Douglas Partners
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REPORT ON PRELIMINARY GEOTECHNICAL AND CONTAMINATION ASSESSMENT

PROPOSED LOCAL ENVIRONMENT PLAN WYEE LAND RELEASE

Prepared for
CONICS PTY LTD

On Behalf of
LAKE MACQUARIE CITY COUNCIL

PROJECT 41810
JULY 2009

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MPG
Project 41810
6 July 2009

REPORT ON PRELIMINARY GEOTECHNICAL AND CONTAMINATION ASSESSMENT
WYEE LAND RELEASE
HUE HUE ROAD, WYEE

1. INTRODUCTION

This report presents the results of a preliminary geotechnical and contamination assessment undertaken for the development of a 153 hectare parcel of land off Hue Hue Road, Wyee. This assessment will form part of the Local Environment Study for future urban (residential and employment) development and public open space. The site boundaries are indicated on Drawing 1 and other relevant drawings which accompany this report (Appendix A). The work was commissioned by Conics Pty Ltd, planners and lead consultant for the project, acting on behalf of Lake Macquarie City Council, who are assessing a rezoning proposal for the site.

The area of study is within the Lake Macquarie City Council Local Government Area and located south of the township of Wyee.

It is understood that re-zoning of the land to facilitate residential development is proposed. The objective of the study was to determine the suitability of the site for urban development, primarily with regard to site stability, erosion potential, soil salinity potential, areas of soft compressible soils, soil contamination.

The investigation comprised limited site history searches, site inspections, non-intrusive and intrusive site investigation (geotechnical only) followed by geotechnical laboratory testing of selected samples, engineering analysis, mapping and reporting.

This report contains details of all work undertaken and results together with comments relating to land capability, engineering design and construction practice. Whilst pertinent results of field work and geotechnical laboratory testing reports are included in the text, further details are provided in the following Appendices:

A Drawings
B Desktop Search Results
C Test Bore Logs
D Laboratory Test Results
E CSIRO Publication *"Guide to Home Owners on Foundation Maintenance and Footing Performance*

2. SITE DESCRIPTION

2.1 Land Area and Topography

The site comprises an irregular shaped parcel of land and is approximately 153 ha in plan area. The site is bound to the south by the unsealed Bushells Ridge Road, to the north by Hue Hue Road and to the east by the unsealed Gorokan Road (refer Drawing 1). The western boundary of the site borders further rural land.

The Great Northern Railway is located immediately adjacent to Gorokan Road to the east of the site; whereas the F3 Sydney to Newcastle freeway is located approximately 600 m to the west of the site (refer Drawing 1).

An unnamed creek runs in a north-south orientation through the site. Remnant stands of trees are shown on Drawing 3 and are generally located:

- in the north-western area of the site;
- in the south-eastern corner of the site;
- along the creek line within the eastern section of the site;
- in the north-eastern corner; and
- along the eastern boundary of the site.

The parcel of land encompasses numerous existing allotments that are identified as follows:

- Lot 17 in DP870597
- Lot 212 in DP866437
- Lot 16 in DP870597
- Lot 1 in DP244839
- Lot 1 in DP785709
- Lot 215 in DP860081
- Lots 202-400 in DP7506
- Lot 210 in DP846801
- Lot 443 in DP755242
- Lot 442 in DP755242
- Lot 441 in DP755242
- Lot 323 in DP755242
- Lot 324 in DP755242
- Lot 9 in DP1058113
- Lot 472 in DP755242
- Lot 473 in DP755242
- Lot 8 in DP1020857
- Lot 4 in DP1013240
- Lot 1 in DP103856
- Lot 1 in DP103857
- Lot 185 in DP650204
- Lot 186 in DP755242
- Lot 187 in DP755242
- Lot 429 in DP755242
- Lot 428 in DP755242
- Lot 431 in DP755242
- Lot 188 in DP755242
- Lot 1582 in DP1121660
- Lot 430 in DP755242
- Lot 189 in DP755242

Review of the 1:25 000 Dooralong Topographical Map (Sheet 9131-I-S) and field inspection shows that topography at the site is broadly summarised as rolling hills within the majority of the site, falling gently to the north-east. Surface elevations range from RL 50 m AHD in the south-western corner to less than RL 20 m AHD in the northern area of the site. An extract from the Dooralong Topographical Map is provided on Drawing 2.

The high points of the site lie:-

- within the south-western corner at approximately RL 50 m AHD, from which there is a broad ridge which protrudes northward into the site;

- In the south-eastern area of the site at approximately RL 40 m AHD, adjacent to Bushells Ridge Road, from which a narrow but low ridge protrudes northwards into the site;
- In the north-eastern corner at approximately RL 30 m AHD.

Generally the site has broad hill slopes within the western, eastern and southern sections of the site with broad ridges and planar hill flanks, leading to a lower lying area within the north-eastern section of the site.

Slopes at the site are generally less than 11%.

2.2 Drainage

Mannering Creek runs through the northern area of the site, entering the western boundary of the site approximately 400 m south of the north-western corner and exiting the site at the north-eastern corner. The creek falls from approximately RL 35 m AHD to less than RL 20 m AHD in the north-eastern corner. It is noted that Wyee Dam is located approximately 800 m to the east of the site along Mannering Creek and therefore levels in the creek will be somewhat affected by the dam.

An unnamed creek, which feeds into Mannering Creek flows from near the southern boundary of the site in a generally northern direction to discharge into Mannering Creek in the northern section of the site.

A large area of waterlogged ground is present within the north-eastern section of the site and also in a broad fan along the unnamed northern flowing creek (refer Drawing 3).

2.3 Site Features

The majority of the site is cleared and vegetated with grass cover (refer Drawing 3). Remnant stands of trees are shown on Drawing 3 and are generally located:

- in the north-western area of the site;
- in the south-eastern corner of the site;
- along the creek line within the eastern section of the site;
- in the north-eastern corner; and
- along the eastern boundary of the site.

Low lying areas were vegetated with mainly clumping grasses and rushes.

The south-western area of the site comprised a “paper” subdivision with at least 100 approved and unapproved low cost houses (refer Photo 1). Numerous areas affected by illegal dumping were identified throughout the “paper” subdivision area (refer Photo 2).

Photo 1 – Dwelling in the “paper” subdivision

Photo 2 – Example of illegal dumping

The north-eastern area of the site, along the Hue Hue Road frontage, has a number of existing rural allotments with existing residences. One of the rural allotments includes an intensive agricultural land use (hydroponics and greenhouses). These allotments back onto Mannering Creek.

A former chicken farm is located in the north-western corner of the site (refer Drawing 3). Evidence of extensive cut and fill was noted in this area (refer Photos 3 to 5)

Photo 3 – Former chicken shed and filling

Photo 4 – Area of filling in former chicken farm

Photo 5 – Mounds of filling in former chicken farm

Numerous dams are scattered across the site, predominantly in the south-western corner and also in the north-western corner.

Photo 6 – Existing dam to the south of former chicken farm

An area, located in the south-western corner of the site, to the west of the existing residence in Lot 212 DP 866437, appears to be a former quarry. This is approximately 100 m wide and has cut faces in the order of 5 m height and was somewhat overgrown at the time of inspection.

Numerous unsealed roads are present within the “paper subdivision” within the south-east corner of the site. Many of these roads have clay exposed at the surface and have not had any gravel placed over the natural subgrade.

Midway along the eastern boundary of the site, in an area of remnant trees, a large formerly cleared area, which is now partially overgrown was observed during the site inspection (refer Drawing 3). Discussion with locals indicates that this area was a former cricket oval.

In between the existing low cost houses in the south-east corner of the site, there are many deposits of dumped materials, such as timber, whitegoods, car bodies and generally rubbish (refer Photo 7)

Photo 7 – Illegally dumped rubbish near former cricket oval in eastern area of site

3. REGIONAL GEOLOGY, SOIL LANDSCAPE AND ACID SULPHATE SOILS

3.1 Regional Geology

Reference to the interim Dooralong 1:25 000 Geological Series indicates that the site is underlain by rocks of the Tuggerah Formation, which is a member of the Clifton Subgroup and Narrabeen Group. The Tuggerah Formation typically comprises lithic sandstone, red-brown and grey-green claystone and siltstone, grey siltstone and laminate, and rare conglomerate.

The central, lower area of the site, along the unnamed creek and also along Mannering Creek, is mapped as being underlain by Quaternary Alluvium, which is characterised by sand, silt, clay and gravel.

An excerpt of the Dooralong Geological sheet is presented on Drawing 4.

Conditions encountered in the intrusive field work included sand and clay soils underlain by sandstone or claystone bedrock. The soils were consistent with residual soils derived from the underlying bedrock, with the weaker deposits in the central area of the site around drainage lines consistent with alluvium.

3.2 Soil Landscape Mapping

Reference to the Department of Conservation and Land Management, Gosford-Lake Macquarie, Soil Landscape Series map indicates that the majority of the site is underlain by soils of the Gorokan Soil Group, which is categorised as undulating low hills and rises of the Tuggerah Formation with slope gradients of less than 15%. Soils within this group are said to be between 0.5 m and 1.5 m deep. The limitations associated with these soils include extreme erosion hazard, rock outcrop, shallow highly permeable soils and very low soil fertility.

The northern area of the site, dominated by Mannering Creek, it mapped as being underlain by soils of the Wyong Soil Group, which is categorised as broad poorly drained deltaic floodplains and alluvial flats of Quaternary deposits. Gradients are generally less than 3%. Soils within this group are said to be generally greater than 2 m deep. The limitations associated with these soils include flooding, waterlogging, foundation hazard, stream bank erosion. The soils can be strongly acidic and poorly drained with very low fertility.

An excerpt from the Gosford-Lake Macquarie, Soil Landscape Series map is presented on Drawing 5.

3.3 Acid Sulphate Soil Mapping

Reference to the Dooralong Acid Sulphate Soil Risk map indicates that there is no known occurrence of acid sulphate soils at the site. An excerpt from the Dooralong Acid Sulphate Soil Risk map is presented on Drawing 6.

Given the elevation of the site, above RL 20, and the underlying geology, it is unlikely that acid sulphate soils will be present at this site.

3.4 Groundwater

A permanent groundwater table is likely to be present at a significant depth below the ground surface (based on the site topography). Some minor seepage zones may be located at the interface of localised boundaries of relatively permeable horizons such as at the interface between sandy surface soils and less permeable residual soils, residual soils and weathered bedrock or in weathered bedding planes (and joints) within the Tuggerah Formation bedrock. A shallow permanent groundwater table maybe encountered within the central, lower area of the site, along the unnamed creek and also along Mannering Creek. This area is mapped as being underlain by Quaternary Alluvium, which is characterised by sand, silt, clay and gravel. Saturated surface soils were noted in these areas during the site walkovers.

A search for registered groundwater bores in the Department of Water and Energy (DWE) groundwater bore database indicated that there was one registered bore located within a 1.0 km radius of the site. The bore was located approximately 500 m to the east of the site boundary Based on the topography and geology of the local area it is considered unlikely that any registered bores would be affected by any contaminated groundwater plume originating from the site (if present). A copy of the search results is provided in Appendix B.

4. PREVIOUS STUDIES

Previous studies undertaken on the site that have been made available during the preparation of this report do not relate to geotechnical or contamination issues.

Douglas Partners Pty Ltd has undertaken a number of investigations in the vicinity of the site, which include:

"Report on Geotechnical Investigation, Proposed Gas Pipeline and Facilities, Munmorah Power Station", Project 41533/2 dated March 2008. This investigation included the excavation of 10 test pits along Bushells Ridge Road and the drilling of three bores to depths ranging from 3 m to 13 m near the crossing of the Great Northern Railway. The bores and test pits along the southern boundary of the site generally encountered hard sandy clay to depths ranging from 0.6 m to 2.4 m overlying extremely low to very low strength claystone, siltstone and sandstone.

"Report on Geotechnical Investigation, Proposed Gas Pipeline and Facilities, Colongra Power Station, Crossing of Main Northern Railway", Project 41533/1 dated March 2008. This investigation included the drilling of four bores within the railway corridor immediately to the east of the site to about 10 m depth. Conditions encountered in the bores included near surface silty sand underlain by very stiff to hard clay soils to depths ranging from 3 m to 4 m, which in turn was underlain by sandstone and siltstone bedrock ranging in strength from extremely low to medium strength.

Relevant results from these previous investigations have been used during the preparation of the present report. Copies of relevant test pit and test bores report sheets are included in Appendix C and shown on Drawing 7.

5. PROPOSED DEVELOPMENT

It is understood that the proposed development of the site will include rezoning of the land for future residential subdivision.

The following sections provide general comment on development constraints relevant to geotechnical factors, soil chemistry, environmental contaminants, and alternative potential land uses to assist in the conceptual planning of the proposed development. It is noted that further investigations will need to be undertaken as the planning, design and construction associated with the development of the site proceeds.

6. SCOPE OF WORKS

From the brief provided, DP identified the following scope of works relevant to the primarily residential development proposed for the site.

6.1 Preliminary Geotechnical Assessment

An assessment of stability, erosion and sedimentation potential covering the entire study site was undertaken and incorporated the following steps:

- Collection and review of background information, predominantly from available mapping and aerial photographs.
- Field mapping by a senior geotechnical engineer, to confirm soil landscape mapping, identify potential unstable areas and to nominate locations for additional subsurface investigation.
- Excavation of 24 test bores across the site using a 4WD mounted continuous push tube sampling rig to profile the subsurface strata. The bores incorporated the collection of regular soil samples to assist in strata identification and for possible laboratory testing to determine soil plasticity, erosion potential, and presence of acid sulphate soils.
- Production of constraint maps showing areas of weak, waterlogged soils.

6.2 Phase 1 Contamination Assessment

A preliminary (Phase 1) contamination assessment was conducted with the objectives of;

- identifying whether properties within the site have been, or are currently, used for potentially contaminating activities.
- identifying the potential contaminants of concern.
- providing a preliminary assessment of site contamination.
- assessing the need for further contamination investigations.

To achieve the objectives, the following scope of field and desktop works were undertaken:

- Collation and interpretation of data from the following sources:-
  - Published public data, including topographical, geological and hydrogeological maps;
  - NSW DECC database search;
  - Registered groundwater bore search;
  - Property enquiry information provided on Lake Macquarie City Council web site, which includes information relating to contaminated land issues pertaining to the site;
  - Interviews with individuals who may be familiar with past operations and site usages (where available).
  - Review of the test bore logs undertaken for the geotechnical assessment.
- Site inspection of accessible areas to provide a visual assessment of potential contamination sources.
- Preparation of relevant sections of this report, providing comments of the objectives previously stated.

A review of Section 149 (2) certificates, land title records and WorkCover licence records for the storage of Dangerous Goods, including underground storage tanks, was not undertaken at this stage of the assessment given the number of properties involved and the scope of work accepted by the client.

The Phase 1 contamination assessment section of the current report includes a plan presenting the identified Areas of Environmental Concern (AEC). The report focuses on the potentially contaminating land uses and contaminants of concern. This forms the basis for the identification of constraints to development from a contamination perspective and lends to recommendations regarding a detailed, field-based environmental investigation programme which has been provided.

A guide to the range of activities that may cause contamination is given in the Department of Planning/Environment Protection Authority's (DoP/EPA) publication Managing Contaminated Land, Planning Guidelines, SEPP 55 – Remediation of Contaminated Land (Ref 1). The following activities are included in SEPP 55 and have been selected as potential activities of concern because of their bias towards their potential to occur in a rural environment rather than a general industrial environment. Whilst it should be noted that the selection does not totally exclude the presence of industrial-based activities within the site, the presence of large scale industrial activities in the site is assessed to be unlikely in this instance. Typical contamination causing activities may include:

- Landfill sites
- Service stations
- Mining and extractive industries
- Sheep and cattle dips
- Agricultural/horticultural industries.

Landfill sites, service stations, and sheep and cattle dips were not identified as either current or historical land uses in the site during this study. Agricultural and horticultural were identified. Although not included in the DoP/EPA list, the agricultural/horticultural industries can be subdivided, based on observations during the field inspections, into:

- Orchards.
- Plant nurseries.
- Market gardens.
- Greenhouses (likely to involve market garden [e.g. tomatoes], flower farm or nursery uses).

- Poultry farming.

7. ENVIRONMENTAL SITE HISTORY SEARCH RESULTS

The following sections describe the results of the desktop and field components of the review of the environmental history of the site.

7.1 Historical Aerial Photography Interpretation

The interpretation of the historical aerial photography for each of the years reviewed is summarised below. The assessment has been based on professional judgement in the interpretation of physical features combined with field observations and correlation between the two. The objective of the interpretation is to give an overall impression of the type of activities undertaken within the site.

1954 Photography (Black and white)

The 1954 aerial photograph indicates that the site is predominantly vegetated with bushland. The majority of the properties adjacent to Hue Hue Road appeared to be partially cleared of the bushland vegetation with rural (orchard) land uses identified. The extent of the 1954 orchard land uses are indicated in Drawing 8, Appendix A. Areas adjacent Gorokan Road had been partially cleared of the bushland vegetation, although no orchard or intensive agricultural land use were identified. The area identified as the “Former Cricket Pitch” was cleared and appeared to have a grass surface cover (refer to Drawing 8).

A dam was identified between the “Former Cricket Pitch” and Gorokan Road. Anecdotal information indicated that this dam was formerly used to supply steam trains with water and may have been used as a quarry.

Surrounding land uses include the Main Northern Railway Line to the east, orchards to the north and bushland to the west and south.

1965 Photography (Black and white)

An overview of the 1965 aerial photograph indicates that further clearing of bushland within the site has occurred compared to the 1954 photograph. Notable changes in land use that may affect the contamination status of the site are identified in Drawing 8 (Appendix A) and include the following:

- an orchard land use in the area off Gorokan Road between Warapara and Pirama Roads.
- disturbed area within Lot 212 DP 866437, located off Bushells Ridge Road. Anecdotal information suggested that this area was historically used as a quarry for the electricity commission.

Surrounding land uses appeared to have remained relatively unchanged although the density of development in surrounding areas has continued to increase.

1975 Photography (Black and white)

An overview of the 1975 aerial photograph indicates that further clearing of bushland has occurred compared to the 1961 photograph with Lot 17 DP 870597 (large central parcel of land) having been cleared and appearing to have a grass surface cover (similar to its current physical condition). Several large buildings including four elongated shed were identified in the north western corner of the site (part of Lot 17 DP870597) (refer to Drawing 8). The aerial photographs and anecdotal information indicated this property had poultry farm land use.

Surrounding land uses appeared to have remained relatively unchanged although the density of development in surrounding areas has continued to be increase.

1985 Photography (Black and white)

An overview of the 1985 aerial photograph indicates that the site had similar physical features to the 1975 photograph, although additional buildings (probably dwellings) are visible in areas adjacent to Gorokan and Hue Hue Roads. The formerly identified orchard land uses appeared to have generally ceased, although a small number of trees were visible on two of the previously identified parcels of land.

Surrounding land uses appeared to have remained relatively unchanged although adjacent areas have continued to be developed.

1994 Photography (Colour)

An overview of the 1994 aerial photograph indicates that the site had similar physical features to the 1985 photograph, although additional buildings (probably dwellings) are visible in areas adjacent to Gorokan and Hue Hue Roads.

Surrounding land uses appeared to have remained relatively unchanged although density of development in surrounding areas has continued increase. Numerous elongated buildings (probably greenhouses) were identified beyond Gorokan Road to the south-east of the site (estimated at least 50 m from the site boundary). This off site land use is unlikely to have affected the contamination status of the site.

2007 Photography (Colour)

An overview of the SKM 2007 aerial photograph indicates that the site had similar physical features to the 1994 photograph, with the exception of Lot 442 DP 755242 (located off Hue Hue Road) where greenhouses were visible.

7.2 Regulatory Notices Search

The NSW EPA Register of Contaminated Land was searched for any Regulatory Notices that may be current on the site issued under the *Contaminated Land Management (CLM) Act* 1997 and Section 55 of the *Protection of the Environment Operations (POEO) Act 1997*. The information obtained indicated that no Licenses, Notices or Orders were issued for the site under the *CLM Act* or the *POEO Act*.

7.3 Property Enquiry Information

Property enquiry information provided on Lake Macquarie City Council web site, which includes information relating to contaminated land issues pertaining to the site was checked. The property enquiry also summarised development applications for each of the properties since around 1980. No information indicating that the individual properties may be potentially contaminated land by reason of its past/present use was provided on Lake Macquarie City Council web site.

