or Field Test | Recovered | DCP | RL (m AHD) | Graphic Log | USCS Symbol | Description (SYMBOL, SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | CI | SILTY CLAY, intermediate plasticity, brown, trace fine to medium sand, moist, firm to stiff, NATURAL |
| 0.5 | | | | | | | | | | | | CI | SILTY CLAY, intermediate plasticity, brown grey mottle, trace fine to medium sand, moist, stiff, NATURAL |
| 1.0 | | | | | | | P 1.00 - 1.50 m PP=180kPa | | | | | | |
| 1.5 | | | | | | | | | | | | | |
| | | | | | | 2.1 mbgl , 14/06/11 , drilled to 13.7 m , cased to 100 m | | | | | | CI-CH | SILTY CLAY, intermediate plasticity, grey, moist, stiff, NATURAL |
| 2.0 | | | | | | | | | | | | | SILTY CLAY, intermediate plasticity, grey red brown mottled, trace fine to medium sand, moist to wet, stiff to very stiff, NATURAL |
| 2.5 | | | | | | | P 2.50 - 3.00 m PP=210kPa | | | | | | |
| 3.0 | | | | | | | | | | | | CI | |
| 3.5 | | | | | | | | | | | | | |

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# BOREHOLE LOG SHEET

| | | | |
|---|---|---|---|
| **Client:** Yeats Consulting<br>**Project:** Riva Vue Estate, Murwillumbah<br>**Location:** Riva Vue Estate, Murwillumbah | | | **Hole No: BH2** |
| | | **Job No: 10024** | **Sheet: 2 of 4** |
| **Position: REFER SITE SKETCH FIGURE 1** | | **Angle from Horizontal: 90°** | **Surface Elevation:** |
| **Rig Type: Edson MRA260** | | **Bit: TC BIT** | **Driller: LB** |
| **Casing Diameter: 100 mm** | | **Contractor: Cardno Bowler** | |
| **Date Started : 14/6/11** | **Date Completed: 14/6/11** | **Logged By: LB** | **Date Logged: 14/6/11** |

| Depth (m) | Drilling: Auger 'V' Bit | Drilling: Auger 'TC' Bit | Drilling: Washbore | Drilling: Casing | Drilling: Coring | Groundwater (m) | Sample or Field Test | Recovered | DCP | RL (m AHD) | Graphic Log | USCS Symbol | Description (SYMBOL, SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.5 | | | | | | | P 4.00 - 4.50 m<br>PP=550kPa | | | | | CI | SILTY CLAY, intermediate plasticity, grey red brown mottle, trace fine to medium sand, moist to wet, very stiff, NATURAL |
| 5.0 | | | | | | | | | | | | | |
| 5.5 | | | | | | | D 5.50 - 5.95 m<br>SPT<br>5,6,9 N=15 | | | | | CH | SILTY CLAY, high plasticity, grey red brown mottle, with fine to coarse sand and bands of extremely weathered rock, moist to wet, very stiff, NATURAL |
| 6.0 | | | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | | | |
| 7.0 | | | | | | | D 7.00 - 7.45 m<br>SPT<br>4,8,7 N=15 | | | | | | |
| 7.5 | | | | | | | | | | | | | |

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# BOREHOLE LOG SHEET

| | | | |
|---|---|---|---|
| **Client:** Yeats Consulting<br>**Project:** Riva Vue Estate, Murwillumbah<br>**Location:** Riva Vue Estate, Murwillumbah | | | **Hole No: BH2** |
| | | **Job No: 10024** | **Sheet: 3 of 4** |
| **Position: REFER SITE SKETCH FIGURE 1** | | **Angle from Horizontal: 90°** | **Surface Elevation:** |
| **Rig Type: Edson MRA260** | | **Bit: TC BIT** | **Driller: LB** |
| **Casing Diameter: 100 mm** | | **Contractor: Cardno Bowler** | |
| **Date Started : 14/6/11** | **Date Completed: 14/6/11** | **Logged By: LB** | **Date Logged: 14/6/11** |

| Depth (m) | Drilling: Auger 'V' Bit | Drilling: Auger 'TC' Bit | Drilling: Washbore | Drilling: Casing | Drilling: Coring | Groundwater (m) | Sample or Field Test | Recovered | DCP | RL (m AHD) | Graphic Log | USCS Symbol | Description (SYMBOL, SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.5 | | | | | | | D 8.50 - 8.95 m<br>SPT<br>6,11,11 N=22 | | | | | CH | SILTY CLAY, high plasticity, grey red brown mottle, with fine to coarse sand and bands of extremely weathered rock, moist to wet, very stiff, NATURAL |
| 9.0 | | | | | | | | | | | | | |
| 9.5 | | | | | | | | | | | | | |
| 10.0 | | | | | | | D 10.00 - 10.45 m<br>SPT<br>5,12,15 N=27 | | | | | | |
| 10.5 | | | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | | | |
| 11.5 | | | | | | | D 11.50 - 11.95 m<br>SPT<br>7,11,18 N=29 | | | | | SC | SILTY CLAYEY SAND, fine to coarse sand, grey, moist, dense, NATURAL |

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# BOREHOLE LOG SHEET

**Client:** Yeats Consulting
**Project:** Riva Vue Estate, Murwillumbah
**Location:** Riva Vue Estate, Murwillumbah

**Hole No: BH2**

**Job No: 10024** | **Sheet: 4 of 4**

**Position: REFER SITE SKETCH FIGURE 1** | **Angle from Horizontal: 90°** | **Surface Elevation:**

**Rig Type: Edson MRA260** | **Bit: TC BIT** | **Driller: LB**

**Casing Diameter: 100 mm** | **Contractor: Cardno Bowler**

**Date Started : 14/6/11** | **Date Completed: 14/6/11** | **Logged By: LB** | **Date Logged: 14/6/11**

| Depth (m) | Drilling: Auger 'V' Bit | Drilling: Auger 'TC' Bit | Drilling: Washbore | Drilling: Casing | Drilling: Coring | Groundwater (m) | Sample or Field Test | Recovered | DCP | RL (m AHD) | Graphic Log | USCS Symbol | Description (SYMBOL, SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12.5 | | | | | | | | | | | | SC | SILTY CLAYEY SAND, fine to coarse sand, grey, moist, dense, NATURAL |
| 13.0 | | | | | | | D 13.00 - 13.45 m<br>SPT<br>20,30/95mm N>50 | | | | | XW | EXTREMELY WEATHERED ROCK, brown grey, NATURAL |
| 13.5 | | | | | | | | | | | | | |
| | | | | | | | D 13.70 m<br>SPT<br>30/75mm N>50 | | | | | | TC bit refusal.<br>BOREHOLE TERMINATED AT 13.70 m |
| 14.0 | | | | | | | | | | | | | |
| 14.5 | | | | | | | | | | | | | |
| 15.0 | | | | | | | | | | | | | |
| 15.5 | | | | | | | | | | | | | |