8. FIELD WORK RESULTS

8.1 Site Observations

8.1.1 Geotechnical

The principal geotechnical observations made during inspections of the site on 5 May and 7 May 2009 are summarised below and further detailed in Drawing 3:

- no rock outcrops were observed within the site.
- erosion along the banks of Mannering Creek and the unnamed creek running south to north through the site (refer Drawing 3). Erosion depths ranged from 0.3 m to 2.5 m.

Photo 10 - Erosion in Mannering Creek

- most of the banks are devoid of trees and hence there is little protection against erosion and associated slumping of undercut sections.
- some slumping of creek banks has occurred in Mannering Creek (refer Photo 10 above).
- waterlogged soils are present in areas around the unnamed creek and also within the north-eastern area of the site (refer Drawing 3 for approximate extent).
- the near surface soils in these wet areas are generally weak and do not allow passage of vehicles (refer Photo 11)

Photo 11 – Deep tracks from 4WD vehicle in vicinity of unnamed creek

- significant areas of cutting and filling are present in the area of the former chicken farm in the north-west corner of the site (refer Drawing 3 and photos 3 to 5)

8.1.2 Site Contamination

The principal site contamination observations made during inspections of the site on 6, 11 and 12 May 2009 are summarised below and approximate areas potentially affected are presented in Drawing 8:

- **Lot 212 DP866437** (located off Bushells Ridge Road) – Anecdotal information suggested that the area currently occupied by Lot 212 was formerly used as a quarry. This information was supported by review of the aerial photographs which indicated bare areas stripped of vegetation in the 1954 and 1965 photographs.

Photo 12 & 13 – Former Quarry Land Use Area

- **Lots 245 to 262 & 273 to 283 DP 7506** (located off Gorokan Road) – Review of the aerial photographs indicates that the area currently occupied by these lots had a historical orchard land use from around 1965. These lots are now part of the "paper" subdivision site area.

- **Lot 430, 188 & 189 DP 755242** (located off Gorokan Road) – Review of the 1954 aerial photograph identified a circular cleared area in the 1954 and 1965 aerial photographs. Anecdotal information confirmed that this cleared area was historically a cricket pitch. Visual inspection of this area identified mounds of illegal dumping waste materials.

Photo 14 & 15 – Example of Illegal Dumping in Former Cricket Pitch Area

- **Lot 1582 DP 1121660** (located off Gorokan Road) – Review of the 1954 and 1965 aerial photographs identified a cleared area with dam. Anecdotal information indicated that this area was possible used as a quarry or as a water storage area supplying water to steam trains on the nearby Main Northern Railway Line. Visual inspection identified significant quantities of illegally dumped waste.

Photo 16 & 17 – Example of Illegal Dumping

- **Lot 186 DP 755242** (located off Gorokan Road) – Anecdotal information suggested that this area had a historical poultry land use. Review of aerial photographs identified that the property was cleared before 1954 although no buildings potentially associated with the historical land use were identified. Inspection of the area did not identify any evidence of the former poultry land use.
- **Lot 472 DP 755242** (accessed from Gorokan Road) – Visual inspection identified large sheds that were currently used as vehicle and farm machinery workshops and storage areas. In the locality of the sheds was an above ground diesel fuel storage tank and bowser. A separate shed had also been constructed on a former tennis court for storage of a helicopter. A separate above ground aviation (A1) fuel storage tank and bowser was also identified in this area of the site. In both cases the refuelling infrastructure appeared well maintained, with only minor visible signs of contamination around the diesel refuelling infrastructure. Anecdotal information indicated that the shade structures located within the site was operated as a commercial nursery, ceasing operations in the 1990's.

Photo 18 & 19 – Identified Above Ground Fuel Storage Tanks & Bowsers

Photo 20 – Shade Structures (Formerly Nursery Land Use)

- **Lot 8 DP 1020857** (located off Gorokan Road) – Visual inspection mound of filling towards the Gorokan Road boundary. Close inspection identified anthropogenic inclusions within the filling.

Photo 21 – Anthropogenic Inclusions with Filling (Lot 8)

- **Lot 323 & 324 DP 755242** (located off Hue Hue Road) – Review of the historical aerial photographs indicated that the majority of the area currently occupied by these lots had a historical orchard land use from around 1954 to 1965. Debris was identified from the 2007 aerial photograph within the Lot 323, although the property could not be accessed during the site walkover.

Photo 22 – Current condition of Lot 323

- **Lot 442 & 443 DP 755242** (located off Hue Hue Road) – Review of the historical aerial photographs indicated that the majority of the area currently occupied by these lots had a historical orchard land use from around 1954 to 1965. Elongated buildings likely to be for hydroponic activities in green houses were identified in the 2007 aerial photograph. This land use was confirmed during the site walkover, although no detailed inspection was possible. The aerial photograph also identified workshop facilities within Lot 442. The site walkover indicated that the derelict dwelling within Lot 443 was significantly damaged by fire and vandalism. The building appeared to be constructed from fibreboard building materials that may contain asbestos.

Photo 23 & 24 – Current condition of Lot 442 and 443 (respectively)

- **Lot 1 DP 785709 & Lot 17 DP 870597** (located off Hue Hue Road) – Review of the historical aerial photographs indicated that the part of the area currently occupied by these lots had a historical orchard land use from around 1954 to 1965. This portion of the site is currently grass covered.
- **Lot 17 DP 870597** (located off Hue Hue Road) – Review of the historical aerial photographs indicated that the part of the area currently occupied by this lot had a historical poultry farm land use from around 1975. This land use may have encroached onto Lot 16 DP 870597. Visual inspection of the site identified that significant disturbance, including cutting and filling and possibly stockpiling of waste materials, had occurred within this area of the site in the past. No former chicken burial pits were identified within this area of the site, although their presence is to be expected.

Photo 25 & 26 – Former poultry sheds & waste materials within Lot 17 (respectively)

8.2 Subsurface Investigation

Details of the subsurface conditions encountered are given on the test bore logs in Appendix C which should be read in conjunction with the accompanying notes defining classification methods and descriptive terms.

Relatively uniform conditions were noted underlying the site, with the succession of strata broadly summarised as follows:

TOPSOIL	typically brown or grey silty sand or clayey silty sand with abundant rootlets to depths ranging from 0.1 m to 0.3 m
SILTY SAND or CLAYEY SILTY SAND	loose to medium dense brown or light brown in all bores except Bores 1, 6, 7, 17 and 19 and to depths ranging from 0.25 m to 0.9 m
SANDY CLAY or CLAY:	generally stiff to very stiff sandy clay generally to termination of the bores at depths ranging from 0.8 m to 2.3 m (generally between 2.1 m and 2.3 m depth). The upper sandy clay and clay tended to be light brown or brown in colour to typically 0.8 m to 1.5 m depth, below which depth, light grey mottled red clay and sandy clay with occasional silty clay was encountered.
BEDROCK:	variably extremely low to very low strength sandstone was encountered in Bores 1, 4, 15,17, 19 and 24 at depths ranging from 0.7 m to 1.7 m. With the notable exception of Bore 4, the bores in which bedrock was encountered were located either within the higher southern areas of the site, the north of Mannering Creek or along the north-south trending ridge in the middle of the site.

Generally, the upper 0.3 m of the soil profile included either loose to medium dense topsoil or firm to stiff clay soils. Weaker conditions, including soft to firm clays, or loose sands, to greater depth, were encountered within a number of bores located along the banks of the unnamed creek and in the lower, north-eastern area of the site. These weaker soils generally correlated to the area of surface moisture and poor drainage, the approximate extent of which is shown on Drawing 3. The results of dynamic penetrometer testing at these test locations returned blow counts of less than 3 for 150 mm penetration, which indicates firm clay conditions and loose sand conditions. The depth of these weaker soils ranged from less than 0.3 m (over the majority of the site) to up to 1.05 m depth in Bores 5, 8 and 21.

Groundwater was observed within Bores 8 and 20 at depths or 0.7 m and 0.4 m respectively. Further, waterlogged soils were observed in a number of bores located in the lower areas along Mannering Creek and the unnamed creek. The waterlogged soils were accordingly weaker in strength. It is noted however that the test bores were immediately backfilled following excavation which precluded long term monitoring of groundwater levels. Further, it is anticipated that some groundwater would have been present at some of the locations and as such, longer term seepage inflow should be anticipated. Groundwater levels are affected by recent climatic conditions and soil permeability and therefore can vary with time.

The areas of surface moisture and weak near surface soils, as shown on Drawing 3, may be as a result of natural springs along the western side of the unnamed creek. Discussion with a nearby landowner indicates that the ground in the area immediately to the west of the unnamed creek never dries out completely and may be continuously recharged from springs daylighting along a line of similar contours.

9. LABORATORY TESTING

Laboratory testing on selected soils samples from the bores comprised the following:

- Five instability index (shrink-swell) tests on samples of the clay soils for site classification purposes;
- One Atterberg limit determination;
- Eleven Emerson Class Dispersion Tests on samples of the clay soils to assess dispersivity;
- 30 pH and EC determinations in an aqueous solution for salinity and soil aggressivity; and
- 36 acid sulphate screening tests on samples of the soils recovered from the bores.

The results of the tests are summarised in Tables 1 to 4 below.

Table 1– Results of Shrink-Swell Tests and Atterberg Limit Determinations

Bore	Depth (m)	Description	FMC (%)	PI (%)	LS (%)	Iss (% per ΔpF)	Initial Pocket Penetrometer Reading (kPa)	Final Pocket Penetrometer Reading (kPa)
3	0.6 – 0.9	Light brown mottled orange brown SANDY CLAY	19.9	-	-	2.3	170	160
11	0.5 – 0.8	Orange brown SANDY CLAY	30.6	-	-	4.1	380	240
16	0.5 – 0.8	Light grey mottled orange brown SANDY CLAY	18.7	-	-	1.5	200	130
19	0.3 – 0.55	Light grey mottled orange brown SANDY CLAY	23.8	-	-	2.9	260	170
23	0.5 – 0.8	Orange brown SANDY CLAY	23.1	-	-	1.2	280	250
20	0.5 – 0.85	Light grey SANDY CLAY with a trace of silt	16.2	24	11	3.5	230	180

Legend: FMC – Field Moisture Content Iss – Shrink-swell value PI – Plasticity Index
LS – Linear Shrinkage

The results of the shrink-swell testing indicate that the soils tested are moderately reactive. It should be noted that some softening occurred within the soaking phase of testing. The results of the Atterberg limit determination (returning a liquid limit of 36% and a plastic limit of 12%) indicates that the sandy clay from Bore 20 is of intermediate plasticity and slight to moderate reactivity.

Table 2– Results of Emerson Class Dispersion Testing

Bore	Depth (m)	Description	Emerson Class Number
1	0.6	Light grey SILTY CLAY	5
2	0.5	Orange brown SANDY CLAY	5
4	0.5	Grey brown SANDY CLAY	6
5	0.5	Brown grey CLAYEY SAND	5
7	0.5	Orange brown CLAY	6
8	1.0	Light grey mottled red SANDY CLAY	5
12	0.5	Orange brown SANDY CLAY	5
13	0.7	Orange brown SANDY CLAY	5
19	0.3	Light grey mottled orange SANDY CLAY	5
21	1.2	Orange brown SANDY CLAY	6
22	1.0	Orange brown SILTY SANDY CLAY	5

The results of the Emerson Class Dispersion testing indicates that the on site soils tested are slightly dispersive.

A total of thirty-six (36) acid sulphate screening tests were undertaken on samples retrieved from the bores. The results of the testing are summarised in Table 3 below.

Table 3– Results of Acid Sulphate Soil Screening

Bore	Depth (m)	Description	pH in H_2O	pH in H_2O_2	pH in H_2O -pH in H_2O_2
2	0.2	Brown silty sand topsoil	6.0	4.7	***1.3***
	0.5	Orange brown sandy clay	5.2	4.8	0.4
	1.0	Orange brown sandy clay	4.8	4.7	0.1
	1.8	Orange brown sandy clay	4.7	4.3	0.4
4	0.1	Brown silty sand topsoil	5.7	3.7	***2.0***
	0.3	Brown clayey silty sand	5.1	4.2	0.9
	0.5	Grey brown clayey sand	4.8	4.4	0.4
	0.8	Extremely low strength sandstone	4.8	4.6	0.2
5	0.05	Brown silty sand topsoil	5.4	4.0	***1.4***
	0.5	Brown grey clayey silty sand	5.3	4.6	0.7
	1.0	Light grey mottled red sandy clay	5.0	4.8	0.2
	2.0	Light grey mottled red sandy clay	5.0	4.7	0.3
6	0.1	Brown clayey silty sand topsoil	4.4	4.0	0.4
	1.0	Orange brown clay	4.6	4.1	0.5
	1.5	Light grey mottled red clay	4.5	4.2	0.3
	2.0	Light grey mottled red clay	4.8	4.7	0.1
7	0.2	Brown silty sand topsoil	4.9	2.8	***1.9***
	1.0	Light grey mottled red clay	4.7	4.2	0.5
	1.5	Light grey mottled red clay	4.5	4.3	0.2
	2.0	Light grey mottled red clay	4.5	4.0	0.5
8	0.1	Brown clayey silty sand topsoil	5.1	3.5	***1.6***
	0.5	Brown clayey silty sand	5.1	4.5	0.6
	1.0	Light grey mottled red sandy clay	4.5	4.3	0.2
	1.5	Light grey mottled red sandy clay	5.1	5.0	0.1

Table 3 (cont')– Results of Acid Sulphate Soil Screening

Bore	Depth (m)	Description	pH in H_2O	pH in H_2O_2	pH in H_2O -pH in H_2O_2
13	0.3	Light grey silty sand topsoil	5.5	4.2	***1.3***
	0.7	Orange brown sandy clay	5.8	5.5	0.3
	1.3	Light grey mottled red gravelly sandy clay	5.0	5.0	0
	2.0	Light grey mottled red sandy clay	4.8	4.8	0
16	0.1	Brown silty sand topsoil	5.8	3.7	***2.1***
	0.6	Light grey mottled orange sandy clay	5.5	4.9	0.6
	1.5	Light grey mottled orange sandy clay	5.2	5.1	0.1
	2.0	Light grey mottled orange sandy clay	4.7	4.6	0.1
20	0.1	Brown clayey silty sand topsoil	4.8	4.1	0.7
	0.5	Grey brown clayey silty sand	4.8	4.4	0.4
	0.8	Light grey sandy clay	5.3	4.4	0.9
	2.0	Light grey clay	5.0	4.7	0.3

Notes to Table 3
Bold italicised results exceed ASSMAC action criteria

These results are discussed in more detail in Section 10.5.

Salinity Testing

A total of 30 samples of the site soils were tested for pH and Electrical Conductivity (EC) in a 5:1 water: soil aqueous solution to assess the presence of saline soil conditions at the site. The results are summarised in Table 4 below. The results have been interpreted into salinity classes based on the correlations presented in the Local Government Salinity Initiative (Ref 2).

Table 4 – pH, EC and moisture content testing of Soil

Bore	Depth (m)	Description	pH	$EC_{1:5}$ (dS/m)	EC_e (dS/m)	Salinity Class
2	0.2	Brown silty sand topsoil	6.0	0.06	0.84	Non-Saline
	0.5	Orange brown sandy clay	5.2	0.01	0.08	Non-Saline
	1.0	Orange brown sandy clay	4.8	0.06	0.48	Non-Saline
5	0.05	Brown silty sand topsoil	5.4	0.18	2.5	Slightly Saline
	0.5	Brown grey clayey silty sand	5.3	0.10	1.0	Non-Saline
	1.0	Light grey mottled red sandy clay	5.0	0.07	0.56	Non-Saline
6	0.1	Brown silty sand topsoil	4.4	0.05	0.7	Non-Saline
	0.5	Orange brown clay	4.7	0.08	0.56	Non-Saline
	1.0	Light grey mottled red clay	4.6	0.05	0.4	Non-Saline
7	0.2	Brown sandy silt topsoil	4.9	0.06	0.6	Non-Saline
	0.5	Orange brown clay	4.7	0.06	0.42	Non-Saline
	1.0	Light grey mottled red clay	4.5	0.08	0.48	Non-Saline
8	0.1	Brown silty sand topsoil	5.1	0.05	0.7	Non-Saline
	0.5	Brown grey clayey silty sand	5.1	0.06	0.6	Non-Saline
	1.0	Light grey mottled red sandy clay	4.5	0.06	0.48	Non-Saline
9	0.05	Brown silty sand topsoil	5.0	0.06	0.84	Non-Saline
	0.2	Light grey brown silty sand	4.9	0.07	0.7	Non-Saline
	0.5	Light grey mottled orange brown clayey sand	4.8	0.06	0.51	Non-Saline
10	0.1	Brown silty sand topsoil	4.9	0.07	0.98	Non-Saline
	0.5	Orange brown sandy clay	4.9	0.04	0.34	Non-Saline
	1.0	Orange brown clay	5.2	0.04	0.28	Non-Saline

Table 4 (cont') – pH, EC and moisture content testing of Soil

Bore	Depth (m)	Description	pH	$EC_{1:5}$ (dS/m)	EC_e (dS/m)	Salinity Class
11	0.1	Brown silty sand topsoil	4.7	0.06	0.84	Non-Saline
	0.3	Brown clayey silty sand	4.9	0.04	0.56	Non-Saline
	0.7	Orange brown sandy clay	5.1	0.03	0.23	Non-Saline
14	0.1	Dark brown silty sand topsoil	5.6	0.05	0.7	Non-Saline
	0.3	Grey clayey silty sand	6.0	0.08	1.12	Non-Saline
	0.7	Light grey mottled orange sandy clay	6.1	0.02	0.16	Non-Saline
23	0.2	Brown silty sand topsoil	5.7	0.04	0.56	Non-Saline
	0.5	Orange brown sandy clay	5.7	0.04	0.34	Non-Saline
	1.0	Orange brown sandy clay	5.8	0.02	0.17	Non-Saline
Water	-	Mannering Creek	5.1	0.36	-	
Water	-	Unnamed Creek	4.9	0.40	-	

Where $EC_{1:5}$ = Electrical conductivity
EC_e = Electrical conductivity of a saturated extract

Soil salinity is often assessed with respect to electrical conductivity of a 1:5 soil:water extract (EC 1:5). This value can be converted to ECe (electrical conductivity of a saturated extract) by multiplication with a factor dependent of soil texture ranging from 6 for shale to 17 for sand (Ref. 2).

Based on the requirements of DIPNR's Booklet (Ref 2, 2003) *Salinity Investigations* soil salinity is classified as follows:

Table 5 - Soil Salinity Classification

Class	ECe (dS/m)	Implication
Non Saline	<2	Salinity effects mostly negligible
Slightly Saline	2 – 4	Yields of sensitive crops effected
Moderately Saline	4 – 8	Yields of many crops effected
Very Saline	8 – 16	Only tolerate crops yield satisfactorily
Highly Saline	>16	Only a few very tolerant crops yield satisfactorily

The salinity measurements on test bore samples from the site indicate that the soil is predominantly non-saline. One result from the topsoil in Bore 5 indicated slightly saline conditions.

10. DISCUSSION

10.1 Slope Instability

No evidence of hill slope instability (landslip) has been observed within the site.

Other than erosion-triggered localised slumping from the low height banks of Mannering Creek and the unnamed creek, there does not appear to be a significant risk of stream bank instability. It is considered that hill slope and stream bank instability do not impose significant constraints on the proposed site development.

A stability hazard map has not been prepared as no stability hazard was apparent within the site.

10.2 Erosion Potential

Erosion hazard forms a landscape limitation for the Gorokan Landscape (Ref. 3). Soils of the Gorokan Soil Landscape are typically of moderate to high erodibility (K values of 0.03 – 0.05), particularly to concentrated flows. The results of the Emerson Class Dispersion testing indicates

that the soils from the higher portions of the site, mapped as being of the Gorokan Soil Landscape Group show slight susceptibility to dispersion. Hence, combined with the absence of saline soil conditions, the erosion hazard of these soils within the majority of the site is deemed to be moderate.

The soils along the alignment of the Mannering Creek and the unnamed creek are mapped as being of the Wyong Soil Landscape Group. Soils of this group are typically of moderate erodibility (K values of between 0.028 and 0.03). Erosion within this soil is not anticipated with the exception of severe stream bank erosion along major drainage channels. This is supported by the evidence of previous erosion within the existing creek lines within the site.