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# BOREHOLE LOG SHEET

**Client:** Yeats Consulting
**Project:** Riva Vue Estate, Murwillumbah
**Location:** Riva Vue Estate, Murwillumbah

## Hole No: BH3

**Job No:** 10024 **Sheet:** 1 of 2

**Position:** REFER SITE SKETCH FIGURE 1 **Angle from Horizontal:** 90° **Surface Elevation:**
**Rig Type:** Edson MRA260 **Bit:** TC BIT **Driller:** LB
**Casing Diameter:** 100 mm **Contractor:** Cardno Bowler
**Date Started :** 8/7/11 **Date Completed:** 8/7/11 **Logged By:** LB **Date Logged:** 8/7/11

| Depth (m) | Drilling: Auger 'V' Bit | Drilling: Auger 'TC' Bit | Drilling: Washbore | Drilling: Casing | Drilling: Coring | Groundwater (m) | Sample or Field Test | Recovered | DCP | RL (m AHD) | Graphic Log | USCS Symbol | Description (SYMBOL, SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | | | | | | | | | | | | | SILTY CLAYEY SAND, fine to coarse sand, orange, with small gravels, dry, very dense, NATURAL |
| 1.0 | | | | | | | D 1.00 - 1.45 m<br>SPT<br>27,30/125mm N>50 | | | | | SC | increased clays, cemented structure |
| 1.5 | | | | | | | | | | | | | |
| 2.0 | | | | | | | | | | | | | |
| 2.5 | | | | | | | D 2.50 - 2.95 m<br>SPT<br>8,9,30 N=39 | | | | | | SILTY CLAYEY SAND, fine to coarse sand, orange, with small gravels, dry, dense, NATURAL |
| 3.0 | | | | | | | | | | | | SC | |
| 3.5 | | | | | | | | | | | | | SILTY CLAY, low plasticity, red/orange, with fine to medium sand, moist, very stiff, cemented structure, NATURAL |
| 4.0 | | | | | | | D 4.00 - 4.45 m<br>SPT<br>5,7,9 N=16 | | | | | CH | |
| 4.5 | | | | | | | | | | | | | |

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# BOREHOLE LOG SHEET

**Client:** Yeats Consulting
**Project:** Riva Vue Estate, Murwillumbah
**Location:** Riva Vue Estate, Murwillumbah

**Hole No: BH3**

**Job No:** 10024 **Sheet:** 2 of 2

**Position:** REFER SITE SKETCH FIGURE 1 **Angle from Horizontal:** 90° **Surface Elevation:**

**Rig Type:** Edson MRA260 **Bit:** TC BIT **Driller:** LB

**Casing Diameter:** 100 mm **Contractor:** Cardno Bowler

**Date Started :** 8/7/11 **Date Completed:** 8/7/11 **Logged By:** LB **Date Logged:** 8/7/11

| Depth (m) | Drilling: Auger 'V' Bit | Drilling: Auger 'TC' Bit | Drilling: Washbore | Drilling: Casing | Drilling: Coring | Groundwater (m) | Sample or Field Test | Recovered | DCP | RL (m AHD) | Graphic Log | USCS Symbol | Description (SYMBOL, SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | SILTY CLAY, low plasticity, red/orange, with fine to medium sand, moist, very stiff, cemented structure, NATURAL |
| 5.5 | | | | | | | D 5.50 - 5.95 m SPT 7,11,13 N=24 | | | | | CH | SILTY CLAY, low plasticity, grey orange brown, with fine to medium sand, moist, very stiff, cemented structure, NATURAL |
| 6.0 | | | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | | | becoming stiffer |
| 7.0 | | | | | | | D 7.00 - 7.45 m SPT 10,17,30/140 N>50 | | | | | CH | SILTY CLAY, low plasticity, light brown, with fine to medium sand, moist, very stiff, cemented structure, moist, NATURAL (XW?) |
| 7.5 | | | | | | | | | | | | XW | XW ROCK |
| 8.0 | | | | | | | D 8.00 - 8.45 m SPT 29,30/130 N>50 | | | | | | BOREHOLE TERMINATED AT 8.00 m |
| 8.5 | | | | | | | | | | | | | |
| 9.0 | | | | | | | | | | | | | |
| 9.5 | | | | | | | | | | | | | |