It is considered that the erosion hazard within the areas proposed for residential and industrial would be within usually accepted limits which could be managed by good engineering and land management practices.

10.3 Soil Salinity

Two means of assessment of soil salinity were adopted:

- Visible indicators of salinity mapped during a geological inspection; and
- EC_e measurements of soil samples from test bores.

Based on the site inspection and results of the laboratory testing, the majority of the site appears to be non-saline. Efforts should be made however throughout the area to prevent or restrict changes to the water balance that will result in rises in groundwater levels, bringing more saline water closer to the ground surface. As a precaution, development must be planned to mitigate against the effects of any potential salinisation that could occur.

10.4 Site Contamination Potential

In summary, the site history review and walkover inspections indicated that the sites had been used primarily for rural, intensive agricultural and residential purposes, although extractive (quarrying) land uses were identified in two areas of the site. Uses included orchards, poultry farming and market gardening (hydroponics), which may have resulted in widespread contamination. More localised areas of potential contamination were also identified; these included illegal dumping, workshop facilities, refuelling infrastructure and placement filling. The widespread and more significant localised Areas of Environmental Concern (AEC) are identified in Drawing 8, Appendix A. Many of the buildings observed on-site were noted to be at least in part constructed from fibreboard which may have resulted in asbestos contamination. Further it is also noted that areas in the vicinity of past or present development can be expected to have isolated areas of filling or disturbance. Areas of filling or disturbance typically indicate a low potential for contamination.

Based on the findings of the desktop review and detailed site walkover, the principal sources of potential contamination within the site are presented in Table 6 below:

Table 6 – Potential Contamination Sources

Lot	Potential Contamination Source/Activity	Potential For Contamination	Primary Potential Contaminates of Concern
Lot 212 DP866437	Quarrying Activities	Low (Soil & Groundwater)	Heavy Metals, TPH, BTEX, PAH & Phenols
Lots 245 to 262 & 273 to 283 DP 7506	Orchard Activities	Low (Soil)	Heavy Metals & OCP
Lot 430, 188 & 189 DP 755242	Illegal Dumping	Moderate (Soil)	Heavy Metals, OCP, TPH, BTEX, PAH, Phenols, PCB, Cyanide Asbestos & Sulphate
Lot 1582 DP 1121660	Quarrying Activities	Low (Soil & Groundwater)	Heavy Metals, TPH, BTEX, PAH & Phenols
	Illegal Dumping	Moderate to High (Soil & Groundwater)	Heavy Metals, OCP, TPH, BTEX, PAH, Phenols, PCB, Cyanide Asbestos & Sulphate
Lot 186 DP 755242	Poultry Activities	Low (Soil & Groundwater)	Heavy Metals, OCP, Nutrients & Microbiological
Lot 472 DP 755242	Machinery Workshops, Storage Areas & Refuelling Infrastructure	Low to Moderate (Soil & Groundwater)	Heavy Metals, TPH, BTEX, PAH & Phenols
	Nursery Activities	Low to Moderate (Soil)	Heavy Metals, OCP, OPP & Cyanide
Lot 8 DP 1020857	Importation of Filling	Low to Moderate (Soil)	Heavy Metals, OCP, TPH, BTEX, PAH, PCB & Asbestos
Lot 323 & 324 DP 755242	Orchard Activities	Low (Soil)	Heavy Metals & OCP
	Importation of Filling (or Deleterious Materials)	Low to Moderate (Soil)	Heavy Metals, OCP, TPH, BTEX, PAH, PCB & Asbestos
Lot 442 & 443 DP 755242	Orchard Activities	Low (Soil)	Heavy Metals & OCP
Lot 442 DP 755242	Market Gardens (Hydroponics)	Low to Moderate (Soil)	Heavy Metals, OCP, OPP & Cyanide
	Workshop	Low to Moderate (Soil & Groundwater)	Heavy Metals, TPH, BTEX, PAH & Phenols
Lot 1 DP 785709 &	Orchard Activities	Low (Soil)	Heavy Metals & OCP
Lot 17 DP 870597	Orchard Activities	Low (Soil)	Heavy Metals & OCP
	Poultry Activities	Low (Soil & Groundwater)	Heavy Metals, OCP, Nutrients & Microbiological

Notes:
The potential for contamination is based Stage 1 scope of work.
Heavy Metals = Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel & Zinc
TPH = Total Petroleum Hydrocarbons, BTEX = Benzene, Toluene, Ethyl Benzene & Xylene
PAH = Polyaromatic Hydrocarbons, PCB = Polychlorinated Biphenyls
OCP = Organochlorine Pesticides, OPP = Organophosphorus Pesticides
Nutrients = Nitrogen, Phosphorus and Ammonia
Microbiological = Faecal Coliforms and E-Coli

The potential for off site sources of contamination were generally considered not to be significant based on the following factors:

- Surrounding land uses are generally semi-rural residential with the exception of the Main Northern Railway and areas to the north east and east.
- Historical land uses adjacent to the site were not identified as potentially contaminating.

The walkover assessment identified various potential sources of asbestos contamination to the surface soils, filling or waste disposal areas on-site. This walkover assessment does not constitute a hazardous building materials assessment. Further, a hazardous building materials assessment would be recommended prior to demolishing the any buildings at the site.

Phase 2 (Detailed) Contamination Assessment to assess contamination levels in the identified AEC should be undertaken in accordance with *Contaminated Site: Sampling Design Guidelines* (Ref 4) and *Contaminated Site: Guidelines for Assessing Former Orchards and Market Gardens* (Ref 5) [where applicable].

It recommended that some broad space systematic assessment is undertaken on the remaining site areas. This assessment would include a combination of visual observation and limited composite sampling (for a limited suite of analytes). If contamination is encountered or subsurface conditions are considered to be significantly variable then additional sampling locations would be recommended.

The following judgemental sampling scope is recommended in addition to the systematic sampling scope of work outlined above:

- Sediments and surface waters within drainage alignments and dams.
- Existing building footprints where the natural topography has been modified for the construction of buildings.
- Supplementary Phase 2 Contamination Assessment targeting areas where illegal dumping had occurred. This assessment would include the identification and demarcation of areas affected, classification of wastes and validation of the area following appropriate disposal/re-use of the materials.
- Assessment of access roads/tracks affected by surface filling or disturbance.

10.5 Acid Sulphate Soils

Review of the acid sulphate soil screening results presented in Table 3, indicates that soils on-site would generally not be considered to be potential or actual acid sulphate soils. This conclusion is consistent with the acid sulphate soil risk mapping and site surface elevations. Notwithstanding this, review of Table 3 indicated that several surface or near surface soil samples reported exceedences of the ASSMAC action criteria. These false positive results were considered to have been caused by organics (rootlets) within the topsoil profile rather than acid sulphate soil minerals.

Given the preliminary nature of the current assessment, if development is proposed within areas mapped as “weak soils” (refer to Drawing 3), then further detailed investigation would be recommended for these areas only.

10.6 Mine Subsidence Board Issues

Discussion with Mr Tom Hole of the Mine Subsidence Board indicates that the site lies outside a mine subsidence district and holds no interest to the Mine Subsidence Board.

10.7 Presence of Weak Soils

A number of bores located generally within the lower northern area of the site and around the existing creeks encountered weak soils, including firm clay and loose sand. A summary of the location of these weaker soils (where present to greater than 0.3 m depth) is presented in Table 7 below.

Table 7 – Presence of Weak Soils

Bore	Depth to base of strata (m)	Strata Description
5	1.05	Loose clayey silty sand over initially firm sandy clay
6	0.35	Loose silty sand topsoil over initially firm clay
7	0.35	Loose silty sand topsoil over initially firm clay
8	1.0	Loose clayey silty sand over initially firm sandy clay
9	0.45	Loose silty sand
20	0.6	Loose clayey silty sand
21	1.05	Loose to medium dense sand over firm to stiff sandy clay
22	0.9	Loose to medium dense silty sand

Reference to the test location plan and Table 7 above indicates that the majority of these weak soils coincide with the wetter areas of the site along the unnamed creek and in the north-eastern corner. Drawing 3 in Appendix A, indicates the approximate extent of the moisture affected, weak near surface soils based on the results of the test bores and visual inspection.

Traffickability of earthworks machinery on these soils will be highly dependant on the prevailing moisture condition at the time of construction. Further, given the low lying terrain over a significant portion of the site, it is possible that significant areas of the site may become inundated with surface water following rainfall events. Traffickability of waterlogged soils after inundation will become difficult. Hence, it will be of critical importance to address surface water flows during construction. Placement of filling from working platforms pushed out over the weak soils may be required depending on the conditions at the time of construction. Site drainage measures should also be installed early in the construction programme if development of these areas of the site is proposed.

10.8 Presence of Filling

Filling mounds and platforms were observed within the north-western area of the site in the location of the former chicken farm. Minor filling may also be present within the areas of previous development at the site, including the northern Area B and also within the “paper subdivision”

along the eastern boundary of the site. A filling platform of approximately 2 m in height was observed within the north-eastern corner of the site, adjacent to Gorokan Road.

No subsurface investigation has been undertaken within these areas during this preliminary investigation.

In absence of specific investigations of the filling, the filling must be considered unsuitable for the support of structural loadings, footings or pavements. Further assessment would be required to assess the suitability of the filling to either remain in place or for re-use as engineered filling elsewhere on site.

10.9 Excavation Conditions

At this stage, the depth of excavation associated with the proposed development at the site is not known. It is anticipated, however, that it would be limited to approximately less than 2 m. Based on the conditions encountered in the bores, excavation within the sand, clays and extremely low strength to very low strength sandstone is anticipated to be relatively straightforward with conventional hydraulic excavators, possibly assisted by rippers and rockbreaking equipment.

10.10 Retaining Wall Parameters

Any non-propped or laterally unrestrained walls of less than 3 m in height and away from property boundaries or existing structures/services may be designed based upon “active” (K_a) lateral earth pressure coefficients. Under these circumstances movements of the order of 0.01 to 0.02 times the overall wall height can be tolerated with the soil “relaxing” from an “at rest” to “active” condition. Braced rigid retaining walls are generally not free to move and should be designed based on “at-rest” (K_o) earth pressure coefficients.

Recommended lateral earth pressure design parameters are presented in Table 8 below. The earth pressure coefficients are for well drained level backfill. Separate account should be taken in the design of additional surcharge loads, during or after construction.

Table 8 – Retaining Wall Design Parameters

Parameter	Symbol	Stiff or stronger silty clay or sandy clay	Extremely low strength sandstone	Very low strength or stronger sandstone
Bulk density (above water table)	γ_b	18 kN/m^3	20 kN/m^3	20 kN/m^3
Active earth pressure coefficient	K_a	0.3	0.25	0.2
At-rest earth pressure coefficient	K_o	0.5	0.4	0.35

For toe restraint, an ultimate passive pressure of 400 kPa is suggested in sandstone of at least extremely low strength.

The earth pressure design parameters given above are based on the assumption that full drainage will be provided behind the retaining walls. All retaining walls, regardless of height, should be provided with geotextile encapsulated free draining backfill (such as 10 mm single size aggregate) with a slotted drainage pipe at the base of the wall for the relief of hydrostatic pressures.

10.11 Excavation and Filling Batters

Where excavation is sufficiently distant from site boundaries, adjacent structures or in-ground services, a short term (construction) batter slope of 1.5H:1V is suggested for excavations of up to 3 m in stiff or better clay or extremely low strength sandstone (if encountered).

If the batter slopes are left bare it is possible that minor erosion may occur as the results of laboratory testing indicates that the on site soils have a slight potential for dispersion. Hence, as part of a detailed site investigation, it is recommended that a detailed assessment of the dispersive tendency of the soils is undertaken.

For batters on placed filling embankments, it is suggested that long term slopes of 3H:1V are suitable for controlled filling, provided such batters are protected from erosion.

Furthermore, batter slopes of 6H:1V are generally preferred to allow passage of mowing and maintenance equipment.

Notwithstanding the above comments on excavation stability, the contractor should comply with all statutory requirements for excavation support and worker safety.

10.12 Groundwater

Groundwater was not encountered in the majority of the bores during excavation.

It is noted, however, that surface water and waterlogging of the near surface soils was observed within the lower areas of the site along the banks of the unnamed creek and also within the north-eastern area of the site. Hence control of surface stormwater should be planned during the design of construction activities.

10.13 Indicative Site Preparation Measures

The site preparation measures required during construction will be dependant on the design level, type of footing or pavement proposed and the soil conditions exposed at the time of construction. Based on the conditions encountered in the bores, however, it is anticipated that site preparation measures for the support of high level spread footings or pavements is likely to include the following:

- Excavation to design subgrade or formation level in areas of new construction;
- Removal of all existing topsoil or deleterious material;
- Rolling the surface to receive filling with at least six passes of a minimum 6 tonne deadweight roller, with a final proof rolling pass accompanied by careful visual inspection by an experienced geotechnical consultant to allow detection and treatment of any soft or compressible zones;
- Additional excavation and replacement with suitable select filling if required, based on the results of the proof rolling and inspection of the exposed subgrade. Typically on the Central

Coast, ripped sandstone is used for this select layer and preliminary design could be based on an assumed CBR of 15% for this material;

- Moisture conditioning of the upper 300 mm of the exposed pavement subgrade and compaction to 100% dry density ratio (Standard compaction). Additional layers of filling or replacement select filling (if required) should be placed in near horizontal layers no thicker than 250 mm (loose thickness) and each layer compacted to the same density ratio. Moisture contents of scarified subgrade (and additional filling) should be maintained within -4% (dry) of optimum moisture content (OMC) to OMC for Standard compaction;
- Protection of the area after subgrade preparation to maintain moisture content as far as practicable. The placement of the select subgrade or subbase gravels would normally provide adequate protection.

During decommissioning of the existing farm dams, removal of the existing stored water, followed by any accumulated silt and the embankment filling material will be required. The suitability of the recovered materials for re-use as engineering filling should be assessed at the time of decommissioning. It is unlikely that the silt which may be present at the base of the dams will be suitable for reuse as engineered filling.

Geotechnical inspection and testing will be required during preparation of subgrades within areas to accept filling or in areas of pavement subgrades and during placement of filling.

10.14 Reuse of Excavated Material

It is understood that some of the material excavated from the site may be transported off-site. The suitability of the excavated material for re-use as filling is dependent upon the properties of the material excavated. The existing clay, sandy clay soil and weathered bedrock may be suitable for reuse as controlled filling, subject to geotechnical inspection at the time of excavation. The reactivity of the upper clay soils should be assessed in relation to the intended use at the site to receive the filling.

Reuse of excavated soil from the wet area of the site, as approximated on Drawing 3, would require moisture reconditioning (i.e. drying out) and removal of organics and may not be practicable.

It is noted that the Department of Environment and Conservation (formerly the NSW EPA) requires that soils excavated for off-site disposal be classified in accordance with the NSW DECC's *Waste Classification Guidelines Part 1: Classifying Waste* (Ref 6).

10.15 Anticipated Site Classification

Classification of residential sites as described in AS 2870 – 1996 *"Residential Slabs and Footings – Construction"* (Ref 7) is based on ground movement limits, which are defined by the characteristic surface movement (y_s). The parameter y_s represents the surface movement expected at a site between dry and wet periods, and can be estimated from soil shrinkage and instability indices, I_{PS} and I_{PT} respectively; and design suction change which provides an indication of the suction profile with depth within a soil, based on the climatic region of the site.

Laboratory testing indicates that the site soils have a characteristic shrink-swell index ranging from 1.2% to 4.1% per ΔpF. An in-house programme "Reactive" has been used to model soil behaviour and estimate characteristic free surface movements for the future allotments.

Based on the existing surface levels and a clay cover of the bedrock ranging in depth from 0.8 m to 2.8 m and the results of the shrink-swell testing, it is anticipated that the individual sites of the proposed buildings within the majority of the site would be classified as either Class M (moderately reactive) or Class H (highly reactive).

Clause 2.3.5 states that "*the allowable bearing pressure at foundation level shall not be less than 100 kPa for strip and pad footings, and under the edge footing of footing slabs used without tie bars between the edge footing and slab*". The area of weak soils, approximated on Drawing 3, includes weak near surface soils which would not satisfy this clause and hence this area of the site would be classified as Class P (Problem Site). Footings for residential development would need to be designed based on first principles and additional more intensive investigation would be required to assess the extent of the weak soils and depth to suitable foundation strata.

The final classifications for the proposed buildings at the site will be affected by excavations within the building envelope, by the placement of additional filling or by the presence of existing filling.

Furthermore, the levelling of a site for building may require reassessment of the classification, depending upon the depth of cutting and filling or the compaction achieved within any new filling. Individual site classification could be undertaken for the proposed buildings once the final layout is established. This would require additional analysis and supplementary field work.

10.16 Footings

The existing filling anticipated within the area of the former chicken farm and also within the areas of previous development at the site, together with filling associated with the existing dams on the site should not be relied upon for support of structural loads and all foundations should be constructed to derive uniform support from the underlying stiff to hard clay or bedrock. Alternatively, should the results of geotechnical inspection and testing indicate that the existing filling would be suitable for reuse, support of high level footings within the reworked and controlled filling may be applicable.

All footing systems should be designed and constructed in accordance with AS 2870 – 1996 (Ref 7) for the appropriate classification.

Spread footings founded within the natural stiff to hard clay or underlying bedrock would be suitable for the support of the one to two storey buildings. Footings for residential structures founded on stiff clay or stronger should be designed for a maximum allowable bearing pressure of 100 kPa.

In areas requiring removal of existing filling and replacement with engineered filling, spread footings founded within Level 1 inspected and tested filling should be designed for a maximum allowable bearing pressure of 100 kPa.

Spread footings on extremely low strength or stronger bedrock should be designed for a maximum allowable bearing pressure of 500 kPa, unless the results of further specific investigation and assessment indicate that higher bearing pressures are appropriate.

For larger structures, such as three to four stories, piled foundations may be required.

All footing excavations (including bored piers) should be inspected by an experienced geotechnical engineer prior to construction.

For bored piles it is suggested that they be designed for a maximum allowable end bearing pressure of 500 kPa within the extremely low strength sandstone bedrock and with an allowable shaft adhesion of 30 kPa in stiff or stronger clay and 60 kPa in the extremely low sandstone. It is also suggested that contribution to shaft adhesion of the upper 1.5 m of the pile profile is ignored due to the effects of shrink-swell behaviour of the clay soil.

Settlements for foundations proportioned in accordance with the parameters outlined above are estimated to less than 0.5% of the footing width (or pile diameter) under the applied working load, with differential settlements between adjacent columns expected to be less than half of this value.

10.17 Anticipated Subgrade Conditions for Pavements

No conceptual plans have been provided at this stage and hence the layout of the proposed internal roads is unknown. It is likely that development of the lower areas around the unnamed creek and also along the banks of Mannering Creek will not be undertaken.

Based on the conditions encountered in the bores, the anticipated subgrade will consist of either clay, silty clay or sandy clay with isolated areas of sand or silty sand. Depending on the depth of excavation required along pavement alignments, extremely low strength sandstone may also be encountered at formation level.

In the area of weak soils, as approximated on Drawing 3, poor subgrade conditions are anticipated. Further, more detailed investigation would be required in the event that pavements are proposed in this area.

Laboratory testing of subgrade conditions would be required once the vertical and horizontal layout of the proposed pavements and design traffic loading is finalized.

10.18 Footings

All footing systems should be designed and constructed in accordance with AS 2870 – 1996 (Ref 7) for the appropriate classification. Conventional high level footing systems would be appropriate for Class M or H sites. Suitable foundation systems for Class P lots could include (depending on the depth of suitable founding stratum and the presence of groundwater) backhoe excavated blockdowns, pier and beam, screw piles or possibly driven timber piles founding on the underlying stiff clays or weathered rock.

10.19 Site Preparation and Earthworks

Site preparation for the construction of residential structures should include the removal of topsoils and other deleterious materials from the proposed building areas.

In areas that require filling, the stripped surfaces should be proof rolled in the presence of a geotechnical engineer. Any areas exhibiting significant deflections under proof rolling should be appropriately treated by over-excavation and replacement with low plasticity filling placed in near horizontal layers no thicker than 250 mm compacted thickness. Each layer should be compacted to a minimum dry density ratio of 98% relative to standard compaction with placement moisture contents maintained within 2% of standard optimum. The upper 0.5 m in areas of pavement construction should achieve a minimum dry density ratio of 100% relative to standard compaction.