See Standard Sheets for details of abbreviations & basis of descriptions

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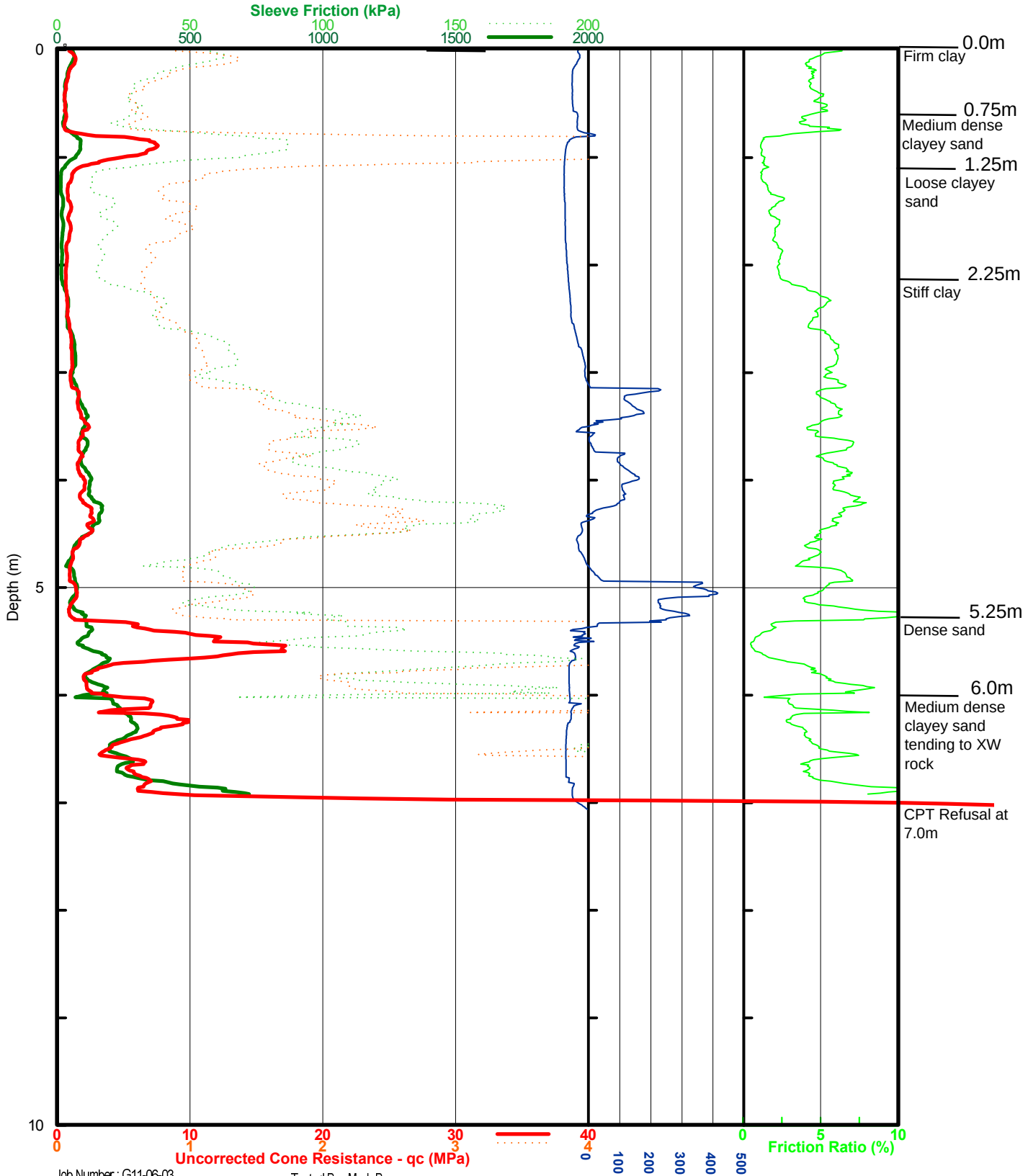
# CONE PENETROMETER TEST RESULT

**Cardno Bowler**
**Riva Vue Estate**
**Murwillumbah NSW**

# CPT-01




Job Number : G11-06-03
Test Date : 06/06/2011
DGPS Position : 56 J 0536844, 6866394
DGPS Format : WGS 84

Tested By : Mark Barrow
Test Class : IGS-1
Checked By : Russell Vincenzi

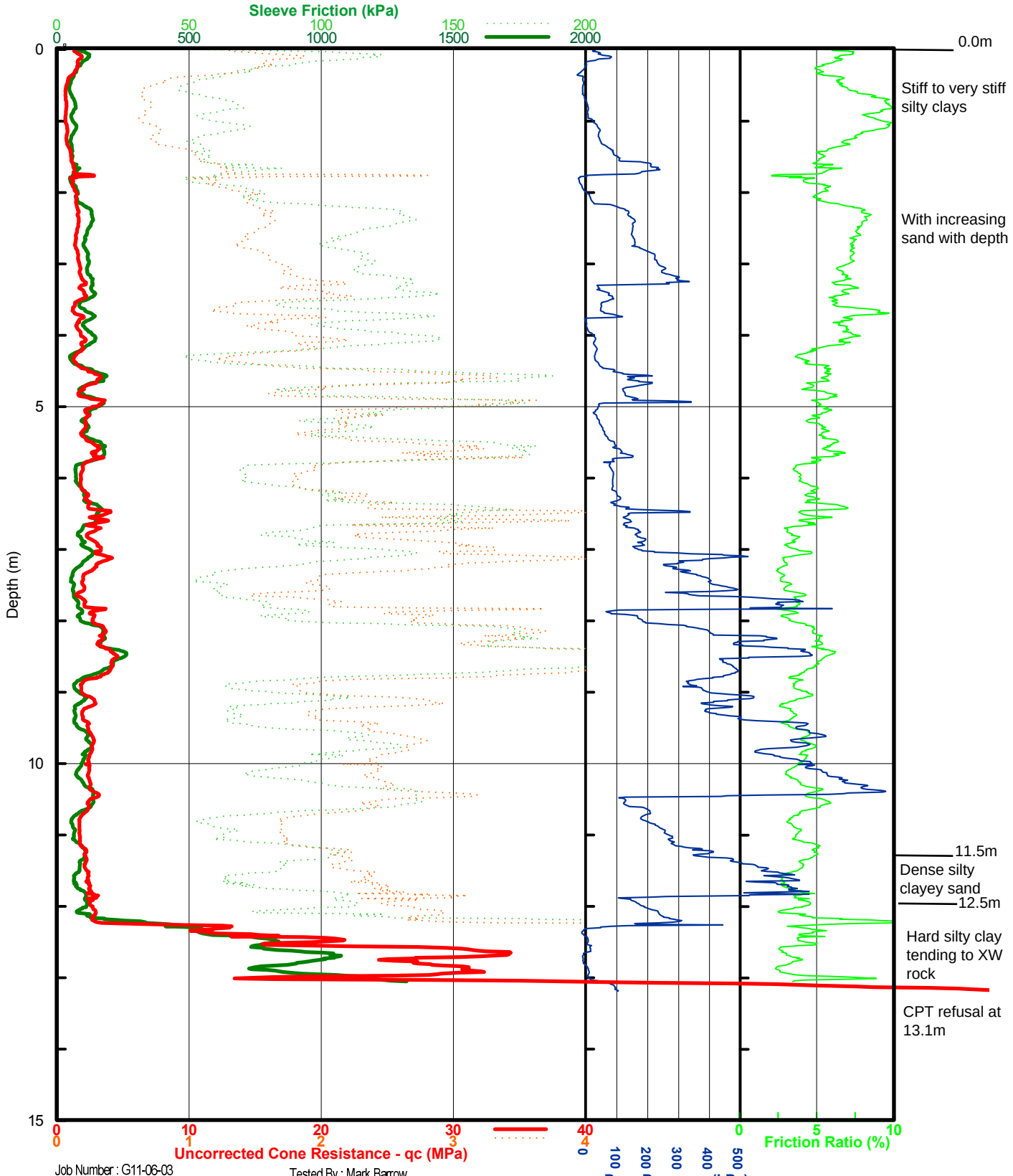
Cone Number : C10CFIIP.F89
Predrill Depth : 0.00m
Dissipation Tests @ : N/A
Terminated Due To : Equipment at Risk