All batters should be constructed no steeper than 3:1 (horizontal:vertical) and appropriately vegetated to reduce the effects of erosion.

To validate site classifications, sufficient field inspections and in-situ testing of future earthworks should be undertaken in order to satisfy the requirements of a Level 1 inspection and testing service as defined in AS 3798 – 1996 (Ref 8).

Earthworks required for pavement construction will need to be based on batters formed no steeper than 3:1 (H:V) in the residual clays. All batters should be suitable protected against erosion with toe and spoon drains constructed as a means of controlling surface flows on the batters.

10.20 Site Maintenance and Drainage

The developed residential lots should be maintained in accordance with the CSIRO publication *"Guide to Home Owners on Foundation Maintenance and Footing Performance"*, a copy of which is included in Appendix E Whilst it must be accepted that minor cracking in most structures is inevitable, the guide describes suggested site maintenance practices aimed at minimising foundation movement to keep cracking within acceptable limits.

Adequate surface drainage should be installed and maintained at the site. All collected stormwater, groundwater and roof runoff should be discharged into the stormwater disposal system.

11. SUMMARY OF LAND CAPABILITY FOR SITE DEVELOPMENT

No evidence of hill slope instability was observed within the site. It is considered that hill slope and stream bank instability do not impose significant constraints on the proposed site development.

The presence of erosive soils on site should not present significant constraints to development provided they are well managed during earthworks and site preparation stages. Gully erosion already present on site should be remediated during site works as discussed earlier in Section 10.2.

Salinity Risk across the site is generally considered low. Development at the site must be planned to mitigate against the effects of any potential salinisation that could occur.

Soil contamination risk across the site is generally low. However, a range of further investigations will be required to assess the actual degree of contamination present on site. That said, it is not anticipated that soil contamination will present a constraint to development and any areas of contamination identified, once remediated, will be suitable for the proposed land use. Illegally dumped waste material will require validation testing then removal to a suitably licensed waste facility prior to site development.

Discussion with the Mine Subsidence Board indicates that the area is outside a prescribed subsidence district and that the mine subsidence board has no interest in the site.

12. FURTHER INVESTIGATION

Further investigation will be required as conceptual design/planning progresses together with additional work during the construction phase. Specific investigation would include (but not necessarily limited to):

- Preparation of a Site Contamination: Sampling & Analysis Quality Plan (SAQP) that outlines the scope and sampling methodology for the Phase 2 (Detailed) Contamination Assessment.
- Phase 2 (Detailed) Contamination Assessment (comprising subsurface sampling and laboratory testing) in the nominated areas of environmental concern (refer to Drawing 8). The purpose of this work would be to quantify the level of contamination (if any) and delineate contaminated areas in order to facilitate the preparation of remediation action plans (RAP).
- Remediation and validation monitoring of areas subject to an RAP, to render such areas appropriate for the proposed land use, from the contamination viewpoint. (if required)
- Detailed geotechnical investigations on a stage-by-stage residential development basis for determination of pavement thickness designs and lot classifications.
- Detailed acid sulphate soil assessment if development is proposed in the within areas mapped as “weak soils”. This investigation would also more accurately define the “weak soils” mapped areas.

- Routine inspections and earthworks monitoring during construction.

13. LIMITATIONS OF THIS REPORT

DP's assessment is necessarily based upon the result of a site history search and limited site inspection that was set out in the original proposal. Neither DP, nor any other reputable consultant, can provide unqualified warranties nor does DP assume any liability for site conditions not observed, or accessible during the time of the investigations.

Despite all reasonable care and diligence, site characteristics may change at any time in response to variations in natural conditions, chemical reactions and other events, e.g. groundwater movement and or spillages of contaminating substances. These changes may occur subsequent to DP's investigations and assessment.

This report and associated documentation have been prepared for the use of Lake Macquarie City Council, owners of the site. The report was prepared in accordance with a specific scope of works. It is the responsibility of any third parties to investigate fully to their satisfaction if any information prepared by DP is suitable for their specific objective.

Before passing on to a third party any information or a report prepared by DP, the Client is to inform fully the third party of the objective and the scope, and all limitations and conditions, under which the reports were prepared.

Any reliance assumed by third parties on this report outside of the stated scope shall be at such parties' own risk. Any ensuing liability resulting from this use of the report by third parties cannot be transferred to DP.

DOUGLAS PARTNERS PTY LTD Reviewed by:

Michael Gawn
Senior Associate

T J Wiesner
Principal

Brent Kerry
Associate

REFERENCES

1. Managing Land Contamination, Planning Guidelines SEPP 55 – Remediation of Land, 1998.
2. DLWC, 2002. Site Investigations for Urban Salinity, Department of Land and Water Conservation, New South Wales.
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6. DECC, 2008. *Waste Classification Guidelines Part 1: Classifying Waste*, Department of Environment & Climate Change (NSW).
7. Standards Australia. 1996. AS2870 – 1996 *Residential Slabs and Footings*.
8. Standards Australia. 1996. AS 3798 – 1996 *Guidelines on Earthworks for Commercial and Residential Developments.*

APPENDIX A

Notes Relating to the Report & Drawings

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NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigations Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow

sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7

  as 4, 6, 7
  N = 13

- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm

  as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

q_c (MPa) = (0.4 to 0.6) N (blows per 300 mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

q_c = (12 to 18) c_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on

soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Bore Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers,

Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Approximate Site Area

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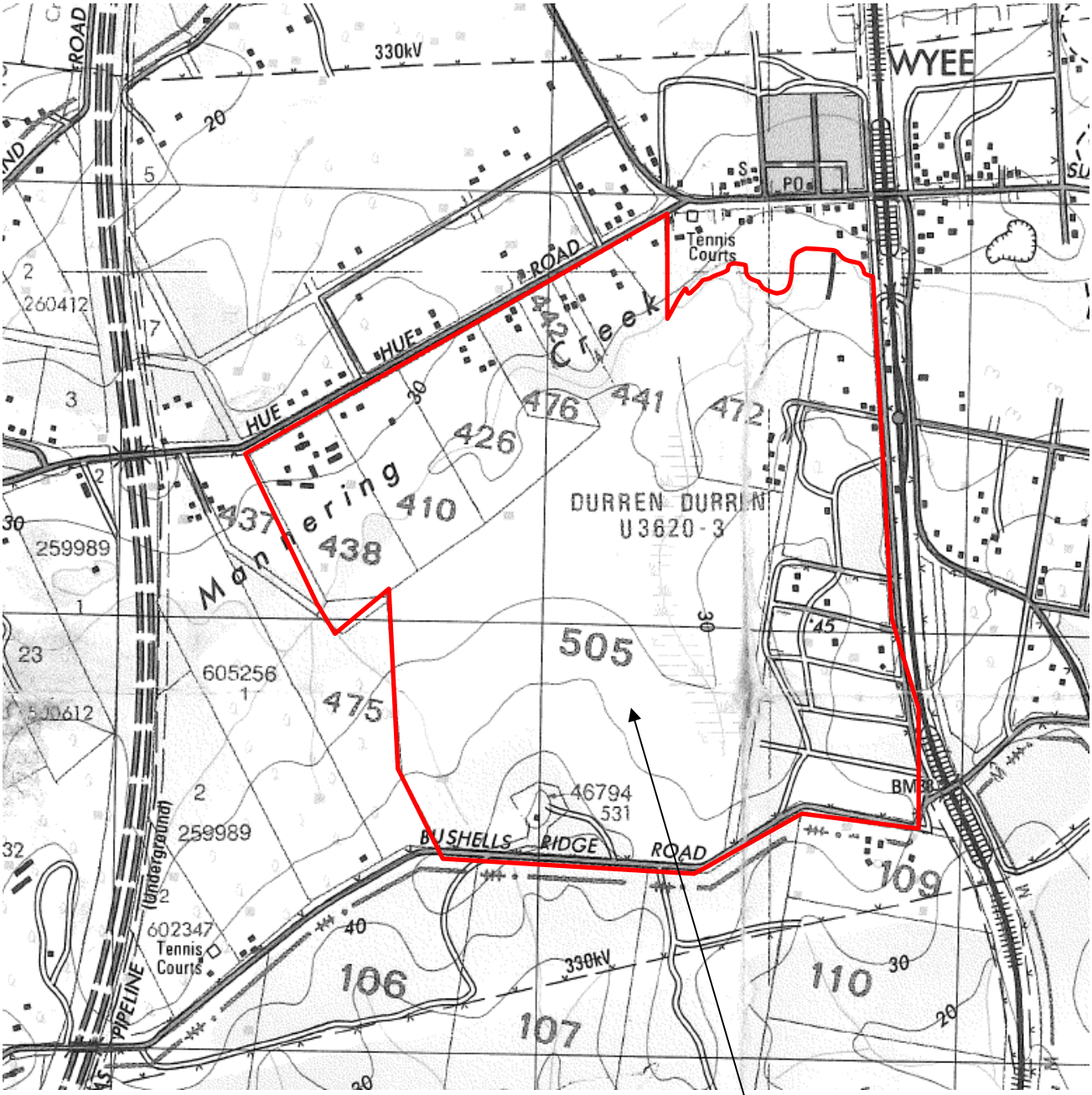
Sydney, Newcastle
Brisbane, Melbourne,
Perth, Wyong

Cairns, Campbelltown,
Darwin, Townsville

TITLE: Site Location Plan
Wyee Land Release
Hue Hue Road, Wyee

CLIENT: Conics Pty Ltd			OFFICE: Wyong
DRAWN BY: MPG	SCALE: NTS	PROJECT No: 41810	DRAWING No: 1
APPROVED BY:		DATE: June 2009	



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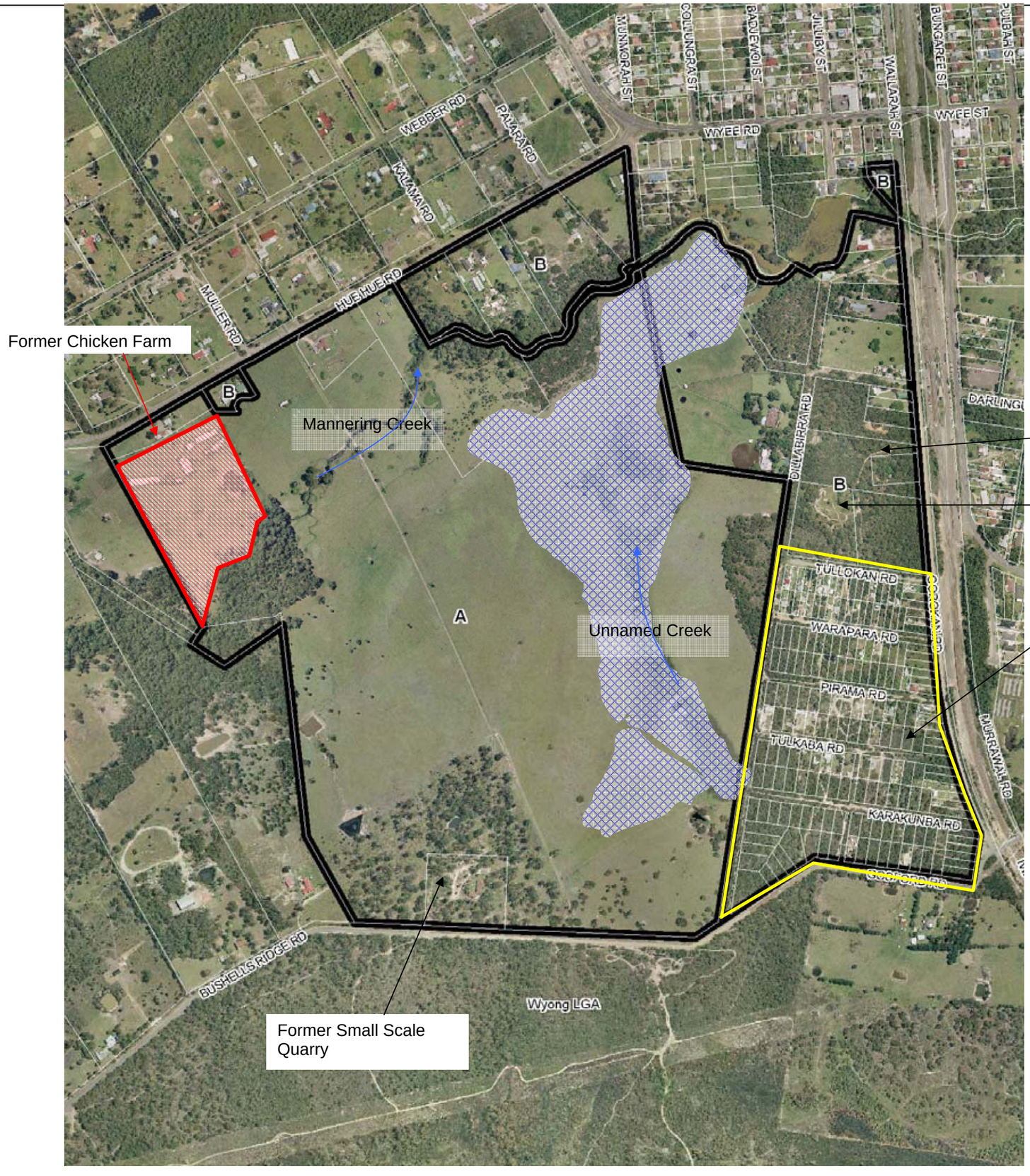
Sydney, Newcastle Brisbane, Melbourne, Perth, Wyong

Cairns, Campbelltown, Darwin, Townsville

TITLE: Site Topography Plan
Wyee Land Release
Hue Hue Road, Wyee

CLIENT: Conics Pty Ltd			OFFICE: Wyong
DRAWN BY: MPG	SCALE: NTS	PROJECT No: 41810	DRAWING No: 2
APPROVED BY:		DATE: June 2009	



Legend

Approximate Extent of Wet Area with weak soils

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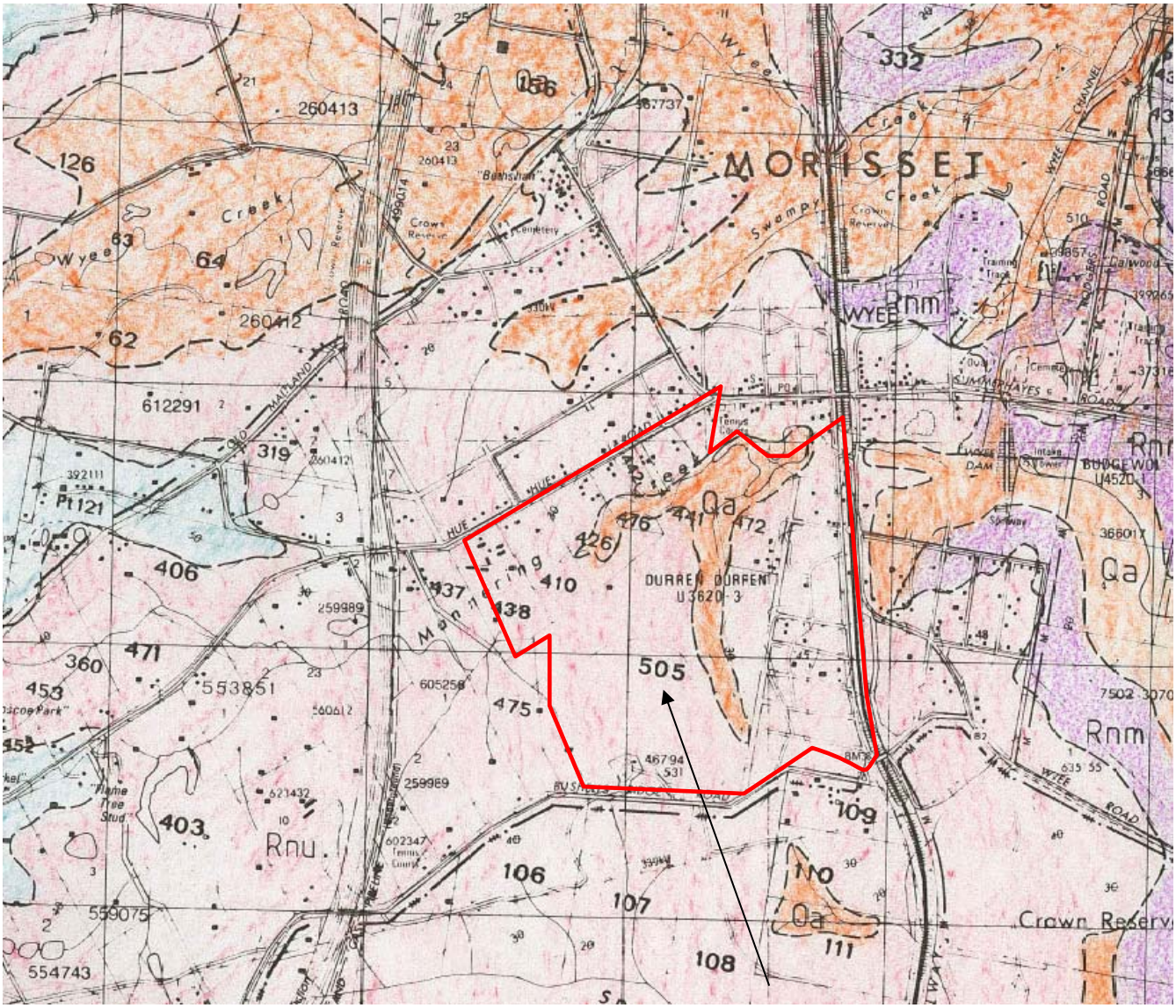
Sydney, Newcastle, Brisbane, Melbourne, Perth, Wyong, Canberra, Campbelltown, Townsville, Cairns, Darwin

TITLE: SITE FEATURES PLAN
WYEE LAND RELEASE
HUE HUE ROAD, WYEE

CLIENT: Conics Pty Ltd			
DRAWN BY: MPG	SCALE: NTS	PROJEST No: 41810	OFFICE: WYONG
APPROVED BY: MPG		DATE: 4 May 2009	DRAWING No: 3



LEGEND

- *Tuggerah Formation*
- *Quaternary Alluvium*

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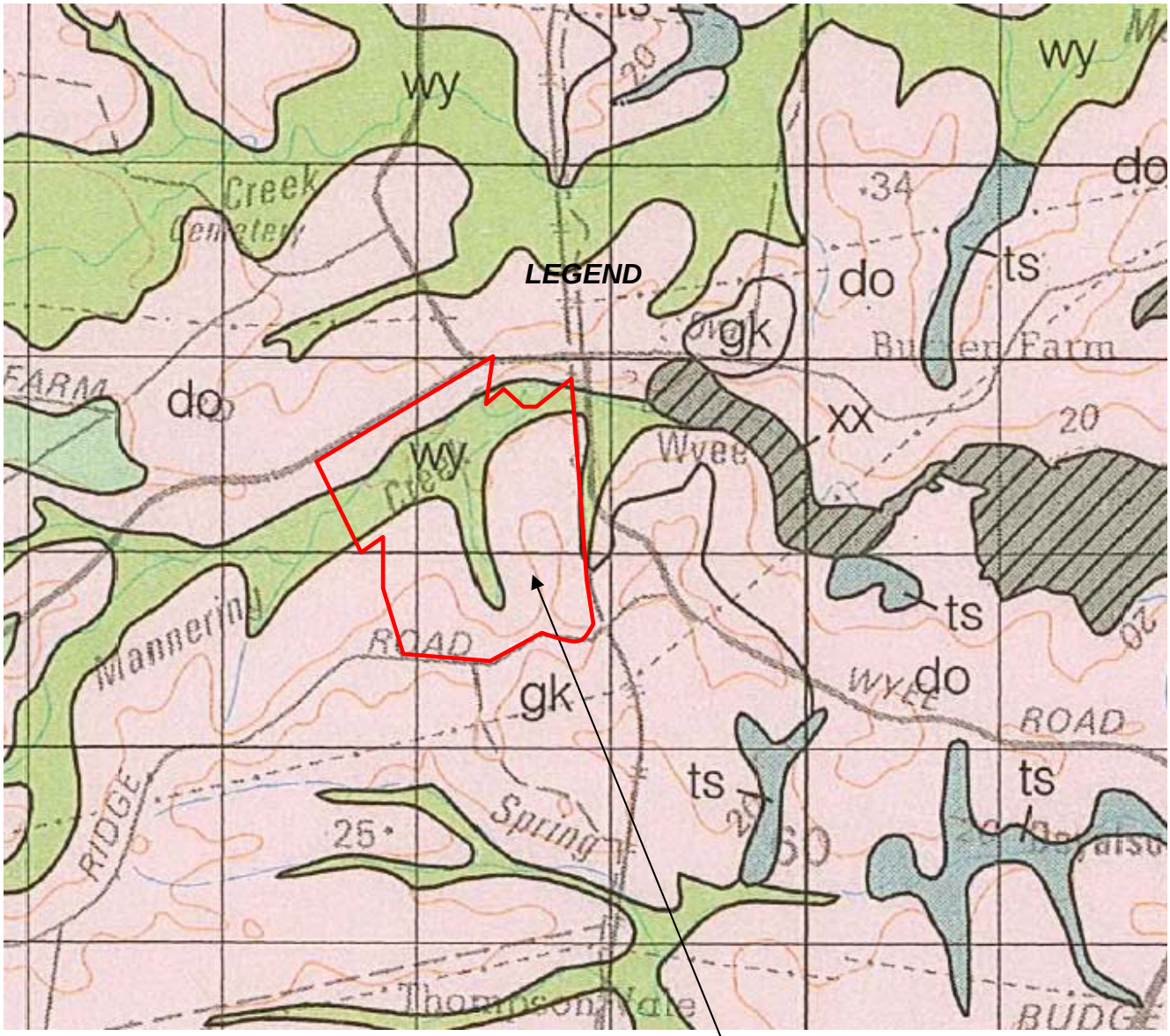
Cairns, Campbelltown, Darwin, Townsville