Insitu Geotech Services Pty Ltd IGS

# CONE PENETROMETER TEST RESULT

**Cardno Bowler**
**Riva Vue Estate**
**Murwillumbah NSW**

# CPT-02




Job Number : G11-06-03
Test Date : 06/06/2011
DGPS Position : 56 J 0536852, 6866539
DGPS Format : WGS 84

Tested By : Mark Barrow
Test Class : IGS-1
Checked By : Russell Vincenzi

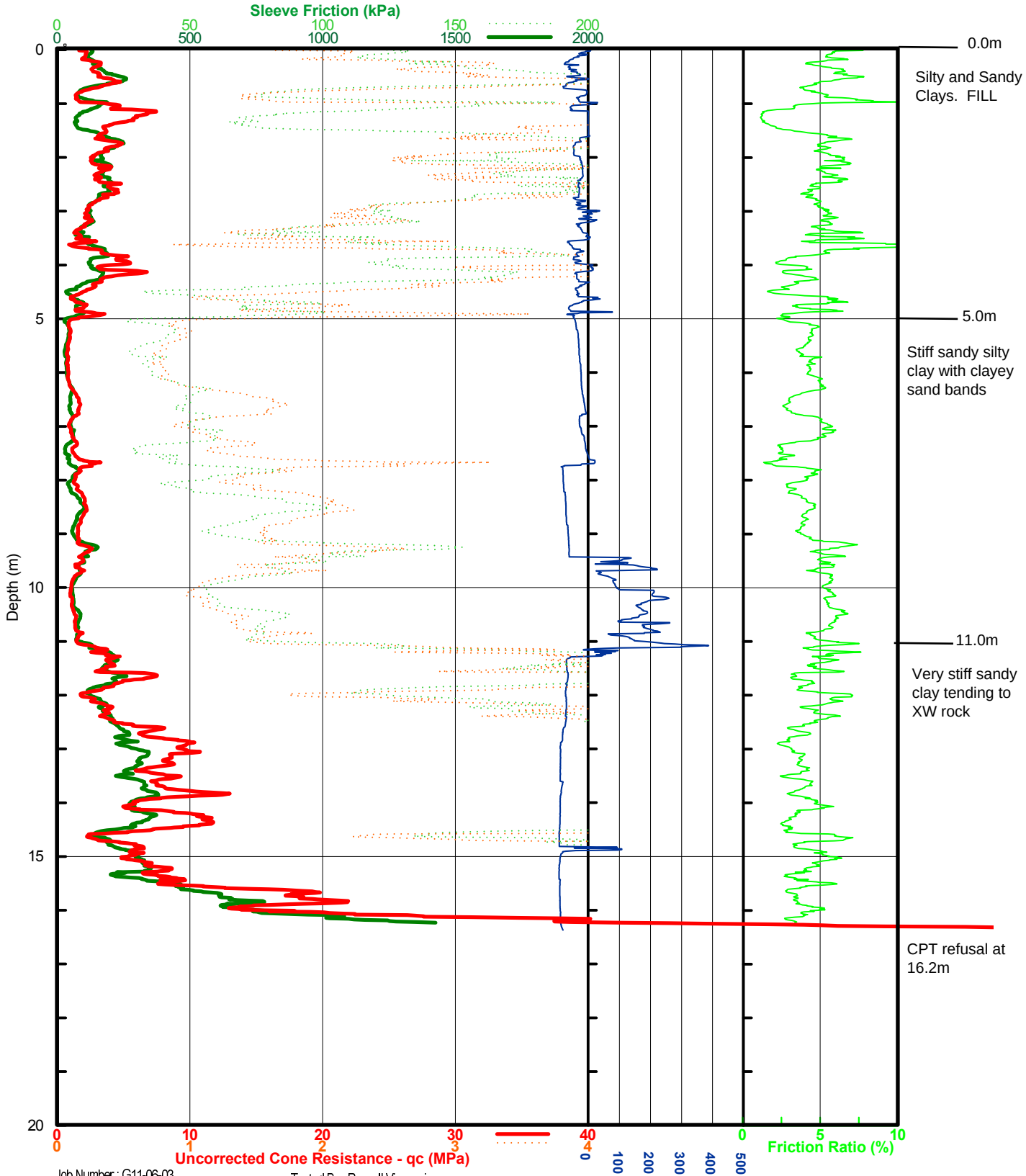
Cone Number : C10CFIIP.F89
Predrill Depth : 0.00m
Dissipation Tests @ : N/A
Terminated Due To : Equipment at Risk

Insitu Geotech Services Pty Ltd IGS

# CONE PENETROMETER TEST RESULT

**Cardno Bowler**
**Riva Vue Estate**
**Murwillumbah NSW**

# CPT-03




Job Number : G11-06-03
Test Date : 07/06/2011
DGPS Position : 56 J 0536990, 6866374
DGPS Format : WGS 84

Tested By : Russell Vincenzi
Test Class : IGS-1
Checked By : Russell Vincenzi

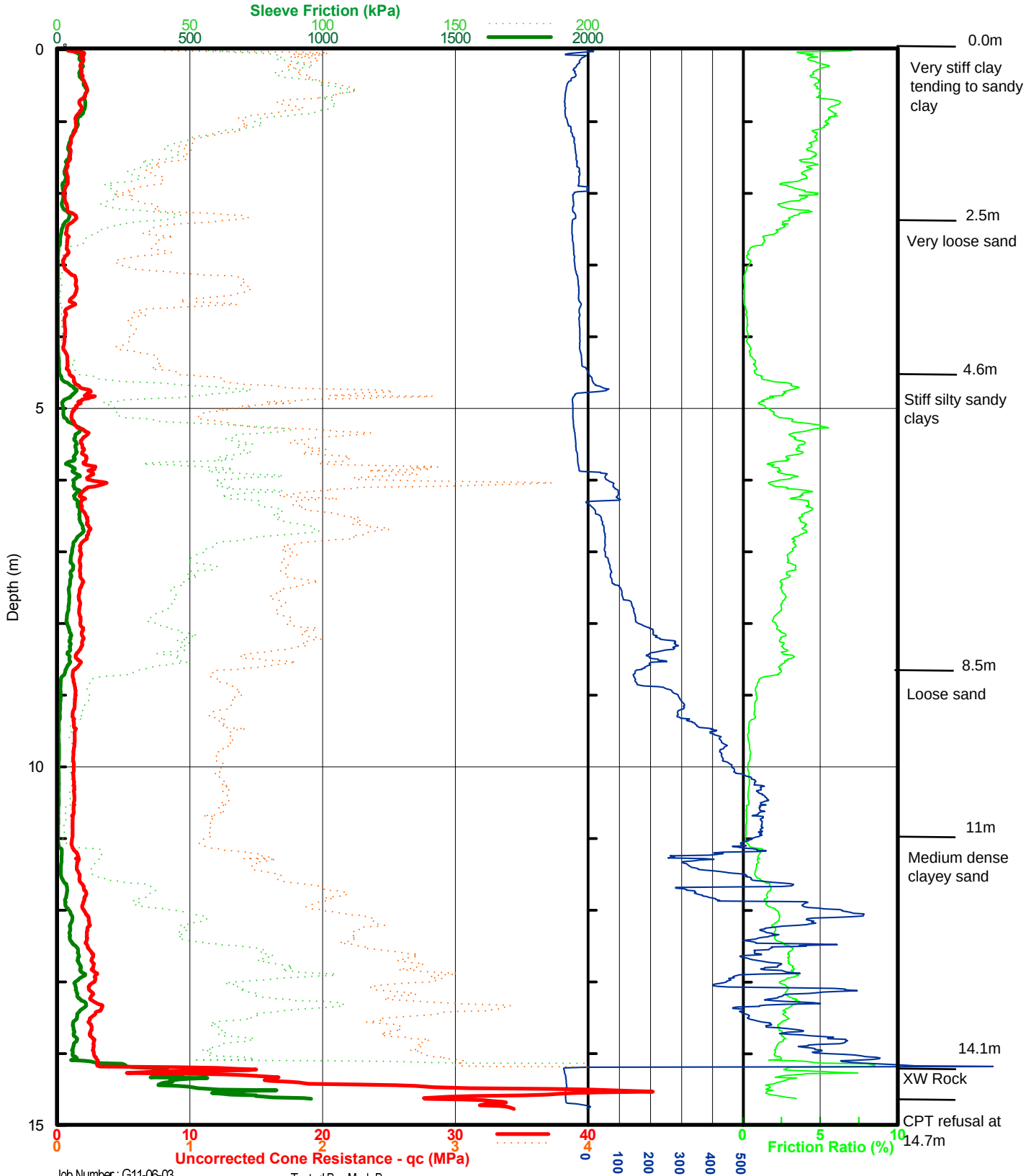
Cone Number : C10CFIIP.F89
Predrill Depth : 0.00m
Dissipation Tests @ : N/A
Terminated Due To : Equipment at Risk

Insitu Geotech Services Pty Ltd IGS

# CONE PENETROMETER TEST RESULT

**Cardno Bowler**
**Riva Vue Estate**
**Murwillumbah NSW**

# CPT-04




Job Number : G11-06-03
Test Date : 06/06/2011
DGPS Position : 56 J 0537017, 6866630
DGPS Format : WGS 84