TITLE: Excerpt from interim Dooralong 1:25 000 Geological Sheet
Wyee Land Release
Hue Hue Road, Wyee

CLIENT: Conics Pty Ltd			OFFICE: Wyong
DRAWN BY: MPG	SCALE: NTS	PROJECT No: 41810	DRAWING No: 4
APPROVED BY:		DATE: June 2009	



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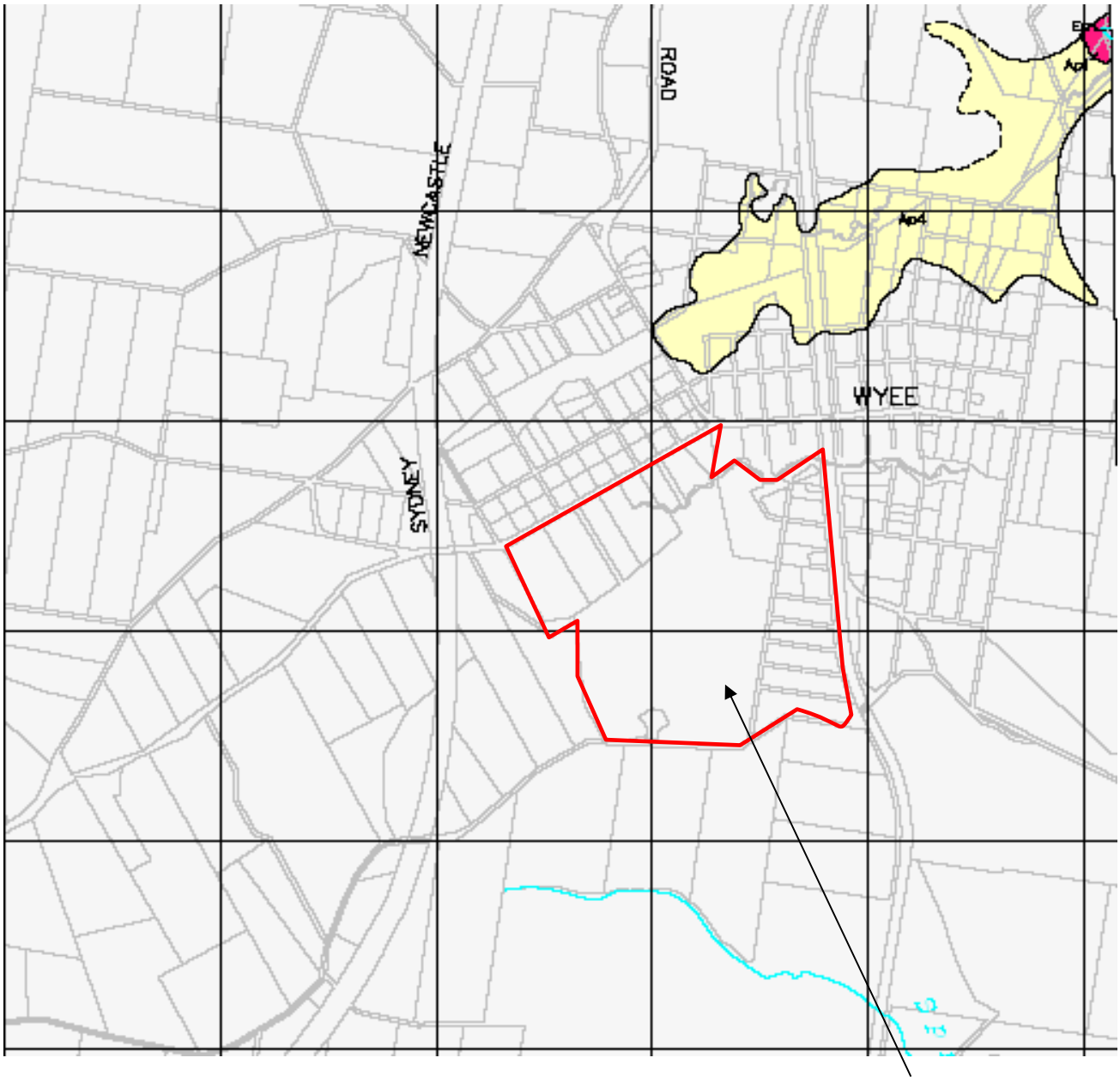
TITLE: Excerpt from interim Dooralong 1:25 000 Soil Landscape Mapping
Wyee Land Release
Hue Hue Road, Wyee

CLIENT: Conics Pty Ltd			OFFICE: Wyong
DRAWN BY: MPG	SCALE: NTS	PROJECT No: 41810	DRAWING No: 5
APPROVED BY:		DATE: June 2009	



LEGEND

- *Low Probability within 1 and 3 metres of ground surface*
- *High Probability between 1 and 3 metres of ground surface*
- *High Probability at or near ground surface*
- *No Known Occurrence*

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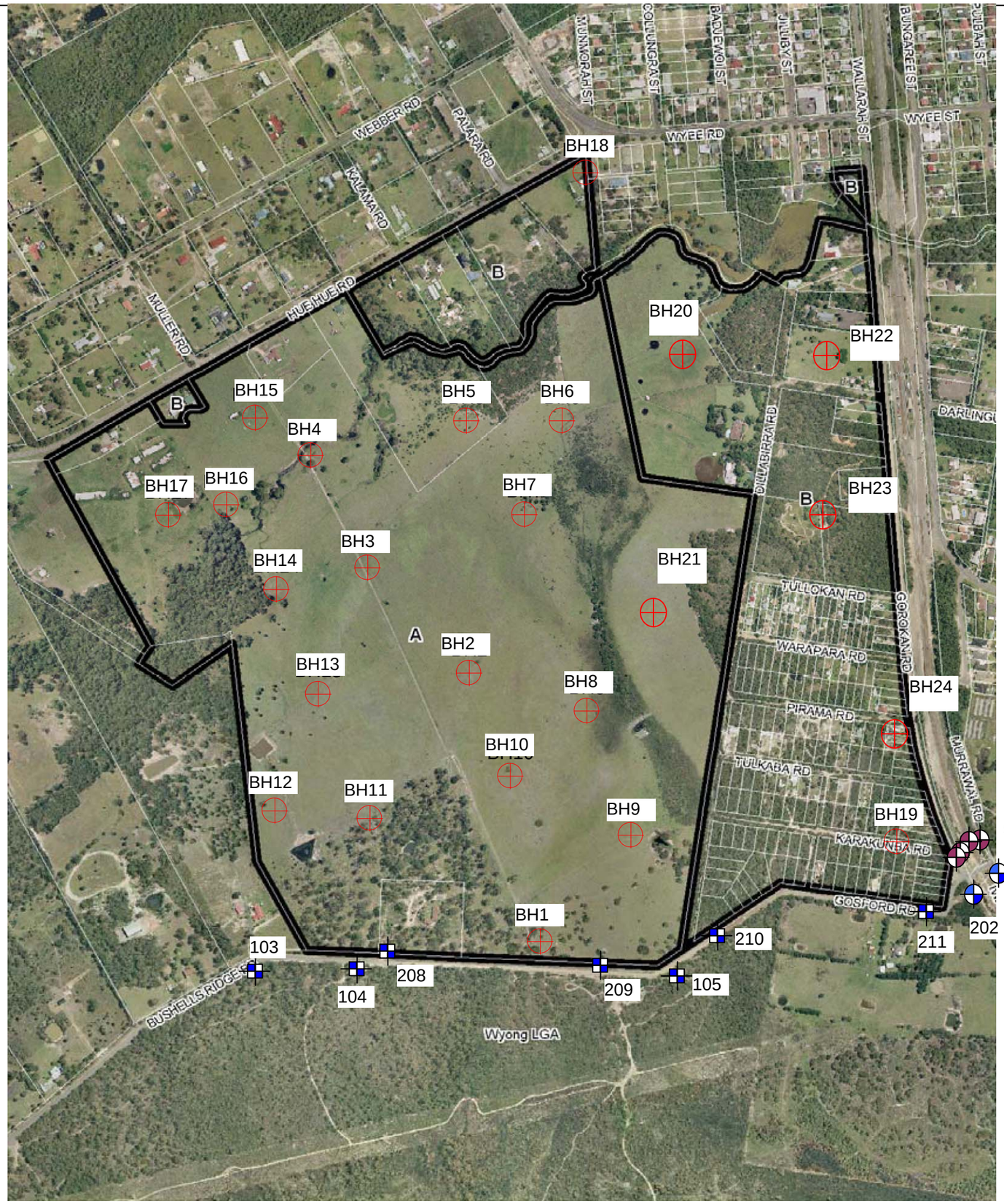
TITLE: Excerpt from Dooralong 1:25 000 Acid SUlphate Soil Risk Map
Wyee Land Release
Hue Hue Road, Wyee

CLIENT: Conics Pty Ltd			OFFICE: Wyong
DRAWN BY: MPG	SCALE: NTS	PROJECT No: 41810	
APPROVED BY:		DATE: June 2009	DRAWING No: 6



N

Legend

- Test Bore location and number
- Test Bore Location and Number (Previous Investigation 41533/2)
- Test Pit Location and Number (Previous Investigation 41533/2)
- Test Bore Location and Number (Previous Investigation 41533/1)

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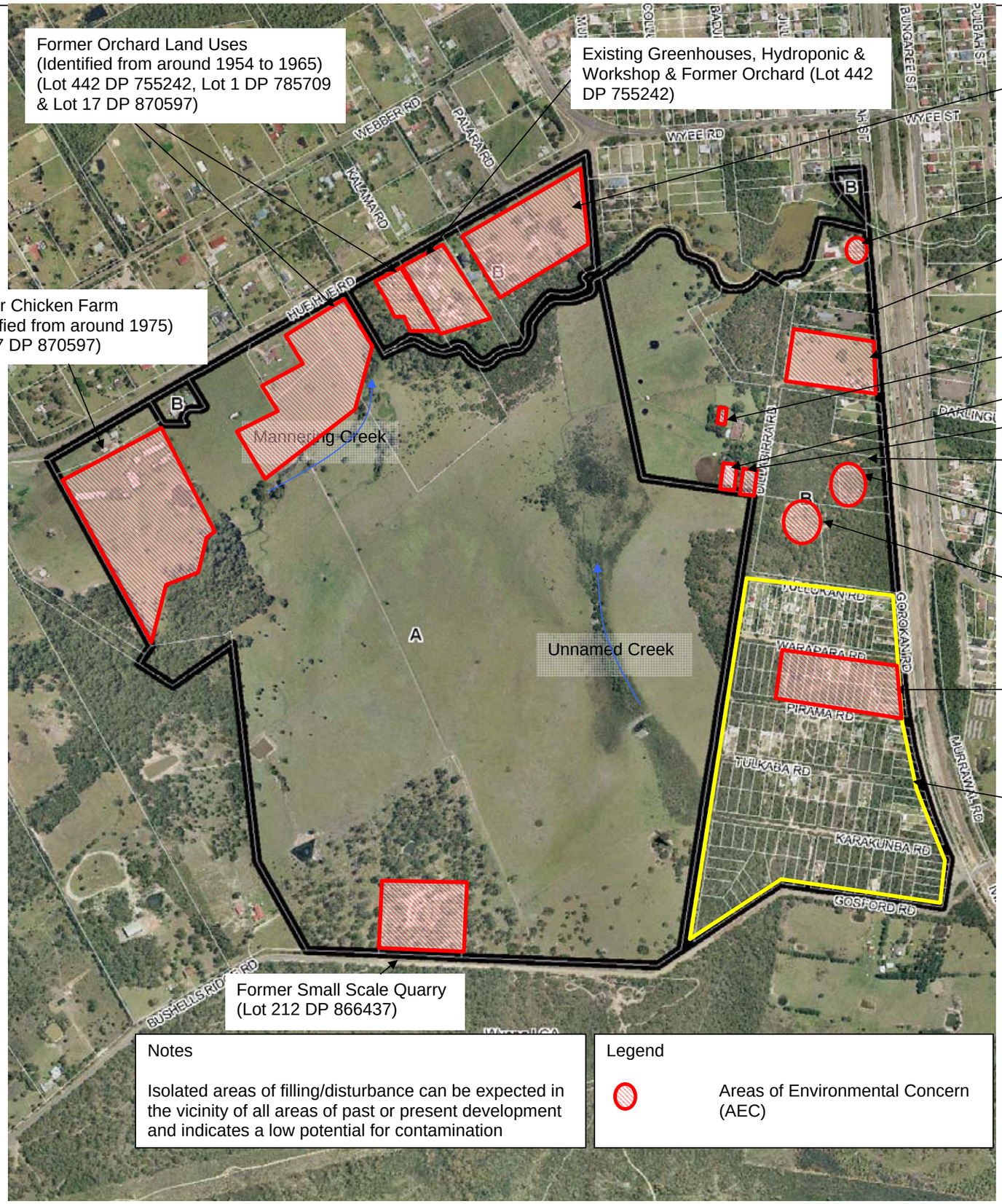
Sydney, Newcastle, Brisbane, Melbourne, Perth, Wyong, Canberra, Campbelltown, Townsville, Cairns, Darwin

TITLE: TEST LOCATION PLAN
WYEE LAND RELEASE
HUE HUE ROAD, WYEE

CLIENT: Conics Pty Ltd			
DRAWN BY: MPG	SCALE: NTS	PROJEST No: 41810	OFFICE: WYONG
APPROVED BY: MPG		DATE: 4 May 2009	DRAWING No: 7



Former Orchard Land Uses
(Identified from around 1954 to 1965)
(Lot 442 DP 755242, Lot 1 DP 785709
& Lot 17 DP 870597)

Existing Greenhouses, Hydroponic &
Workshop & Former Orchard (Lot 442
DP 755242)

Former Chicken Farm
(Identified from around 1975)
(Lot 17 DP 870597)

Former Small Scale Quarry
(Lot 212 DP 866437)

Former Orchard Land Uses
(Identified from around 1954 to 1965)
(Lot 323 & 324 DP 755242)

Mound of Filling – Anthropogenic Inclusion Identified
(Lot 8 DP 1020857)

Mounds of Filling within Lot 185 DP 650204

Former Poultry Land Use (Based on Anecdotal Information Only)
(Lot 186 DP 755242)

Workshop Including Above Ground Fuel Storage Tank and Bowser
(Lot 472 DP 755242)

Workshop Including Above Ground Fuel Storage Tank and Bowser
(Lot 472 DP 755242)

Commercial Nursery Land Use ending in 1990's (Lot 472 DP 755242)

Isolated areas of illegal dumping & filling
scattered around access trails

Former Dam with areas of illegal dumping
(Lot 1582 DP1121660)

Former Cricket Oval (areas of illegal dumping)
(Lot 430, 188 & 189 DP755242)

Former Orchard Land Use
(Identified from around 1965 to 1985)
(Lots 245 to 262 & 273 to 283 DP 7506)

"Paper Subdivision" (Isolated Areas of
Illegal Dumping & Filling)

N

Notes

Isolated areas of filling/disturbance can be expected in the vicinity of all areas of past or present development and indicates a low potential for contamination

Legend

Areas of Environmental Concern (AEC)

Douglas Partners
Geotechnics · Environment · Groundwater

Sydney, Newcastle, Brisbane, Melbourne, Perth, Wyong, Canberra, Campbelltown, Townsville, Cairns, Darwin

TITLE: AREAS OF ENVIRONMENTAL CONCERN
WYEE LAND RELEASE
HUE HUE ROAD, WYEE

CLIENT: Conics Pty Ltd

DRAWN BY: BJK	SCALE: NTS	PROJEST No: 41810	OFFICE: WYONG
APPROVED BY: MPG		DATE: July 2009	DRAWING No: 8

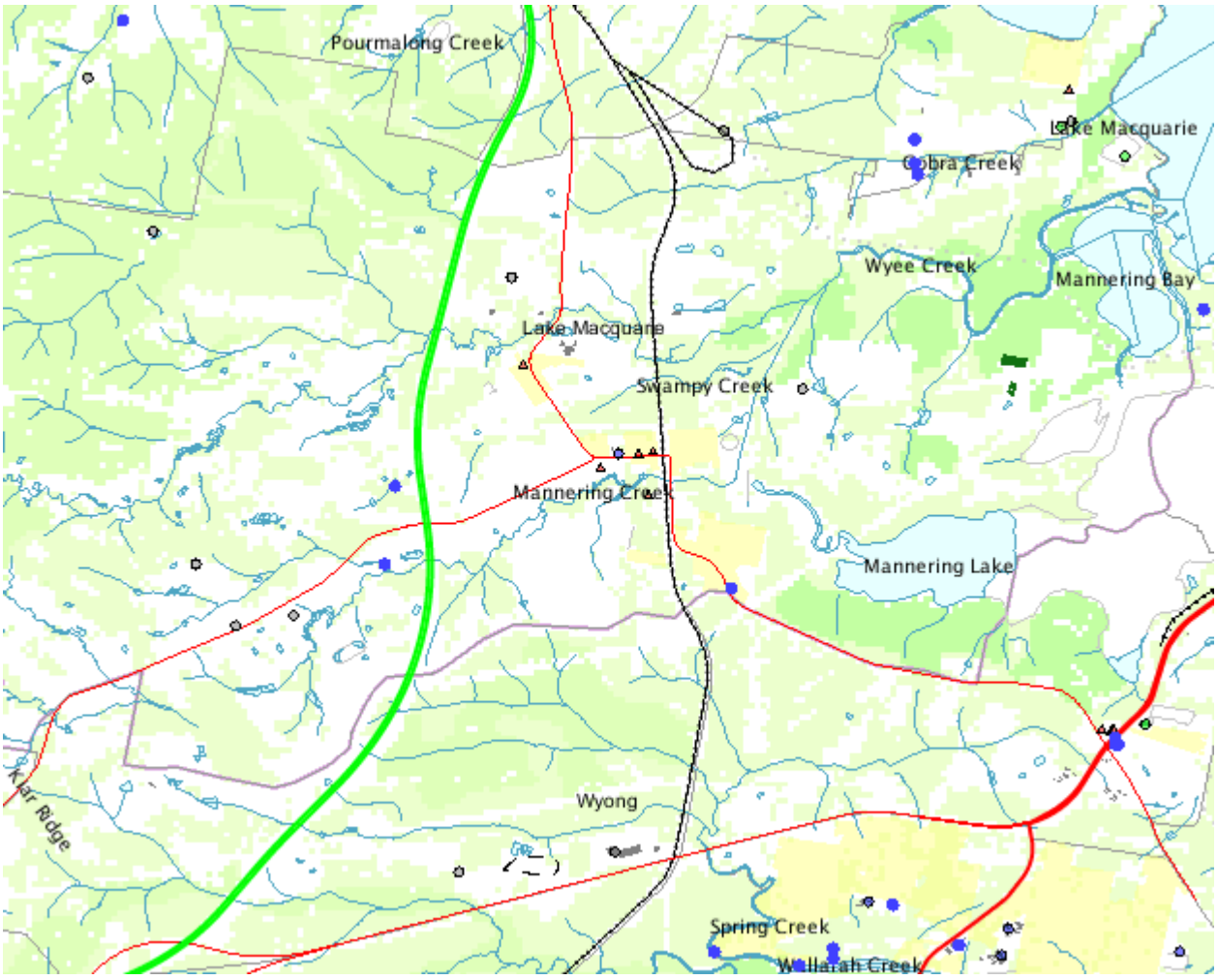
APPENDIX B

Desktop Search Results

Wyee

Map created with NSW Groundwater Works - http://test.nratlas.nsw.gov.au

Monday, July 06, 2009



0 9 Km

Legend

Symbol	Layer	Custodian
	Cities and large towns renderImage: Cannot build image from features	
Cowra	Populated places renderImage: Cannot build image from features	
	Towns	
	Groundwater bores	
1 Pipe 2 Pipes 3 Pipes 4 Pipes 5 or more Pipes	Groundwater levels	
	Catchment Management Authority boundaries	
	Major rivers	