Tested By : Mark Barrow
Test Class : IGS-1
Checked By : Russell Vincenzi

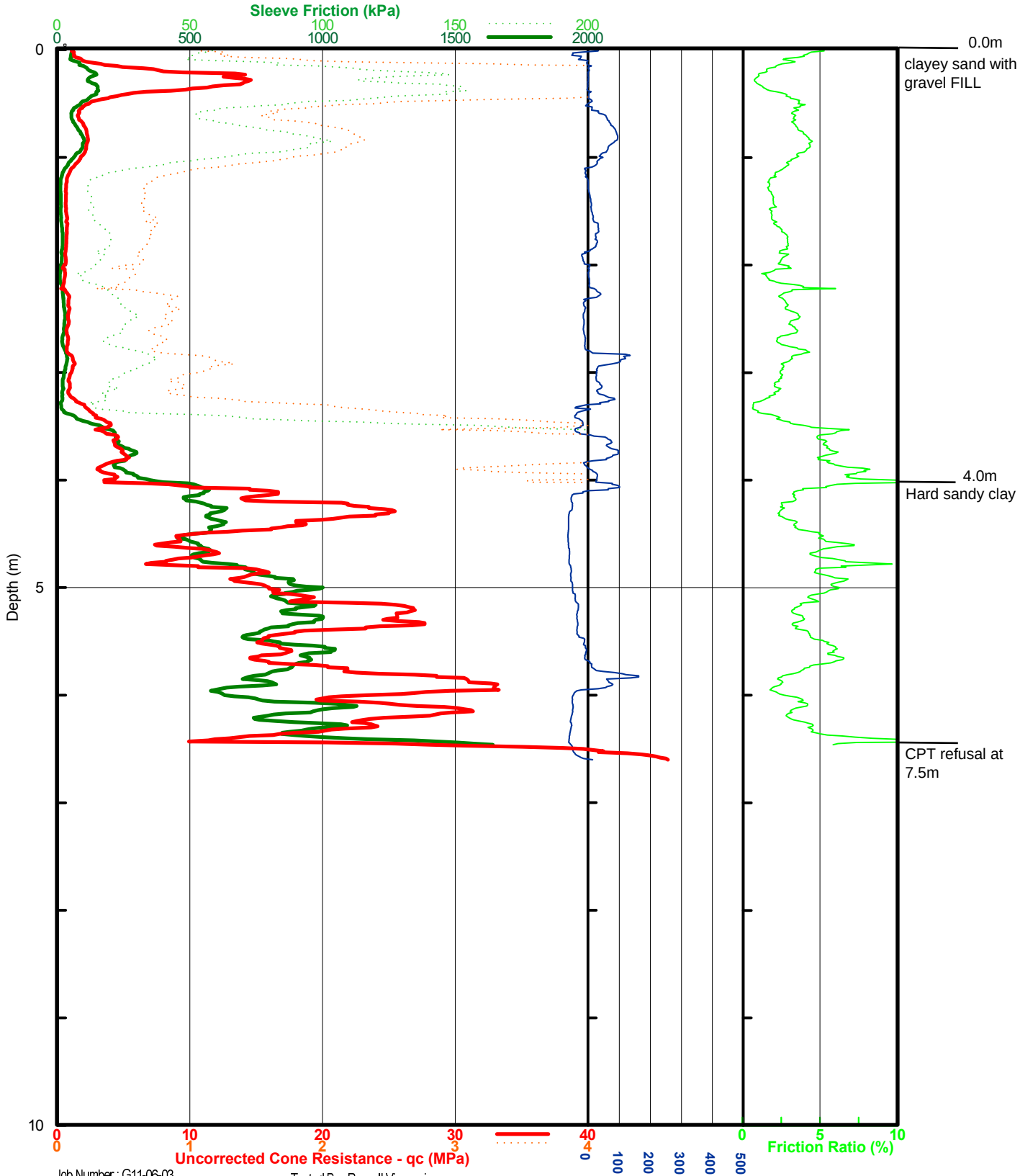
Cone Number : C10CFIIP.F89
Predrill Depth : 0.00m
Dissipation Tests @ : N/A
Terminated Due To : Abrupt Tilt

Insitu Geotech Services Pty Ltd IGS

# CONE PENETROMETER TEST RESULT

**Cardno Bowler**
**Riva Vue Estate**
**Murwillumbah NSW**

# CPT-05




Job Number : G11-06-03
Test Date : 07/06/2011
DGPS Position : 56 J 0537153, 6866691
DGPS Format : WGS 84

Tested By : Russell Vincenzi
Test Class : IGS-1
Checked By : Russell Vincenzi

Cone Number : C10CFIIP.F89
Predrill Depth : 0.00m
Dissipation Tests @ : N/A
Terminated Due To : Sleeve Refusal

Insitu Geotech Services Pty Ltd IGS

Annex B

# Laboratory Test Results

*September, 2001*

# LABORATORY TESTING

## GENERAL

Samples extracted during the fieldwork stage of a site investigation may be "disturbed" or "undisturbed" (as generally indicated on the test hole logs) depending upon the nature and purpose of the sample as well as the method of extraction. Nominally "undisturbed" samples may suffer a varying degree of disturbance during extraction, transportation, extrusion and testing. This aspect should be taken into account when assessing test results which must of necessity reflect the effects of such disturbance.

All soil properties (as measured by laboratory testing) exhibit inherent variability and thus a certain statistical number of tests is required in order to predict an average property with any degree of confidence. The site variability of soil strata, future changes in moisture and other conditions, and the discrete sampling positions must also be considered when assessing the representative nature of the laboratory programme.

Certain laboratory test results provide interpreted soil properties as derived by conventional mathematical procedures. The applicability of such properties to engineering design must be assessed with due regard to the site, sample condition, procedure and project in hand.

## TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 as amended, or Queensland Transport Standards when specified. The routine Australian Standard tests are as follows:

| | |
|---|---|
| Sample Preparation | Test 1 |
| Moisture Content | Test 2.1.1 |
| Liquid Limit | Test 3.1.1) |
| Plastic Limit | Test 3.2.1) collectively known as Atterberg Limits |
| Plasticity Index | Test 3.3.1) |
| Linear Shrinkage | Test 3.4.1 |
| Particle Density | Test 3.5.1 |
| Particle Size Distribution | Tests 3.6.1, 3.6.2, 3.6.3 |
| Emerson Class Number | Test 3.8.1) |
| Percent Dispersion | Test 3.8.2) collectively, Dispersion Classification |
| Pinhole Dispersion Classification | Test 3.8.3) |
| Organic Matter | Test 4.1.1 |
| Sulphate content | Test 4.2.1 |
| pH Value | Test 4.3.1 |
| Resistivity | Test 4.4.1 |
| Standard Compaction | Test 5.1.1 |
| Modified Compaction | Test 5.2.1 |
| Dry Density Ratio | Test 5.4.1 |
| Minimum/Maximum Density | Test 5.5.1 |
| Density Index | Test 5.6.1 |
| California Bearing Ratio | Tests 6.1.1, 6.1.2 |
| Undrained Triaxial Shear | Test 6.4.1 |
| One Dimensional Consolidation | Test 6.6.1 |
| Constant Head Permeability | Test F7.1 |
| Shrink Swell Index | Test 7.1.1 |

Where tests are used which are not covered by appropriate standard procedures, details are given in the report.

## LABORATORY

Our laboratory is a Registered Laboratory with the National Association of Testing Authorities (NATA).