Topographic base map

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Monday, July 6, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW064662

Works Details (top)

GROUNDWATER NUMBER	GW064662
LIC-NUM	20BL137176
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1987-12-01
FINAL-DEPTH (metres)	24.00
DRILLED-DEPTH (metres)	24.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	20 - HUNTER
RIVER-BASIN	212 - HAWKESBURY RIVER
AREA-DISTRICT	
CMA-MAP	9131-1S
GRID-ZONE	56/1
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6327028.00
EASTING	359443.00
LATITUDE	33 11' 11"
LONGITUDE	151 29' 32"
GS-MAP	0055B1

AMG-ZONE	56
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	NORTHUMBERLAND
PARISH	MORISSET
PORTION-LOT-DP	L192 DP8005 (220)

Licensed (top)

COUNTY	NORTHUMBERLAND
PARISH	MORISSET
PORTION-LOT-DP	192 8005

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	6.00	150			(Unknown)

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
7.00	10.00	3.00	Consolidated	7.00		0.00			(Unknown)

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	4.00	4.00	Soil Clay		
4.00	7.00	3.00	Sandstone Yellow		
7.00	15.00	8.00	Sandstone Grey Water Supply		
15.00	24.00	9.00	Conglomerate		

APPENDIX C

Copies of Relevant Test Pit and Test Bore Report Sheet from Previous Investigations & Preliminary Geotechnical Assessment Test Bore Logs

BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	TOPSOIL: Brown clayey silty sand with trace of fine rootlets, moist - some ironstone gravel at 0.1m		D	0.05				
	0.55	SANDY CLAY: Stiff, light brown grey sandy clay with trace of fine rootlets and silt, M>Wp		D/PP	0.3		pp = 200kPa		
	0.8	SILTY CLAY: Stiff to very stiff, light grey silty clay with trace of sand, M>Wp		D/PP	0.6		PP = 200-260 kPa		
		- hard and grading into a siltstone from 0.75m		D/PP	0.75		PP = >400 kPa		
		Bore discontinued at 0.8m. Refusal on weathered rock							
	1								
	2								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown silty sand with trace of fine rootlets, moist							
	0.15	SILTY SAND: Medium dense, brown silty sand with trace of clay, moist		D	0.2				
	0.25	SANDY CLAY: Stiff to very stiff, orange brown sandy claty, M>Wp		D/PP	0.5		PP = >400 kPa		
	0.6	CLAYEY SAND/SANDY CLAY: Very stiff to hard, orange brown clayey sand/sandy clay, M=Wp							
1				D/PP	1.0		PP = 380-400 kPa		1
		- becoming more sandy from 1.1m							
				D/PP	1.5		PP = >400 kPa		
				D/PP	1.8		PP = >400 kPa		
		- hard, light grey medium to coarse grained from 1.8m							
2	2.0	Bore discontinued at 2.0m. Limit of investigation							2

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧗ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown silty sand, moist		D	0.05				
	0.12	CLAYEY SILTY SAND: Medium dense, light brown clayey silty sand, moist		D	0.2				
	0.3	SANDY CLAY: Stiff, light brown, orange brown sandy clay, M>Wp		D/PP	0.5		PP = 50-100 kPa		
					0.6				
				U_{50}					
		- becoming stiff to very stiff, light grey mottled red and less sandy from 0.9m			0.9				
	1				1.0		PP = 190-200 kPa		1
					1.5		PP = 190-210 kPa		
	2				2.0		PP = 250-270 kPa		2
	2.1	Bore discontinued at 2.1m. Limit of investigation							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		TOPSOIL: Brown silty sand with trace of fine rootlets, moist		D	0.1				
	0.2	CLAYEY SILTY SAND: Medium dense, brown clayey silty sand, moist		D	0.3				
	0.4	CLAYEY SAND/SANDY CLAY: Very stiff, grey brown clayey sand/sandy clay		D	0.5				
		- hard and grading into an extremely low strength, extremely weathered sandstone with soil like properties from 0.7m		D/PP	0.8		PP = >400 kPa		
	0.9	Bore discontinued at 0.9m. Refusal							
	1								1
	2								2

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased
TYPE OF BORING: 60mm ϕ push tube
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧗ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown slightly clayey silty sand, moist/wet		D	0.1				
	0.2	CLAYEY SILTY SAND: Loose, brown grey clayey silty sand, wet							
		- more clayey from 0.5m		D	0.5				
	0.8	SANDY CLAY: Stiff, light grey mottled red sandy clay with a trace of ironstained gravel, M>Wp							
	1			D/PP	1.0		PP = 100-120 kPa		1
		- becoming hard and more sandy from 1.45m		D/PP	1.5		PP = >400 kPa		
	2			D/PP	2.0		PP = >400 kPa		2
	2.1	Bore discontinued at 2.1m. Limit of investigation							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 41810
DATE: 12 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown slightly clayey silty sand, moist/wet		D	0.1				
	0.2	CLAY: Stiff, orange brown clay with some sand, M>Wp		D/PP	0.5		PP = 150-200 kPa		
		- becoming very stiff, light grey mottled red from 0.8m							
	1			D/PP	1.0		PP = 220-280 kPa		1
				D/PP	1.5		PP = 240-260 kPa		
		- trace of ironstained gravel at 1.8m							
	2			D/PP	2.0		PP = 300-340 kPa		2
	2.2	Bore discontinued at 2.2m. Limit of investigation							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 7
PROJECT No: 41810
DATE: 12 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown sandy silt topsoil, M>Wp		D	0.2				
	0.3	CLAY: Stiff orange brown clay with traces of sand and silt, M>>Wp		D	0.5		pp = 150-180kPa		
		- very stiff and light grey red mottled from 0.8m, M>Wp							
	1			D	1.0		pp = 320-400kPa		1
				D	1.5		pp = 350-400kPa		
	2			D	2.0		pp = >400kPa		2
		- traces of ironstained gravel at 2.1m, M>Wp							
	2.25	Bore discontinued at 2.25m. Limit of investigation							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: CPTSR **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 8
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown slightly clayey silty sand, moist/wet		D	0.1				
	0.2	CLAYEY SILTY SAND: Brown grey clayey silty sand, wet							
		- more clayey from 0.5m		D	0.5				
	0.8	SANDY CLAY: Stiff, li9ght grey mottled red sandy clay with a trace of ironstained gravel, M>Wp							
	1			D/PP	1.0		PP = 100-120 kPa		1
		- becoming hard and more sandy from 1.45,		D/PP	1.5		PP = >400 kPa		
	2			D/PP	2.0		PP = >400 kPa		2
	2.1	Bore discontinued at 2.1m. Limit of investigation							

RIG: CPTSR **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: Free Groundwater Observed at 0.7m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

Douglas Partners
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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 9
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown silty sand, wet		D	0.05				
	0.15	SILTY SAND: Loose to medium dense, light grey brown silty sand, wet		D	0.2				
	0.3	CLAYEY SAND: Medium dense, light grey orange brown clayey sand with trace of silt, wet		D	0.5				
	0.8	SANDY CLAY: Stiff, light grey sandy clay with trace of silt, M>Wp							
1				D/PP	1.0		PP = 100-120 kPa		1
		- becoming hard and ironstained (red) from 1.45m		D/PP	1.5		PP = >400 kPa		
		- trace of fine gravel from 1.6m							
2	2.0	Bore discontinued at 2.0m. Limit of investigation		D/PP	2.0		PP = >400 kPa		2

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED	
Initials:	
Date:	

Douglas Partners
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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 10
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown silty sand with trace of fine rootlets, moist		D	0.1				
	0.2	SILTY SAND: Medium dense, grey, brown silty sand with trace of clay, moist		D	0.3				
	0.4	SANDY CLAY/CLAYEY SAND: Stiff to very stiff, orange brown sandy clay/clayey sand with trace of silt, M>Wp/moist		D/PP	0.5		pp = 150kPa		
	0.7	CLAY: Stiff to very stiff, orange brown clay with some sand, M>Wp			0.7				
				U_{50}					
	1			D/PP	1.0		pp = 280kPa		1
		- becoming light grey with some ironstone gravel inclusions from 1.2m							
				D/PP	1.5		pp = 320kPa		
	2			D/PP	2.0		PP = >400 kPa		2
	2.1	Bore discontinued at 2.1m. Limit of investigation							

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧗ Water level

CHECKED
Initials:
Date:

Douglas Partners
Geotechnics · Environment · Groundwater

BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 11
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown silty sand with trace of fine rootlets, moist		D	0.1				
	0.2	CLAYEY SILTY SAND: Loose, brown, clayey silty sand with trace of ironstone gravel, moist		D	0.3				
	0.4	SANDY CLAY: Stiff, orange brown sandy clay, M>Wp			0.5				
		- light grey mottled red from 0.7m		U_{50} D	0.7				
					0.8				
1									1
	1.3	SILTY CLAY: Very stiff, light grey silty clay, M=Wp		D	1.5				
	1.6	SANDY CLAY: Very stiff, light grey orange brown sandy clay, M=Wp		D	1.8				
2	2.0	Bore discontinued at 2.0m. Limit of investigation							2

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧩ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 12
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Grey brown silty sand, moist		D	0.05				
	0.15	CLAYEY SILTY SAND: Loose, light brown and orange brown clayey silty sand, moist/wet		D	0.2				
	0.35	SANDY CLAY: Stiff, orange brown sandy clay, M>Wp		D/PP	0.5		PP = 180-200 kPa		
	0.7	CLAY: Stiff to very stiff, light grey clay with some red ironstained gravel inclusions with a trace of silt, M>Wp		D/PP	1.0		PP = 330-360 kPa		
				D/PP	1.5		PP = 250-300 kPa		
		- ironstained gravel at 1.8-1.9m		D/PP	1.9		pp = 300kPa		
	2.05	Bore discontinued at 2.05m. Limit of investigation							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED	
Initials:	
Date:	

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 13
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Grey brown silty sand, moist		D	0.1				
	0.2	SILTY SAND: Medium dense, light grey slightly clayey silty sand, moist/wet		D	0.3				
	0.4	SANDY CLAY: Stiff to very stiff, orange brown sandy clay, M>Wp		D/PP	0.7		PP = 150-180 kPa		
	1								1
	1.1	GRAVELLY SANDY CLAY: Very stiff, light grey/red/orange ironstained gravelly sandy clay, M>Wp		D/PP	1.3		PP = 150-200 kPa		
	1.5	SANDY CLAY: Hard, light grey mottled red sandy clay, M>Wp		D/PP	1.6		PP = >400 kPa		
	2			D/PP	2.0		PP = >400 kPa		2
	2.1	Bore discontinued at 2.1m. Limit of investigation							

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧗ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 14
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL: Dark brown silty sand/sandy silt, moist/wet/M>Wp							
	0.5	CLAYEY SILTY SAND: Medium dense, grey clayey silty sand, wet							
	1.0	SANDY CLAY: Very stiff to hard, light grey, orange brown sandy clay, M<Wp - moist from 0.6m							
		CLAY: Very stiff, light grey mottled orange clay with some sand and trace of silt, M=Wp - M>Wp at 1.9m depth							
	2.2	Bore discontinued at 2.2m. Limit of investigation							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED	
Initials:	
Date:	

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 15
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		TOPSOIL: Brown slightly clayey silty sand, moist/wet		D	0.05				
	0.15	CLAYEY SILTY SAND: Medium dense, brown clayey silty sand, moist/wet		D	0.2				
	0.36	SANDY CLAY: Very stiff, light grey mottled orange red sandy clay, M>Wp		D/PP	0.5		PP = 220-280 kPa		
1	0.9	CLAY: Very stiff, light grey clay with some sand and silt with trace of gravel, M>Wp		D/PP	1.0		PP = 280-320 kPa		1
	1.3	SANDY CLAY: Hard, light grey mottled orange brown sandy clay, M=Wp		D/PP	1.5		PP = >400 kPa		
		- grading into a weathered rock with soil like properties from 1.7m		D	1.8				
2	2.0	Bore discontinued at 2.0m. Limit of investigation							2

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased
TYPE OF BORING: 60mm ϕ push tube
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 16
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		TOPSOIL: Brown silty sand with trace of clay, moist/wet		D	0.1				
	0.25	SILTY SAND: Stiff, grey brown silty sand with some clqay, moist/wet		D	0.3				
	0.5	SANDY CLAY: Stiff, light grey mottled orange brown sandy clay, M>Wp		D/PP U_{50}	0.5 0.6 0.8		pp = 150kPa		
	1	- becoming very stiff from 1.0m		D/PP	1.1		PP = 200-240 kPa		1
		- hard from 1.4m, M=Wp		D/PP	1.5		PP = >400 kPa		
	2			D/PP	2.0		PP = >400 kPa		2
	2.3	Bore discontinued at 2.3m. Limit of investigation							

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased
TYPE OF BORING: 60mm ϕ push tube
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 17
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		TOPSOIL: Brown slightly clayey silty sand, moist/wet		D	0.1				
	0.15	CLAY: Stiff, orange brown clay with some sand, M>Wp		D/PP	0.4		PP = 180-200 kPa		
	0.6	CLAYEY SAND: Dense, light grey clayey sand, moist - very dense from 0.7m - grading into an extremely low strength, extremely weathered sandstone with soil like properties from 0.8m		D	0.7				
				D	0.9				
1	1.0	Bore discontinued at 1.0m. Limit of investigation							1
2									2

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased
TYPE OF BORING: 60mm ϕ push tube
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 18
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		TOPSOIL: Brown silty sand with trace of fine rootlets, moist		D	0.1				
	0.2	SILTY SAND: Loose to medium dense, brown silty sand with trace of clay and fine rootlets, moist		D	0.3				
	0.4	CLAY: Very stiff, orange brown clay with some sand and trace of silt, M>Wp		D/PP	0.5		PP = 280-320 kPa		
		- light grey mottled red from 0.8m							
	1								1
	1.1	SANDY CLAY: Hard, light grey sandy clay with some silt and ironstained gravel, M=Wp		D/PP	1.2		PP = >400 kPa		
		- more sandy from 1.8m		D	1.9				
	2								2
	2.2	Bore discontinued at 2.2m. Limit of investigation							

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased
TYPE OF BORING: 60mm ϕ push tube
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 19
PROJECT No: 41810
DATE: 07 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		TOPSOIL: Grey silty sand, moist/wet		D	0.1				
	0.25	SANDY CLAY: Stiff, light grey, orange brown sandy clay, M>Wp			0.3		PP = 180-200 kPa		
				U/D/PP50					
		- becoming more sandy from 0.5m			0.55				
				D	0.7				
	0.8	SANDSTONE: Extremely low strength, extremely weathered sandstone		D	0.9				
	1.0	Bore discontinued at 1.0m. Refusal on rock							

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased
TYPE OF BORING: 60mm ϕ push tube
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 20
PROJECT No: 41810
DATE: 12 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown clayey silty sand wth some fine rootlets, moist/wet		D	0.1				
	0.2	CLAYEY SILTY SAND: Medium dense, grey/brown clayey silty sand with trace of fine rootlets, moist/wet			0.5				
	0.6	SANDY CLAY: Very stiff, light grey sandy clay with trace of silt, M>Wp		U/D_{50}					
		- becoming light grey mottled red with a trace of ironstained gravel from 0.8m		D/PP	0.8 0.85		PP = 200-210 kPa		
	1								1
				D/PP	1.4		PP = >400 kPa		
	1.5	CLAY: Very stiff to hard, light grey clay with some sand and trace of silt, M>Wp		D/PP	1.6		PP = 300-380 kPa		
	2								2
	2.1	Bore discontinued at 2.1m. Limit of investigation							

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: Free Groundwater Observed at 0.4m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 21
PROJECT No: 41810
DATE: 12 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown silty sand with trace of fine rootlets, moist		D	0.1				
	0.2	SILTY SAND: Medium dense, brown slightly clayey silty sand, moist		D	0.4				
	0.5	CLAYEY SAND/SANDY CLAY: Firm to stiff, orange brown clayey sand/sandy clay, moist/M>Wp		D/PP	0.8		PP = 100-150 kPa		
	0.9	SANDY CLAY: Stiff, orange brown sandy clay with trace of ironstained gravel, M>Wp		D/PP	1.2		PP = 150-200 kPa		
	1.3	GRAVELLY SANDY CLAY: Very stiff, orange brown gravelly sandy clay, M>Wp - less sandy more clayey grey mottled red from 1.5m		D/PP	1.5		PP = 300-350 kPa		
	2.2	Bore discontinued at 2.2m. Limit of investigation		D/PP	2.0		PP = >400 kPa		

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧩ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 22
PROJECT No: 41810
DATE: 12 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown silty sand with trace of fine rootlets, moist		D	0.1				
	0.25	SILTY SAND: Loose to medium dense, light brown slightly clayey silty sand, moist		D	0.4				
					0.5				
		- more clayey from 0.6m		U_{50}					
					0.85				
	0.9	SILTY SANDY CLAY: Stiff to very stiff, orange brown silty sandy clay, M>Wp		D/PP	1.0		PP = 150-200 kPa		
1									1
	1.5	SANDY CLAY: Very stiff to hard, light grey sandy clay, M>Wp		D/PP	1.6		pp = 220kPa		
		- becoming more sandy from 1.7m							
2				D/PP	2.0		PP = >400 kPa		2
	2.1	Bore discontinued at 2.1m. Limit of investigation							

RIG: Toyota 4WD **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 23
PROJECT No: 41810
DATE: 12 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL: Brown silty sand topsoil, moist							
		CLAYEY SILTY SAND: Medium dense, orange brown clayey silty sandy clay, moist		D	0.2				
	0.45	SANDY CLAY: Stiff, orange brown sandy clay, M=Wp			0.5		pp = 150-200kPa		
				U_{50}					
					0.8				
	1	- becoming very stiff and more clayey with some ironstained gravel, M>Wp		D	1.0		pp = 300-370kPa		1
		- hard red mottled grey sandy clay from 1.4m, M=Wp		D	1.5		pp = >400kPa		
				D	1.9		pp >400kPa		
	2 2.0	Bore discontinued at 2.0m. Limit of investigation							2

RIG: CPTSR **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧭ Water level

CHECKED
Initials:
Date:

Douglas Partners
Geotechnics · Environment · Groundwater

BOREHOLE LOG

CLIENT: Conics Pty Ltd
PROJECT: Preliminary Geotechnical Assessment
LOCATION: Hue Hue Road, Wyee

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 24
PROJECT No: 41810
DATE: 12 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL: Brown silty sand topsoil with a trace of fine rootlets, moist		D	0.1				
	0.15	CLAYEY SILTY SAND: Medium dense, brown clayey silty sand, moist		D	0.2				
	0.3	GRAVELLY SANDY CLAY: Very stiff, orange brown mottled red gravelly sandy clay, M=Wp		D	0.5		pp = 230-260kPa		
		- becoming hard light grey from 0.7m							
	1			D	1.0		pp = >400kPa		1
		- grading into an extremely low strength, extremely weathered sandstone from 1.3m		D	1.4		pp = >400kPa		
	1.5	Bore discontinued at 1.5m. Refusal on rock							
	2								2

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: CPTSR **DRILLER:** Hickman **LOGGED:** Hickman **CASING:** Uncased

TYPE OF BORING: 60mm ϕ push tube

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧩ Water level

CHECKED
Initials:
Date:

Douglas Partners
Geotechnics · Environment · Groundwater

TEST PIT LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 103
PROJECT No: 41533
DATE: 07 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		SILTY CLAY: Very stiff light grey mottled orange brown silty clay, M=Wp		pp	0.2		PP = 300-350 kPa		
				D	0.3				
				pp	0.5		PP = 350-400 kPa		
	0.55	CLAYSTONE: Low strength, highly weathered, light grey claystone		D	0.6				
	0.75	Pit discontinued at 0.75m. Excavator refusal on low to medium strength claystone							

RIG: 4 tonne excavator

LOGGED: Gawn

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⫧ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 104
PROJECT No: 41533
DATE: 07 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.4	SILTY CLAY: Very stiff light brown silty clay with trace rootlets, M=WP		D,PP	0.3		PP = 300-350 kPa		
	1	CLAY: Very stiff to hard light grey mottled red clay, M<Wp - hard from 1.0m		D,PP	1.1		PP = 450-500 kPa		
	1.6	CLAYSTONE: Extremely low stength, extremely weatherd light grey mottled red claystone		D	1.7				
	2			D	2.1				
	2.2	Pit discontinued at 2.2m. Excavator refusal							
	3								
	4								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 4 tonne excavator

LOGGED: Gawn

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧗ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 105
PROJECT No: 41533
DATE: 07 Aug 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		SILTY CLAY: Very stiff grey brown silty clay with a trace of fine grained sand, M=Wp		D,PP	0.3		PP = 250-300 kPa		
	0.5	SANDY CLAY: Hard grey mottled orange fine grained sandy clay, M<Wp		D,PP	0.6		PP = >400 kPa		
	0.65			D	0.68				
	0.7	SANDSTONE: Extremely low strength grey mottled orange fine grained sandstone							
		Pit discontinued at 0.7m. Refusal on very low strength to low strength sandstone							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 4 tonne excavator

LOGGED: Gawn

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⫧ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 202
PROJECT No: 41533
DATE: 14 Aug 07
SHEET 1 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SILTY SANDY CLAY: Stiff light grey silty clay with some fine grained sand, M>Wp										
	0.6	SANDSTONE: Very low strength, highly weathered grey mottled orange sandstone										
	1											
	2	- v-Bit refusal from 2.1m (possibly low strength)										
	3											
	4											

RIG: Atkins Mach 11 **DRILLER:** Albert **LOGGED:** Hickman **CASING:** HW to 1.0m

TYPE OF BORING: 100mm ϕ Spiral flight auger to 6.01m, NMLC coring form 6.01m to 11.94m

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 202
PROJECT No: 41533
DATE: 14 Aug 07
SHEET 2 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SANDSTONE: Very low strength, highly weathered grey mottled orange sandstone *(continued)*										
6	6.01	- TC-Bit refusal from 6.0m						6.01m: CORE LOSS: 90mm				
	6.1	CORE LOSS										
		CONGLOMERATE: Low strength, highly weathered, highly fractured orange brown conglomerate							C	83	18	
	6.55	SANDSTONE: Low strength, moderately weathered unbroken, light grey fine grained sandstone										Is (D) = 0.24 (A) = 0.24
7									C	100	100	Is (D) = 0.19 (A) = 0.19
8												Is (D) = 0.25 (A) = 0.18
	8.12	CONGLOMERATE: Low strength, moderately weathered orange brown conglomerate - from 8.2m depth, high strength, highly weathered to 8.51m										Is (D) = 2.1
	8.77	SILTSTONE: Very low strength, extremely weathered unbroken light grey siltstone, M<Wp, hard							C	100	100	
9												Is (D) = 0.16 (A) = 0.08
	9.72	SILTSTONE: Very low strength, extremely weathered slightly fractured to 10.68 light grey siltstone							C	100	100	

RIG: Atkins Mach 11 **DRILLER:** Albert **LOGGED:** Hickman **CASING:** HW to 1.0m

TYPE OF BORING: 100mm ϕ Spiral flight auger to 6.01m, NMLC coring form 6.01m to 11.94m

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 202
PROJECT No: 41533
DATE: 14 Aug 07
SHEET 3 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SILTSTONE: Very low strength, extremely weathered slightly fractured to 10.68 light grey siltstone *(continued)*							C	100	100	Is (D) = 0.07 (A) = 0.05
	11	- becoming low to medium strength from 11.39m to 11.85m							C	100	100	Is (D) = 0.22 (A) = 0.16
	11.94	- low strength siltstone from 11.85m to 11.94m										
	12	Bore discontinued at 11.94m. Limit of investigation										
	13											
	14											

RIG: Atkins Mach 11 **DRILLER:** Albert **LOGGED:** Hickman **CASING:** HW to 1.0m

TYPE OF BORING: 100mm ϕ Spiral flight auger to 6.01m, NMLC coring form 6.01m to 11.94m

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 203
PROJECT No: 41533
DATE: 15 Aug 07
SHEET 1 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.2	TOPSOIL: Brown slightly clayey silty sand with a trace of fine gravel, moist										
		CLAYEY SAND: Orange brown slightly clayey sand with a trace of fine gravel, moist										
	0.9											
	1.0	SANDY CLAY: Very stiff, medium plasticity orange brown fine to medium grained sandy clay, M<Wp										
		TC Bit from 1.0m										
		SANDSTONE: Very low to low strength, extremely weathered light grey orange brown fine to medium grained sandstone										
		- T C Bit refusal at 4.4m										
	4.4	SANDSTONE: Low strength, highly weathered and slightly fractured light grey medium to course grained sandstone						4.49m: P, 10°	C	100	100	Is (D) = 0.29 (A) = 0.22

RIG: Atkins truck mounted **DRILLER:** Atkins **LOGGED:** Hickman **CASING:** HW to 6.0m

TYPE OF BORING: 100mm ϕ Spiral flight auger to 4.4m, NMLC coring form 4.4m to 12.39m depth

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 203
PROJECT No: 41533
DATE: 15 Aug 07
SHEET 2 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SANDSTONE: Low strength, highly weathered and slightly fractured light grey medium to course grained sandstone *(continued)*							C	100	100	
								5.5m: P,sh,un,ro				
	6											ls (D) = 0.23 (A) = 0.23
								6.25m: J,80°,un,ro,ti	C	100	100	
		- from 6.38m depth, slightly weathered, medium strength										
	7											ls (D) = 0.33 (A) = 0.38
									C	100	100	
	8							8.02m: J,80°,un,healed				
		- from 8.1m depth, highly weathered to 8.46m										
	8.6	SILTSTONE: Low strength, highly weathered dark grey siltstone										
	9								C	100	100	ls (D) = 0.5 (A) = 0.19

RIG: Atkins truck mounted **DRILLER:** Atkins **LOGGED:** Hickman **CASING:** HW to 6.0m

TYPE OF BORING: 100mm ϕ Spiral flight auger to 4.4m, NMLC coring form 4.4m to 12.39m depth

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 203
PROJECT No: 41533
DATE: 15 Aug 07
SHEET 3 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	9.99	SILTSTONE: Very low strength, extremely weathered, slightly fractured grey siltstone *(continued)*										
												Is (D) = 0.03 (A) = 0.05
									C	100	100	
								10.58m: J,45°,pl,sm				
	11											
								11.09m: P,pl,sm				Is (D) = 0.08 (A) = 0.05
									C	100	100	
								11.86m: P,pl,sm				
	12											Is (D) = 0.12 (A) = 0.06
								12.16m: P,pl,sm				
	12.39	Bore discontinued at 12.39m. Limit of investigation						12.35m: P,15°,un,ro,clay filled				
	13											
	14											

RIG: Atkins truck mounted **DRILLER:** Atkins **LOGGED:** Hickman **CASING:** HW to 6.0m

TYPE OF BORING: 100mm ϕ Spiral flight auger to 4.4m, NMLC coring form 4.4m to 12.39m depth

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 208
PROJECT No: 41533
DATE: 01 Nov 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
	0.1	FILLNG: Brown gravelly sandy clay filling, humid/M<Wp		D	0.05				
		SANDY CLAY: Hard orange brown sandy clay with some rounded fine grained gravel, M<Wp		D	0.4		pp = 500kPa		
	0.8								
	0.9	SANDSTONE: Very low and low strength orange brown and light grey sandstone		D	0.85				
	1	Pit discontinued at 0.9m. Due to virtual refusal							
	2								
	3								
	4								

RIG: Komatsu PC45MRX

LOGGED: Carson

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⫧ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 209
PROJECT No: 41533
DATE: 01 Nov 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		FILLING: Light brown clayey gravel filling, humid							
	0.2	SANDY SILTY CLAY: Hard grey brown sandy silty clay, M<Wp		D	0.5		pp = 400kPa		
	0.85			D	0.85				
	0.9	SANDSTONE: Low strength, orange brown and light grey fine to medium grained sandstone							
		Pit discontinued at 0.9m. Due to refusal							
	1								1
	2								2
	3								3
	4								4

RIG: Komatsu PC45MRX

LOGGED: Carson

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⫧ Water level

CHECKED
Initials:
Date:

Douglas Partners
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TEST PIT LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 210
PROJECT No: 41533
DATE: 01 Nov 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
		FILLING: Generally comprising orange brown gravelly sandy clay filling, M<Wp		D	0.2				
	0.3	CLAYEY SANDY SILT: Very stiff brown clayey sandy silt with grass cover		pp	0.4		pp = >500kPa		
	0.55	SANDY CLAY: Hard orange brown slightly gravelly sandy clay, M<Wp		D	0.6		pp = 500kPa		
	0.9	SILTY CLAY: Hard red brown mottled light grey silty clay, M<Wp		D	1.2		pp = 450-550kPa		
	1.7	SILTSTONE: Very low strength, light grey siltstone with some fine grained sandstone		D	1.8				
	1.9	Pit discontinued at 1.9m. Due to virtual refusal							

5 10 15 20

1 2 3 4

RIG: Komatsu PC45MRX

LOGGED: Carson

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

Douglas Partners
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TEST PIT LOG

CLIENT: Delta Electricity
PROJECT: Munmorah Gas Pipeline Project
LOCATION: Munmorah

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 211
PROJECT No: 41533
DATE: 01 Nov 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
	0.2	CLAYEY SANDY SILT: Very stiff brown clayey sandy silt with grass cover							
		GRAVELLY SANDY CLAY: Hard yellow brown gravelly sandy clay, M<Wp		D	0.5				
	0.6	SILTY CLAY: Very stiff to hard red brown mottled light grey silty clay with occasional ironstone nodules to 60mm, M<Wp							
	1			D	1.1		pp = 450kPa		
	2								
		- grading to extremely low strength siltstone from 2.4m		D	2.4		pp = 380-500kPa		
				D	2.5				
	2.6	Pit discontinued at 2.6m. Due to virtual refusal							
	3								
	4								

RIG: Komatsu PC45MRX

LOGGED: Carson

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⫧ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Colongra Gas Pipeline Project
LOCATION: Colongra

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 501
PROJECT No: 41533
DATE: 11 Feb 08
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		FILLING: Generally comprising, light brown mottled brown sandy clay filling with some fine to medium sized subrounded gravel, M=Wp							A			
	0.45											
	0.8	SILTY SAND; Loose to medium dense, dark grey fine to medium grained silty sand, moist							A			
	1								S			2,2,3 N = 5
		SANDY CLAY: Stiff, medium plasticity light grey fine to medium grained sandy clay, M>Wp										
	2	- from 2 m depth, very stiff							S			3,7,9 N = 16 pp = 300kPa
	3											
	4											
	4.3	- some fine gravel (5mm) and sandstone lense from 4.1m - 4.3m, M>Wp							S			8,17,14 N = 31 pp = 300kPa
	4.46	SILTY CLAY: Hard, medium plasticity light grey silty clay, M>Wp										
	5	SILTSTONE: Extremely low strength, extremely weathered light grey siltstone - from 4.85m depth, trace 5-10mm sized gravel - from 5.0m depth, trace of fine grained sand - from 5.1m - 5.12m depth, ironstained sandstone lense							C	100	0	
	5.8	SANDSTONE: Extremely low strength, extremely weathered unbroken light grey, medium grained sandstone							C	100	0	
	6											
	7								C	100	0	
	7.2	SILTSTONE: Extremely low strength, extremely weathered siltstone (with soill like properties) - from 7.5m-7.7m depth, red brown ironstained										
	8	- from 8.1m-8.5m depth, ironstaining										
		- from 8.7m depth, slightly sandy							C	100	0	
	9											
		- from 9.7m depth, light brown grey mottled										

RIG: Patrol **DRILLER:** Foody **LOGGED:** Hickman **CASING:** HW to 4 m

TYPE OF BORING: 100mm ϕ Solid flight auger to 4.46 m, NMLC coring from 4.46 m to 10.08 m

WATER OBSERVATIONS: Groundwater observed at 4.0m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

Douglas Partners
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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Colongra Gas Pipeline Project
LOCATION: Colongra

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 501
PROJECT No: 41533
DATE: 11 Feb 08
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	10.08	Bore discontinued at 10.08m. Limit of investigation										
	11											
	12											
	13											
	14											
	15											
	16											
	17											
	18											
	19											

RIG: Patrol **DRILLER:** Foody **LOGGED:** Hickman **CASING:** HW to 4 m

TYPE OF BORING: 100mm ϕ Solid flight auger to 4.46 m, NMLC coring from 4.46 m to 10.08 m

WATER OBSERVATIONS: Groundwater observed at 4.0m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

Douglas Partners
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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Colongra Gas Pipeline Project
LOCATION: Colongra

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 502
PROJECT No: 41533
DATE: 12 Feb 08
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		FILLING: Generally comprising a mixture of fine crushed rock (railway ballast), pedominatly 50-100mm aggregate and brown clayey gravelly sand (ripped sandstone), moist							D			
	0.9	CLAY: Firm/stiff, high plasticity brown clay with some fine grained sand, M>Wp							S			1,2,2 N = 4 pp = 100-150kPa
		↳ from 1.05m depth, becoming light grey										
	2.0	SANDY CLAY: Very stiff, medium plasticity light grey sandy clay with some fine gravel , M=Wp							S			4,9,13 N = 22 pp = 190-220kPa
	3.06	CORE LOSS						3.06m: CORE LOSS: 150mm				
	3.21	SANDY CLAY: Very stiff light grey sandy clay with some fine gravel, M = Wp							C	100	0	
	4.01	CORE LOSS						4.01m: CORE LOSS: 220mm				
	4.23	SANDSTONE: Extremely low strength, extremely weathered sandstone, unbroken with some fine gravel 5mm aggregate							C	82	0	
	4.27	SILTSTONE: Extremely low strength, extremely weathered, unbroken light grey, red brown siltstone (with soil like properties)						5.22m: P5°, r, un, ro				
	4.87	↳ from 4.41m depth, low strength, highly weathered red brown siltstone band unbroken							C	100	0	
		SANDSTONE: Extremely low strength, extremely weathered, light grey, red brown medium grained sandstone										
		↳ from 5.0m depth, becoming extremely low to very low strength, highly weathered						6.65m: P5°, un, ro				
	6.81	6.81m: CORE LOSS: 40mm										
	6.85	↳ from 5.55m depth, very low strength, highly weathered red brown						7.12m: P5°, un, sm 7.18m: P5°, un sm	C	79	0	
		↳ from 6.1m depth, some fine gravel pedominatly 5mm smooth aggregate										
	8.0	↳ from 6.45m depth, low to medium strength, moderately weathered sandstone						8m: CORE LOSS: 320mm				
	8.32	CORE LOSS										
		SILTSTONE: Extremely low strength, extremely weathered, unbroken light grey, red brown mottled siltstone						8.54m: P5°, un 8.64m: P45°, un, ro	C	100	0	
		SANDSTONE: Extremely low strength, extremely weathered, light grey, red brown medium grained sandstone						9.11m: P25°, un	C	100	0	
	9.92	↳ from 7.5m-7.9m depth, siltstone										

RIG: Patrol **DRILLER:** Foody **LOGGED:** Hickman **CASING:** HW to 3.5 m

TYPE OF BORING: 100mm ϕ Solid flight auger to 3.06, NMLC coring from 3.06 m to 9.92 m

WATER OBSERVATIONS: Groundwater observed at 3.8m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED	
Initials:	
Date:	

Douglas Partners
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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Colongra Gas Pipeline Project
LOCATION: Colongra

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 502
PROJECT No: 41533
DATE: 12 Feb 08
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	11	with soil like properties CORE LOSS SILTSTONE: Extremely low strength, extremely weathered, unbroken light grey, red brown mottled siltstone - from 8.66 m depth, very low strength Bore discontinued at 9.92m. Limit of investigation										
	12											
	13											
	14											
	15											
	16											
	17											
	18											
	19											

RIG: Patrol **DRILLER:** Foody **LOGGED:** Hickman **CASING:** HW to 3.5 m

TYPE OF BORING: 100mm ϕ Solid flight auger to 3.06, NMLC coring from 3.06 m to 9.92 m

WATER OBSERVATIONS: Groundwater observed at 3.8m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

Douglas Partners
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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Colongra Gas Pipeline Project
LOCATION: Colongra

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 503
PROJECT No: 41533
DATE: 11 Feb 08
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.1	FILLING: Gravel (railway ballast)										
		GRAVELLY CLAYEY SAND: Light brown gravelly clayey sand (ripped sandstone filling), moist							D			
	0.9	GRAVELLY SANDY CLAY: Very stiff, medium plasticity light grey predominatly smoothed subrounded 5mm gravelly medium to course grained sandy clay, M>Wp							S			2,2,4 N = 6 pp = 200kPa
	1											
	2											
		- from 2.5m depth, grading into an extremely low strength, extremely weathered sandstone							S			10,16,16 N = 32
	3											
	3.0	CORE LOSS						3m: CORE LOSS: 210mm	C	78	0	
	3.21	SILTSTONE: Extremely low strength, extremely weathered light grey siltstone with some red brown very low to low strength mudstone bands										
	3.96	CORE LOSS						3.96m: CORE LOSS: 130mm	C	92	0	
	4											
	4.09	SILTSTONE: Extremely low strength, extremely weathered light grey siltstone with some red brown very low to low strength mudstone bands										
	4.3	SANDSTONE: Very low strength, highly weathered unbroken light grey medium grained sandstone - from 4.5m depth, orange brown										
	5											
	5.56	CORE LOSS						5.56m: CORE LOSS: 500mm	C	63	0	
	6											
	6.06	SANDSTONE: Very low strength, highly weathered unbroken light grey medium grained slightly pebbly sandstone										
	6.5	- from 6.47m depth, extremely low strength, extremely weathered										
	7	SILTSTONE: Extremely low strength, extremely weathered unbroken light grey siltstone - from 6.8m depth, light grey orange brown mottled - from 7.25m, very low strength, highly weathered							C	100	0	
	8											
	8.2	SANDSTONE: Medium strength, moderately weathered unbroken orange brown medium grained sandstone										
	8.6	SILTSTONE: Very low strength, extremely weathered, light grey red brown mottled siltstone						8.65m: P5°, pl, sm 8.75m: P5°, pl, sm 9.1m: P5°, pl, sm	C	100	0	
	9											
									C	100	0	

RIG: Patrol **DRILLER:** Foody **LOGGED:** Hickman **CASING:** HW to 3 m

TYPE OF BORING: 100mm ϕ Solid flight auger to 3.0 m, NMLC coring from 3.0 m to 10.2 m

WATER OBSERVATIONS: Groundwater observed at 2.0m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

Douglas Partners
Geotechnics · Environment · Groundwater

BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Colongra Gas Pipeline Project
LOCATION: Colongra

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 503
PROJECT No: 41533
DATE: 11 Feb 08
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	10.2	Bore discontinued at 10.2m. Limit of investigation						10.15m: P5°, pl, sm	C	100	0	

RIG: Patrol **DRILLER:** Foody **LOGGED:** Hickman **CASING:** HW to 3 m

TYPE OF BORING: 100mm ϕ Solid flight auger to 3.0 m, NMLC coring from 3.0 m to 10.2 m

WATER OBSERVATIONS: Groundwater observed at 2.0m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

Douglas Partners
Geotechnics · Environment · Groundwater

BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Colongra Gas Pipeline Project
LOCATION: Colongra