Cardno BOWLER
Shaping the Future

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# SOIL CLASSIFICATION REPORT SHEET

TEST PROCEDURES:AS1289 1.2.1,2.1.1,3.1.2,3.2.1,3.3.1,3.4.1,3.6.1

| | | | |
|---|---|---|---|
| **CLIENT:** | YEATS CONSULTING | **JOB No.:** | 10024 |
| **ADDRESS:** | PO BOX 9122, GOLD COAST QLD 9726 | **REPORT No:** | 1 |
| | | **DATE ISSUED:** | 07.07.11 |
| **PROJECT:** | STAGE 4 RIVA VUE ESTATE MURWILLUMBAH | | |
| **TEST LOCATION:** | JOSHUA ST, BH 1 | **LEVEL (m):** | 2.5m TO 2.95m |
| **SAMPLE No:** | 151774 | **DATE RECEIVED:** | 30.06.11 |
| **TESTED BY:** | TV | **DATE TESTED:** | 06.07.11 |
| **CHECKED BY:** | JM | **DATE CHECKED:** | 07.07.11 |

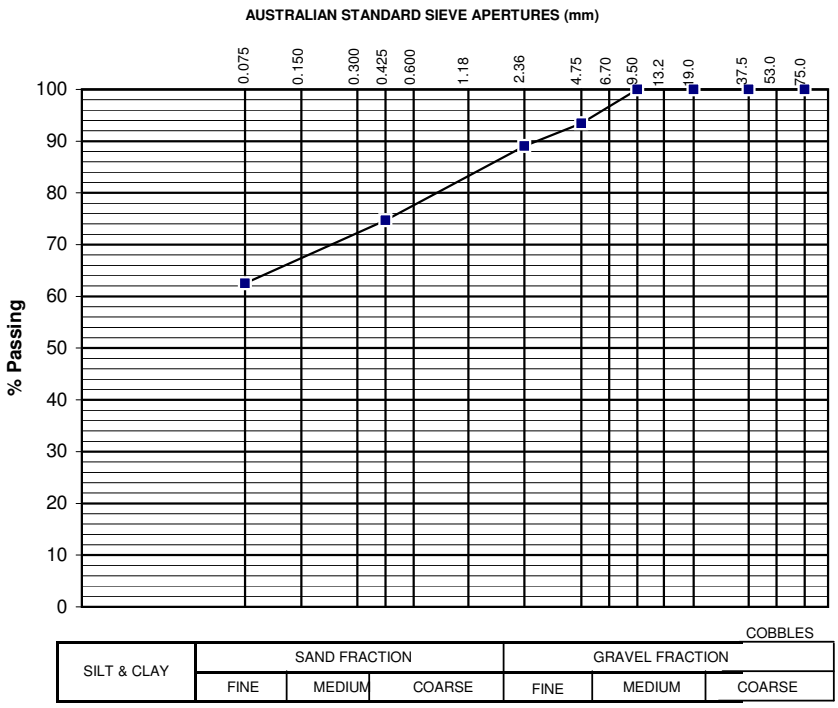
## PLASTICITY & LINEAR SHRINKAGE

**RESULTS**

| | | | | |
|---|---|---|---|---|
| **LIQUID LIMIT:** | 44 | % | **SAMPLE HISTORY:** | OVEN DRIED |
| **PLASTIC LIMIT:** | 23 | % | **PREPERATION METHOD:** | DRY SIEVED |
| **PLASTICITY INDEX:** | 21 | % | **LENGTH OF MOULD:** | 250mm |
| **LINEAR SHRINKAGE:** | 9.0 | % | **CRACKING OR CRUMBLING:** | SOME CRUMBLING |
| **FIELD MOISTURE:** | 19.6 | % | | |

## PARTICLE SIZE DISTRIBUTION

| SIEVE SIZE (mm) | % PASSING (by mass) |
|---|---|
| 75.00 | 100 |
| 37.5 | 100 |
| 19.00 | 100 |
| 13.20 | 100 |
| 9.50 | 100 |
| 6.70 | 100 |
| 4.750 | 93 |
| 2.360 | 89 |
| 0.425 | 75 |
| 0.075 | 63 |




APPROVED BY:.....
J Mckenna NATA Approved Signatory

NATA
WORLD RECOGNISED ACCREDITATION

**NATA Accredited Laboratory Number: 1986**

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**FORM: 265 REV: 0 14/09/2010**

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# SOIL CLASSIFICATION REPORT SHEET

TEST PROCEDURES:AS1289 1.2.1,2.1.1,3.1.2,3.2.1,3.3.1,3.4.1,3.6.1

| | | | |
|---|---|---|---|
| **CLIENT:** | YEATS CONSULTING | **JOB No.:** | 10024 |
| **ADDRESS:** | PO BOX 9122, GOLD COAST QLD 9726 | **REPORT No:** | 2 |
| | | **DATE ISSUED:** | 07.07.11 |
| **PROJECT:** | STAGE 4 RIVA VUE ESTATE MURWILLUMBAH | | |
| **TEST LOCATION:** | JOSHUA ST, BH 2 | **LEVEL (m):** | 4.0m TO 4.5m |
| **SAMPLE No:** | 151775 | **DATE RECEIVED:** | 30.06.11 |
| **TESTED BY:** | TV | **DATE TESTED:** | 06.07.11 |
| **CHECKED BY:** | JM | **DATE CHECKED:** | 07.07.11 |