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 504
PROJECT No: 41533
DATE: 14 Feb 08
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		FILLING: Generally comprising dark grey fine to medium grained silty clayey sand with some fine to medium sized gravel							A			
									A			
	1 1.0	SANDY CLAY: Stiff to very stiff, light grey mottled orange fine to medium grained sandy clay, M<Wp										
	2	- from 2.0m depth orange mottled grey with trace of fine sized gravel							A			
									A			
	3											
	4											
	4.11	SANDSTONE: Low strength, highly weathered, unbroken, medium/coarsed grained light grey sandstone with some fine predominantly smooth rounded 5mm gravel							C	76	0	
	4.6	- from 4.5m depth becoming extremely low/high weathered										
	5 5.11							5.11m: CORE LOSS: 370mm				
	5.48	SILTSTONE: Extremely low strength, extremely weathered, light grey siltstone with some ironstained mudstone bands from 6.8m (soil like properties										
	5.7	CORE LOSS: 0.37 m							C	96	10	
	6	SILTSTONE: Extremely low strength, extremely weathered, light grey siltstone with some ironstained mudstone bands from 6.8m (soil like properties										
	7	SANDSTONE: Very low/low strength, highly weathered, orange brown fine to medium grained slightly pebbly sandstone										
	7.9	- from 5.85m depth light grey and coarse grained							C	84	10	
	8 8.05	- from 5.95m depth becoming low strength										
	8.16	- from 6.15m depth very low strength						8.16m: CORE LOSS: 320mm				
	8.48	SILTSTONE: Extremely low strength, extremely weathered, light grey siltstone with soil like properties										
	9	SANDSTONE: Low strength, highly weathered, orange medium grained sandstone							C	100	0	
	9.6	CORE LOSS: 0.32 m										
	9.92											

RIG: Patrol **DRILLER:** Foody **LOGGED:** Hickman **CASING:** HW to 4m

TYPE OF BORING: 100mm ϕ Solid flight auger to 4.11 m, NMLC coring from 4.11 m to 9.92 m

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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BOREHOLE LOG

CLIENT: Delta Electricity
PROJECT: Colongra Gas Pipeline Project
LOCATION: Colongra

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 504
PROJECT No: 41533
DATE: 14 Feb 08
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SILTSTONE: Extremely low strength, extremely weathered grey mottled orange siltstone										
		SANDSTONE: Very low strength, extremely weathered brown fine to medium grained sandstone										
	11	Bore discontinued at 9.92m. Limit of investigation										
	12											
	13											
	14											
	15											
	16											
	17											
	18											
	19											

RIG: Patrol **DRILLER:** Foody **LOGGED:** Hickman **CASING:** HW to 4m

TYPE OF BORING: 100mm ϕ Solid flight auger to 4.11 m, NMLC coring from 4.11 m to 9.92 m

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

Douglas Partners
Geotechnics · Environment · Groundwater

APPENDIX D

Laboratory Results

Douglas Partners
Geotechnics · Environment · Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
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RESULTS OF MOISTURE CONTENT, PLASTICITY AND LINEAR SHRINKAGE TESTS

Client: Conics Pty Ltd
Project: Geotechnical & Contamination Assessment
Location: Hue Hue Road, Wyee

Project No: 41810
Report No: CC09-318
Report Date: 10.6.2009
Date Sampled: 12.5.2009
Date of Test: 5.6.2009
Page: 1 of 1

TEST LOCATION	DEPTH (m)	DESCRIPTION	CODE	W_F %	W_L %	W_P %	PI %	*LS %
BH 20	0.5 - 0.85	SANDY CLAY - Light grey sandy clay with a trace of silt	2,5	16.2	36	12	24	11.0

Legend:
W_F Field Moisture Content
W_L Liquid limit
W_P Plastic limit
PI Plasticity index
LS Linear shrinkage from liquid limit condition (Mould length 125mm)

Test Methods:
Moisture Content: AS 1289 2.1.1
Liquid Limit: AS 1289 3.1.2
Plastic Limit: AS 1289 3.2.1
Plasticity Index: AS 1289 3.3.1
Linear Shrinkage: AS 1289 3.4.1
Cone Liquid Limit: AS 1289 3.9.1
AS 1289.1.3.1

Code
Sample history for plasticity tests
1. Air dried
2. Low temperature (<50°C) oven dried
3. Oven (105°C) dried
4. Unknown

Method of preparation for plasticity tests
5. Dry sieved
6. Wet sieved
7. Natural

*Specify if sample crumbled CR or curled CU

Sampling Method(s): Sampled by Douglas Partners' Engineers

Remarks:

Approved Signatory:

Tested: JP
Checked: DB

Dan Byrnes
Laboratory Manager

NATA Accredited Laboratory Number: 828
This Document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025
ACCREDITED FOR TECHNICAL COMPETENCE

Douglas Partners
Geotechnics · Environment · Groundwater

Douglas Partners Pty Ltd
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wyong@douglaspartners.com.au

RESULT OF SHRINK-SWELL INDEX DETERMINATION

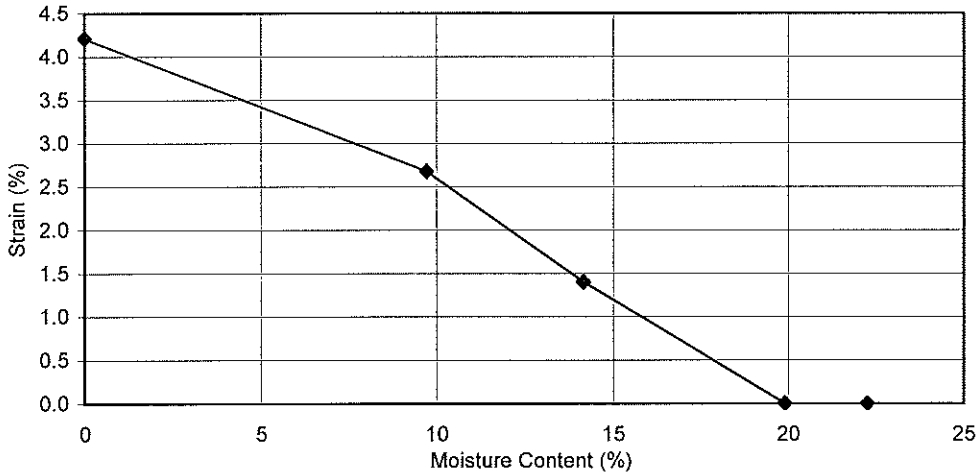
Client :	Conics Pty Ltd	**Project No. :**	41810
		Report No. :	CC09-300
Project :	Geotechnical & Contamination Assessment	**Report Date :**	2.6.2009
		Date Sampled :	12.5.2009
Location :	Hue Hue Road, Wyee	**Date of Test:**	19.5.2009
Test Location :	BH 3		
Depth / Layer :	0.6 - 0.9m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	2.7 %
Shrinkage - oven dried	4.2 %
Significant inert inclusions	0.0 %
Extent of cracking	UC
Extent of soil crumbling	0.0 %
Moisture content of core	19.9 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	170 kPa
Pocket penetrometer reading at final moisture content	160 kPa
Initial Moisture Content	19.5 %
Final Moisture Content	22.3 %
Swell under 25kPa	0.0 %



SHRINK-SWELL INDEX Iss 2.3% per Δ pF

Description: SANDY CLAY - Light brown mottled orange brown sandy clay

Test Method(s): AS 1289.7.1.1 - 2003, AS 1289.2.1.1 - 2005

Sampling Method(s): AS 1289.1.3.1-1999

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

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Approved Signatory:

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RESULT OF SHRINK-SWELL INDEX DETERMINATION

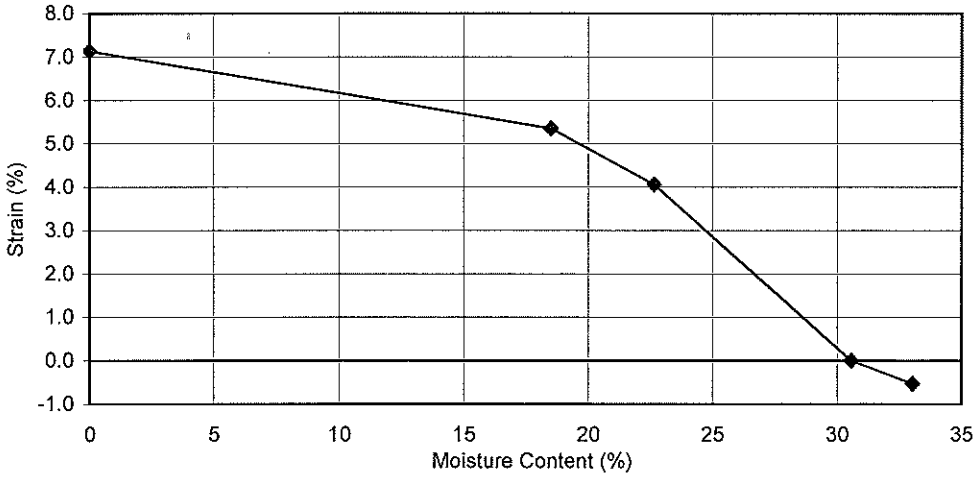
Client :	Conics Pty Ltd	**Project No. :**	41810
		Report No. :	CC09-301
Project :	Geotechnical & Contamination Assessment	**Report Date :**	2.6.2009
		Date Sampled :	12.5.2009
Location :	Hue Hue Road, Wyee	**Date of Test:**	19.5.2009
Test Location :	BH 11		
Depth / Layer :	0.5 - 0.8m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	5.3 %
Shrinkage - oven dried	7.1 %
Significant inert inclusions	0.0 %
Extent of cracking	UC
Extent of soil crumbling	0.0 %
Moisture content of core	30.6 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	380 kPa
Pocket penetrometer reading at final moisture content	240 kPa
Initial Moisture Content	30.2 %
Final Moisture Content	33.0 %
Swell under 25kPa	0.5 %



SHRINK-SWELL INDEX Iss 4.1% per Δ pF

Description: SANDY CLAY - Orange brown sandy clay

Test Method(s): AS 1289.7.1.1 - 2003, AS 1289.2.1.1 - 2005

Sampling Method(s): AS 1289.1.3.1-1999

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

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RESULT OF SHRINK-SWELL INDEX DETERMINATION

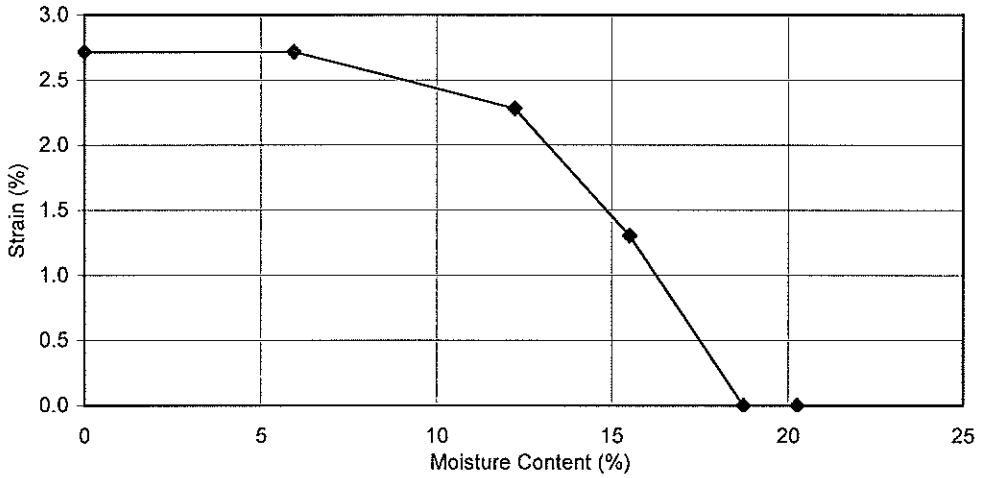
Client :	Conics Pty Ltd	**Project No. :**	41810
		Report No. :	CC09-302
Project :	Geotechnical & Contamination Assessment	**Report Date :**	2.6.2009
		Date Sampled :	12.5.2009
Location :	Hue Hue Road, Wyee	**Date of Test:**	27.5.2009
Test Location :	BH 16		
Depth / Layer :	0.5 - 0.8m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	2.7 %
Shrinkage - oven dried	2.7 %
Significant inert inclusions	0.0 %
Extent of cracking	SC
Extent of soil crumbling	0.0 %
Moisture content of core	18.7 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	200 kPa
Pocket penetrometer reading at final moisture content	130 kPa
Initial Moisture Content	13.8 %
Final Moisture Content	20.3 %
Swell under 25kPa	0.0 %



SHRINK-SWELL INDEX Iss 1.5% per Δ pF

Description: SANDY CLAY - Light grey mottled orange brown sandy clay

Test Method(s): AS 1289.7.1.1 - 2003, AS 1289.2.1.1 - 2005

Sampling Method(s): AS 1289.1.3.1-1999

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

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RESULT OF SHRINK-SWELL INDEX DETERMINATION

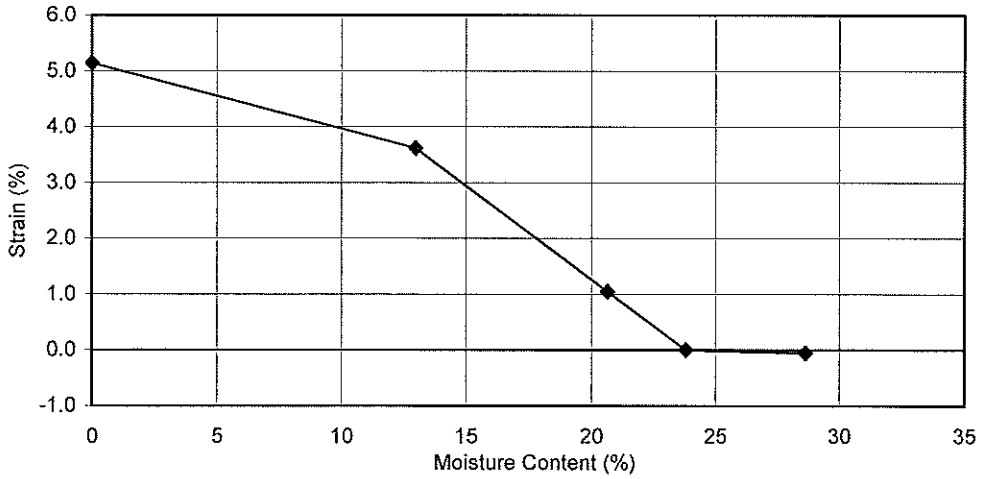
Client :	Conics Pty Ltd	**Project No. :**	41810
		Report No. :	CC09-303
Project :	Geotechnical & Contamination Assessment	**Report Date :**	2.6.2009
		Date Sampled :	12.5.2009
Location :	Hue Hue Road, Wyee	**Date of Test:**	19.5.2009
Test Location :	BH 19		
Depth / Layer :	0.3 - 0.55m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	3.6 %
Shrinkage - oven dried	5.1 %
Significant inert inclusions	0.0 %
Extent of cracking	UC
Extent of soil crumbling	0.0 %
Moisture content of core	23.8 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	260 kPa
Pocket penetrometer reading at final moisture content	170 kPa
Initial Moisture Content	22.7 %
Final Moisture Content	28.6 %
Swell under 25kPa	0.1 %



SHRINK-SWELL INDEX Iss 2.9% per Δ pF

Description: SANDY CLAY - Light grey mottled orange brown sandy clay

Test Method(s): AS 1289.7.1.1 - 2003, AS 1289.2.1.1 - 2005

Sampling Method(s): AS 1289.1.3.1-1999

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

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RESULT OF SHRINK-SWELL INDEX DETERMINATION

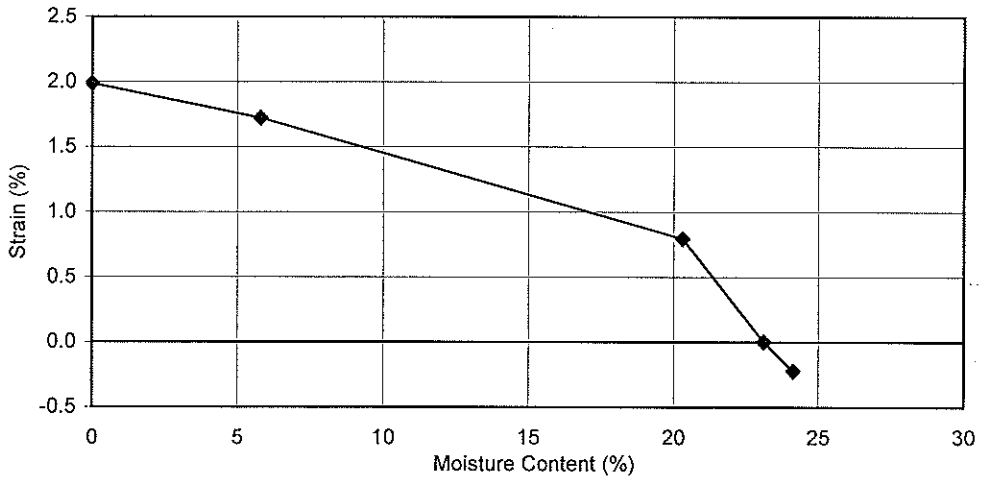
Client :	Conics Pty Ltd	**Project No. :**	41810
		Report No. :	CC09-317
Project :	Geotechnical & Contamination Assessment	**Report Date :**	10.6.2009
		Date Sampled :	12.5.2009
Location :	Hue Hue Road, Wyee	**Date of Test:**	2.6.2009
Test Location :	BH 23		
Depth / Layer :	0.5 - 0.8m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	1.7 %
Shrinkage - oven dried	2.0 %
Significant inert inclusions	0.0 %
Extent of cracking	SC
Extent of soil crumbling	0.0 %
Moisture content of core	23.1 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	280 kPa
Pocket penetrometer reading at final moisture content	250 kPa
Initial Moisture Content	22.3 %
Final Moisture Content	24.1 %
Swell under 25kPa	0.2 %



SHRINK-SWELL INDEX Iss 1.2% per Δ pF

Description: SANDY CLAY - Orange brown sandy clay

Test Method(s): AS 1289.7.1.1 - 2003, AS 1289.2.1.1 - 2005

Sampling Method(s): AS 1289.1.3.1-1999

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

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APPENDIX E

CSIRO Publication

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- **Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.**
- **Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.**

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

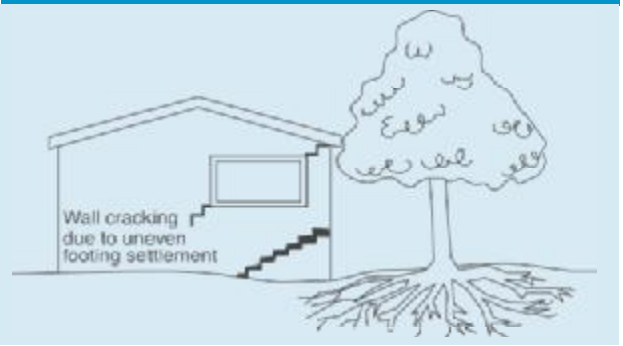
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

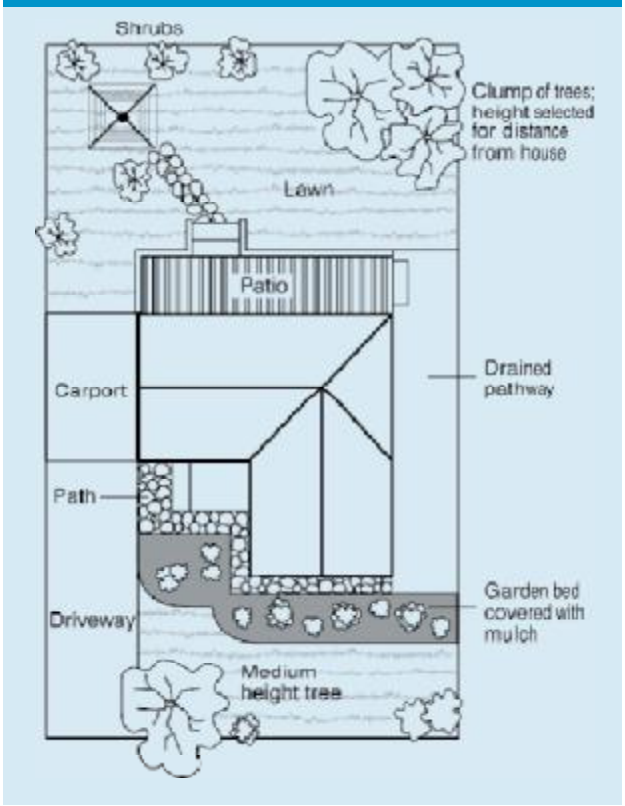
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

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Distributed by

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