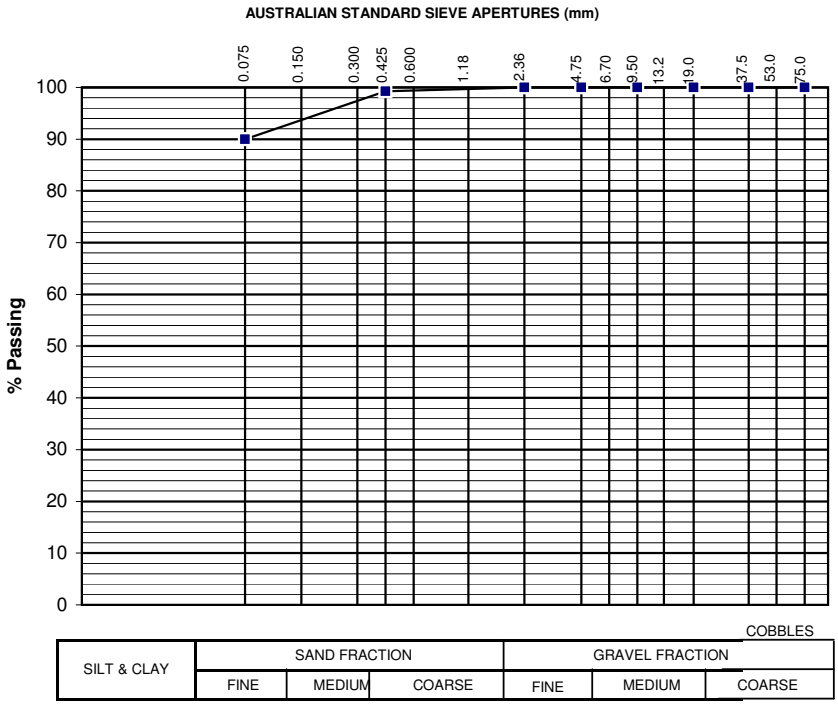
## PLASTICITY & LINEAR SHRINKAGE

**RESULTS**

| | | | | |
|---|---|---|---|---|
| **LIQUID LIMIT:** | 59 | % | **SAMPLE HISTORY:** | OVEN DRIED |
| **PLASTIC LIMIT:** | 21 | % | **PREPERATION METHOD:** | DRY SIEVED |
| **PLASTICITY INDEX:** | 38 | % | **LENGTH OF MOULD:** | 250mm |
| **LINEAR SHRINKAGE:** | 15.5 | % | **CRACKING OR CRUMBLING:** | SOME CRUMBLING |
| **FIELD MOISTURE:** | 34.0 | % | | |

## PARTICLE SIZE DISTRIBUTION

| SIEVE SIZE (mm) | % PASSING (by mass) |
|---|---|
| 75.00 | 100 |
| 37.5 | 100 |
| 19.00 | 100 |
| 13.20 | 100 |
| 9.50 | 100 |
| 6.70 | 100 |
| 4.750 | 100 |
| 2.360 | 100 |
| 0.425 | 99 |
| 0.075 | 90 |

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# SOIL CLASSIFICATION REPORT SHEET

TEST PROCEDURES:AS1289 1.2.1,2.1.1,3.1.2,3.2.1,3.3.1,3.4.1,3.6.1

| | | | |
|---|---|---|---|
| **CLIENT:** | YEATS CONSULTING | **JOB No.:** | 10024 |
| **ADDRESS:** | PO BOX 9122, GOLD COAST QLD 9726 | **REPORT No:** | 3 |
| | | **DATE ISSUED:** | 07.07.11 |
| **PROJECT:** | STAGE 4 RIVA VUE ESTATE MURWILLUMBAH | | |
| **TEST LOCATION:** | JOSHUA ST, BH 2 | **LEVEL (m):** | 10.0m TO 10.45m |
| **SAMPLE No:** | 151776 | **DATE RECEIVED:** | 30.06.11 |
| **TESTED BY:** | TV | **DATE TESTED:** | 06.07.11 |
| **CHECKED BY:** | JM | **DATE CHECKED:** | 07.07.11 |

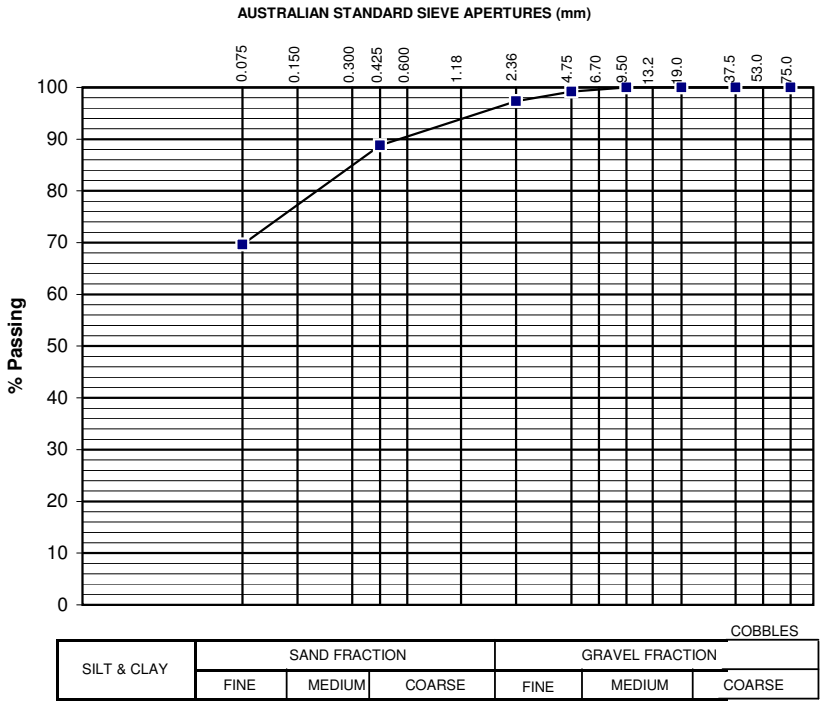
## PLASTICITY & LINEAR SHRINKAGE

**RESULTS**

| | | | | |
|---|---|---|---|---|
| **LIQUID LIMIT:** | 47 | % | **SAMPLE HISTORY:** | OVEN DRIED |
| **PLASTIC LIMIT:** | 17 | % | **PREPERATION METHOD:** | DRY SIEVED |
| **PLASTICITY INDEX:** | 31 | % | **LENGTH OF MOULD:** | 250mm |
| **LINEAR SHRINKAGE:** | 12.5 | % | **CRACKING OR CRUMBLING:** | NIL |
| **FIELD MOISTURE:** | ND | % | | |

## PARTICLE SIZE DISTRIBUTION

| SIEVE SIZE (mm) | % PASSING (by mass) |
|---|---|
| 75.00 | 100 |
| 37.5 | 100 |
| 19.00 | 100 |
| 13.20 | 100 |
| 9.50 | 100 |
| 6.70 | 100 |
| 4.750 | 99 |
| 2.360 | 97 |
| 0.425 | 89 |
| 0.075 | 70 |

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*REMARKS: ND = NOT DETERMINED*

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